

WP5 Community of Practice Deliverable 5.2 First Annual Report for Researchers

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EXECUTIVE SUMMARY

Precision Livestock Farming (PLF) can be defined as the management of livestock farming by continuous automated real-time monitoring of the health and welfare of livestock and the associated impact on the environment. The benefits associated with PLF are far-reaching: improved animal welfare, improved profitability, improved product quality, minimised adverse environmental impacts and reduced use of antibiotics through preventive health measures. A survey was developed to investigate the use of sensor technologies in relation to improved productivity and profitability on dairy farms, in order to give some hints for further research priorities in the 4D4F research project for funding organizations around Europe. The survey was sent to partners in different occupations (farmers, veterinarians, farm advisors and researchers) across nine countries in Europe. In total, there were 103 replies with the majority having come from farmers. Overall, the majority identified the following areas of dairy farming productivity to be core; lameness, udder health, metabolic diseases, nutrition and reproduction. On experiences in the use of sensors, most respondents seem to have experience in more than one sensor while pressure sensor were least common on farms and very few had experience from this devices.

The study has highlighted the following areas as the top priority for research;

- Research on refining sensors which can provide rapid information on health issues, reproduction, nutrition. Precisely on the following areas; lameness, mastitis, and metabolic diseases. In particular, the sensors ought to have better algorithms for health. More research in the area of integration of information was stressed by researchers.
- Further research on wide spectrum sensors i.e. those which can capture multiple dairy cow health issues.
- Simplifying the data so that it would be easy to understand in order to enable prompt action with regards to areas of dairy farm productivity.

In conclusion, the survey has highlighted several areas where research on sensor technologies should focus on in order to improve productivity and sustainability on dairy farms.



Report on research priorities on the use of sensor technologies to improve productivity and sustainability on dairy farms

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1. INTRODUCTION

This report is part of the Horizon 2020 EU Data Driven Dairy Decision For Farmers (4D4F) project looking into the use of sensors in dairy farming. It highlights areas for future research on the use of sensor technologies to improve productivity and sustainability on dairy farms. The report, in particular, discusses the top future research priorities identified by farmers, veterinarians, advisors and researchers in project partner countries.

The dairy farming sector is facing substantial challenges, including reduced profit margins, food safety, welfare and pressure from both government and non-governmental organizations to minimise on farming activities which degrade the environment. There is urgent need for precision approach to tackle some of these challenges. The dairy farming sector requires smart approaches which aim to increase efficiency while reducing the cost of production, improving general animal welfare and minimising on the environmental impact.

Precision Livestock Farming (PLF) which can be defined as the management of livestock farming by continuous automated real-time monitoring of the health and welfare and the associated impact on the environment might be the immediate thought for farmers in addressing some of the issues associated with dairy production in the EU and across the world. This development is currently changing the shape of dairy farming across the globe, with the majority becoming more common in the developed countries. The benefits associated with PLF are far-reaching: improved animal welfare, improved profitability, improved product quality, minimised adverse environmental impacts and reduced use of antibiotics through preventive health measures (Norton and Berckmans, 2017).

PLF is proving to be the next important technological breakthrough for the 21st century dairy industry where it can provide the farmer with real time information about the animal, to support speedy decision-making in the busy farming environment. This report therefore aims to identify areas for future research priorities on the use of sensor

technologies to improve productivity and sustainability in dairy farms. It is hoped that the findings will provide some guidance to project funders in allocating future research funds. Additionally, it may also act to inform researchers working on sensor technologies, dairy cattle health, reproduction, nutrition, housing and other relevant areas that contribute to sustainable dairy production.

2. DAIRY FARMING AND THE USE OF SENSOR TECHNOLOGIES

2.1 Areas of dairy farming productivity

There are a number of key areas that determine productivity in dairy farming. These include udder health, lameness, nutrition, data management, milking data, dairy cow activity and behaviour, metabolic diseases, calves and young stock, grassland management, and housing. Improved udder health has been associated with reduced usage of antibiotics, better animal welfare, improved production efficiency (Barberg *et al.*, 2007; Hogeveen and Lam, 2012). With increasing focus on milk quality and demand for lower somatic cell counts, it is important that dairy producers have tools with high precision in detecting early signs of disease which will help to take quick action which ultimately leads to reducing mastitis incidence and effectively managing any clinical cases.

Lameness is one of the most common dairy cattle issues which impacts on performance, profitability and general health and welfare. The disease has been shown to hinder the animal to express normal behaviour; less interaction with the rest of the animals in the herd thus reduced activities such as oestrus behaviour (Green *et al.*, 2002; Juarez *et al.*, 2003; Huxley, 2013). Undeniably, the problem justifies a cognisant effort on the part of every dairy to invest in whatever technology is needed to optimise foot health which is among the key areas for improved productivity. Metabolic diseases such as subclinical ruminal acidosis have also been associated with reduced productivity in dairy farming,

and any management system identifying early warning signs for such diseases would be ideal for the dairy farming business.

Dairy cow nutrition remains a fundamental pillar in farm business and measurements to improve the daily performance of the dairy enterprise are frequently followed by disappointing results. This is because the majority of systems lack the latest tools to monitor aspects such as daily intake. PLF technologies seem to be among the immediate tools which may help tackle both areas of feeding and nutrition in modern dairy farms. A number of these tools allow for measurements of parameters such as cow feeding behaviour and intake, rumen Ph, rumination, rumen temperature and β -Hydroxy Butyric Acid levels which is a series of metabolic tests used in monitoring the transition dairy cow for energy balance and general health. Dairy cow activities, specifically, rumination often predicts cows at risk of metabolic disorders such as sub-clinical acidosis among others (Norton and Berckmans, 2017).

2.2 Types of sensor technologies used in dairy farming

Sensor technologies are used in dairy farming to electronically monitor livestock, their environment, and to collect real-time data to make more informed decisions. Currently there are several sensors which are being used in a number of dairy farms across Europe and other countries. Specifically, these sensors are being employed on farms to monitor areas such as; reproduction activities, herd and individual animal health status, feeding and nutrition, milking data, and housing among others. Research on specific health parameter measurement in dairy cows have been documented. For example, Poikalainen and others demonstrated that infrared temperature patterns of cow's body can be an indicator for hoof and udder health, where increased temperature readings were associated with early signs of lameness and mastitis (Poikalainen *et al.*, 2012). The findings demonstrate the use of precision technologies in detecting early signs of disease ultimately resulting to quick action for better animal welfare and general productivity. Table 1 shows the examples of different types of sensors, what they measure and the various alerts.

Table 1: Examples of sensor technologies used in dairy farming

Type of Sensor		Measuring	Alerts
Movement Sensors	•	<ul style="list-style-type: none"> Activity Rumination Eating time Resting time Lying time Walking time 	<ul style="list-style-type: none"> Heat Health Calving
Milk Analysis	•	<ul style="list-style-type: none"> Progesterone Ketones Lactate Dehydrogenase Fat and Protein Colour Somatic cell count Conductivity 	<ul style="list-style-type: none"> Heat Ketosis Mastitis
pH	•	<ul style="list-style-type: none"> Rumen pH 	<ul style="list-style-type: none"> Rumen health Acidosis
Positioning	•	<ul style="list-style-type: none"> Cow behaviour 	<ul style="list-style-type: none"> Heat Location Health
Cameras	•	<ul style="list-style-type: none"> Heat Body form Movement 	<ul style="list-style-type: none"> Mastitis Lameness Body condition
Thermometer	•	<ul style="list-style-type: none"> Temperature 	<ul style="list-style-type: none"> Health Calving
Pressure	•	<ul style="list-style-type: none"> Locomotion 	<ul style="list-style-type: none"> Lameness

3. SURVEY AIMS AND OBJECTIVES

The project aimed to identify research priorities for the Data Driven Dairy Decision for Farmers (4D4F) project on the use of dairy sensors to improve productivity and sustainability on dairy farms across the European partner countries. It was based on the questionnaire which was distributed among the participating farmers, farm advisors, researchers and veterinarians in project partner countries.

The objectives of the questionnaire survey were:

- to gain information on areas which participants would regard as key in dairy farming profitability and the need for further research
- to identify problems on the farm which would require a solution
- to identify participants' experience on sensor technologies and suggestions for improvement or how best these could be adopted to improve dairy farming
- to identify top research priorities in relation to use of sensors in the dairy farming industry.

4. MATERIALS AND METHODS

A word and web version (www.surveymonkey.com) based questionnaire was designed with the main source of data provided by farmers, veterinarians, researchers and farm advisors from the 4D4F partner countries. The questionnaire had 6 sections which were; to identify the importance with regard to profitability of the different areas of dairy farming, identify the need for further research on sensor technology in the different areas of dairy farming, identify any farm problems that require a solution, identify whether participants had any experience on the use of different types of sensor technologies and to suggest any improvement/adoption on sensor technologies which might be applied to address other management areas, and to identify their top three research priorities in relation to use of sensor technologies to improve productivity and sustainability in dairy farms.

Data was cleaned in Microsoft Excel (Microsoft Corp) and exported to R (R, 2016) for general analysis in order to be able to understand the trends for the variables in question. The questionnaire can be found in Appendix 1.

5. RESULTS

A total 103 completed surveys were received and deemed to be a fair sample size. The highest response came from farmers while lowest responses were from veterinarians and farm advisors. The breakdown on the number of responses by occupation can be found in table 2. Comparing response by partner countries Netherlands reported the highest while the rest of the other countries were also fairly represented (table 3).

Table 2: Number of responses from the survey based on different occupations

Occupation	Number of responses
Farmer	46
Vet	14
Researcher	28
Farm Advisor	14
Total	103

Table 3 : Number of response from partner countries

Country	Number of response
United Kingdom	8
Sweden	9
Romania	12
Spain	13
Belgium	9
Latvia	8
Malta	4
Netherlands	40
Total	103

5.1 Farmers

5.1.1 Areas of profitability in dairy farming

Farmers identified top 6 research areas as the most important with regards to profitability in dairy farming (figure 1). These were nutrition, calves and young stock, udder health, lameness, reproduction and grassland management.

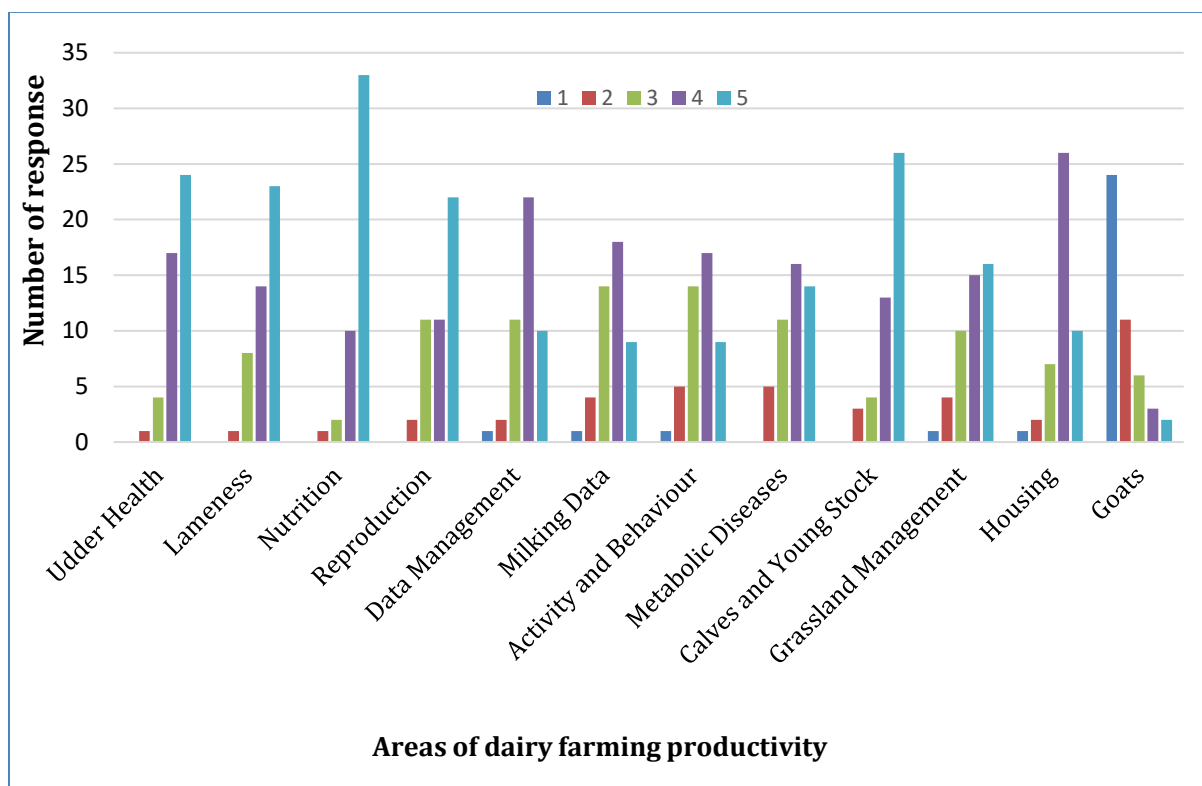


Figure 1: Farmers' responses on areas of profitability in dairy farming (1 = the area has little importance in the dairy farming industry, 5 = the area is of great importance in the dairy farming industry).

5.1.2 Availability of information on sensor technologies in dairy farming

Farmers identified the following areas to have very scarce information with regards to use of sensor technologies in dairy farming; calves and young stock, data management, nutrition, udder health, metabolic diseases and grassland management (figure 2).

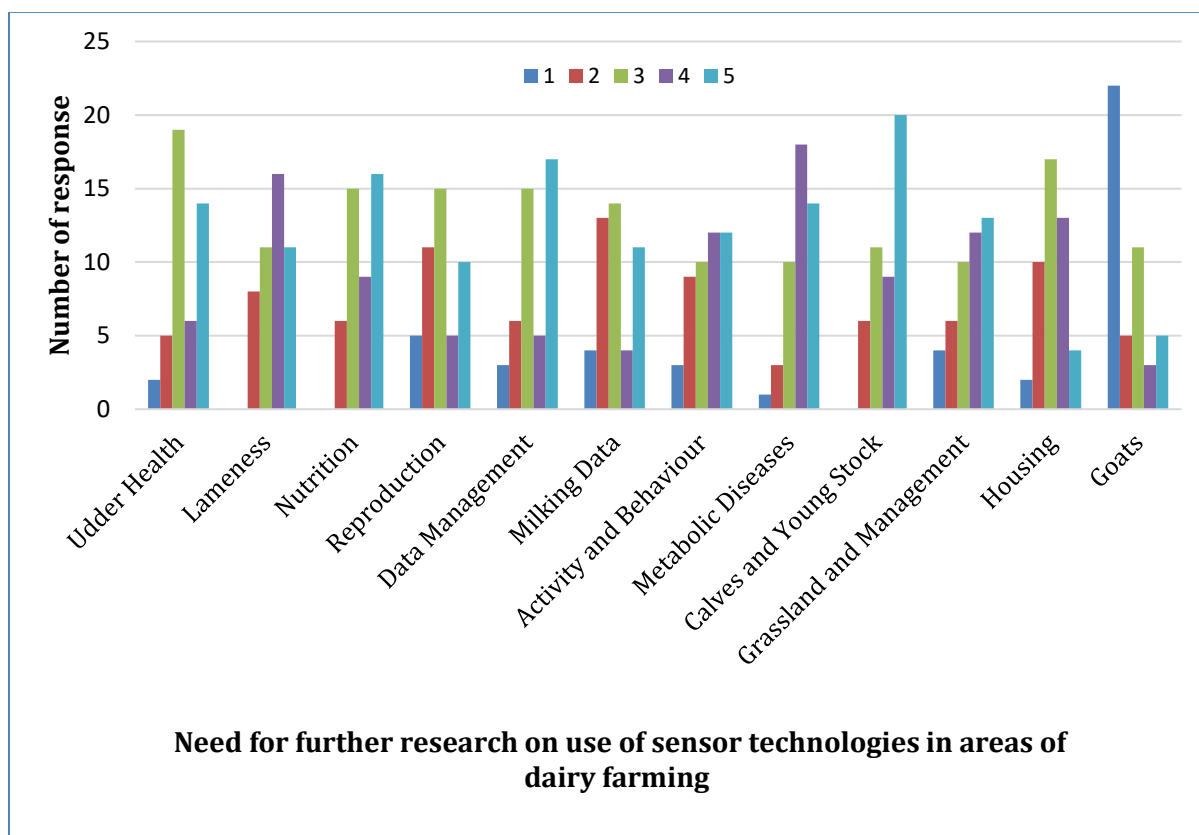


Figure 2: Farmers' responses on availability of information in relation to sensor technologies in areas of dairy farming (1 = there is currently a large amount of information available on the topic and no research is needed, 5 = there is currently very limited information available on this topic and a lot of research is needed).

5.1.3 Farm problems which require a solution

The majority of farmers identified problems that sensors were complex making it difficult to read out data to convert the same into a usable advice. They also felt that sensors were not user friendly while the minority thought they were too expensive.

Table 4: Problems in farms which require a solution

Problem	Number of response
Complex sensors/not user friendly	38
High Cost	3
No answer/response	5
Total	46

Metabolic problems (e.g. rumen acidosis), lameness, oestrus detection, mastitis and housing were identified as some of the key areas which will benefit from more input on sensor technologies.

5.1.4 Experience with sensor technologies

The majority of farmers have experience on movement and milk analysis sensors, while fewer had experience on the use of cameras. Seven farmers indicated they did not have any experience with any of the sensor technologies (table 5).

Table 5: Farmers experience with sensor technologies

Type of sensor	Number of respondents
Movement Sensors	22
Milk Analysis	17
pH	2
Positioning	6
Cameras	4
Thermometer	8
Pressure	5
No experience	7

5.1.5 Suggested areas for improvement/adoption

Table 6 summarises farmer's response in relation to areas of sensor technology which require improvement. The majority (18 out of 35) suggested that it would be beneficial to have sensors which capture early warning signs across a number of dairy productivity parameters such as lameness, oestrus detection, udder health among others. Only 5 out of 35 farmers find sensors to be too costly.

Table 6: Areas of sensor technology which require improvement

Area for improvement	Number of response
Cost	5
Training	3
Multiple use	18
User friendly	6
Accuracy	3
No reply	11
Total	46

5.1.6 Top research priorities

The majority of farmers (21 out of 43) indicated that several areas of dairy herd health as the most significant. The common health issues reported were udder health, lameness, metabolic diseases. They also pointed out that reproduction (heat detection) and nutrition as other areas which call for further research, and in particular, technologies which might help with accurate early warning signs would be much more beneficial. The full response can be found in table 7.

Table 7: Research priorities areas identified by farmers

Research Priorities	Number of respondents
Herd health	21
Reproduction	7
Nutrition	9
Better ways of making data simple	4
Housing	2
No response	3
Total	46

5.2. Veterinarians

5.2.1 Areas for profitability in dairy farming

Veterinarians identified 6 areas of major importance with regards to profitability in dairy farming; reproduction, nutrition, udder health, lameness, calves and young stock, and metabolic diseases (figure 3).

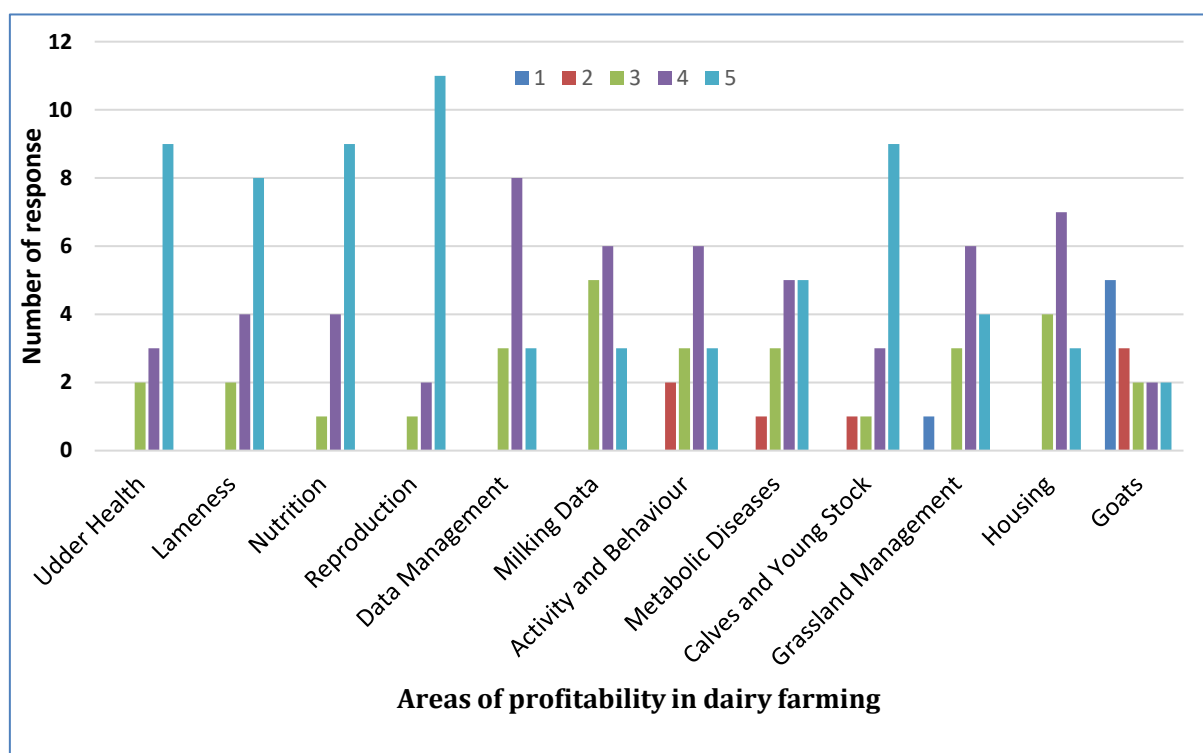


Figure 3: Veterinarians' responses in relation to profitability in dairy farming (1 = the area has little importance, 5 = the area is of great importance).

5.2.2 Availability of information on sensor technologies

Figure 4 shows veterinarians response on the availability of information on sensor technologies in relation to areas of dairy farming. They identified the following areas to have very scarce information with regards to use of sensor technologies in dairy farming; data management,

milking data, grassland management, nutrition, metabolic diseases, activity and behaviour.

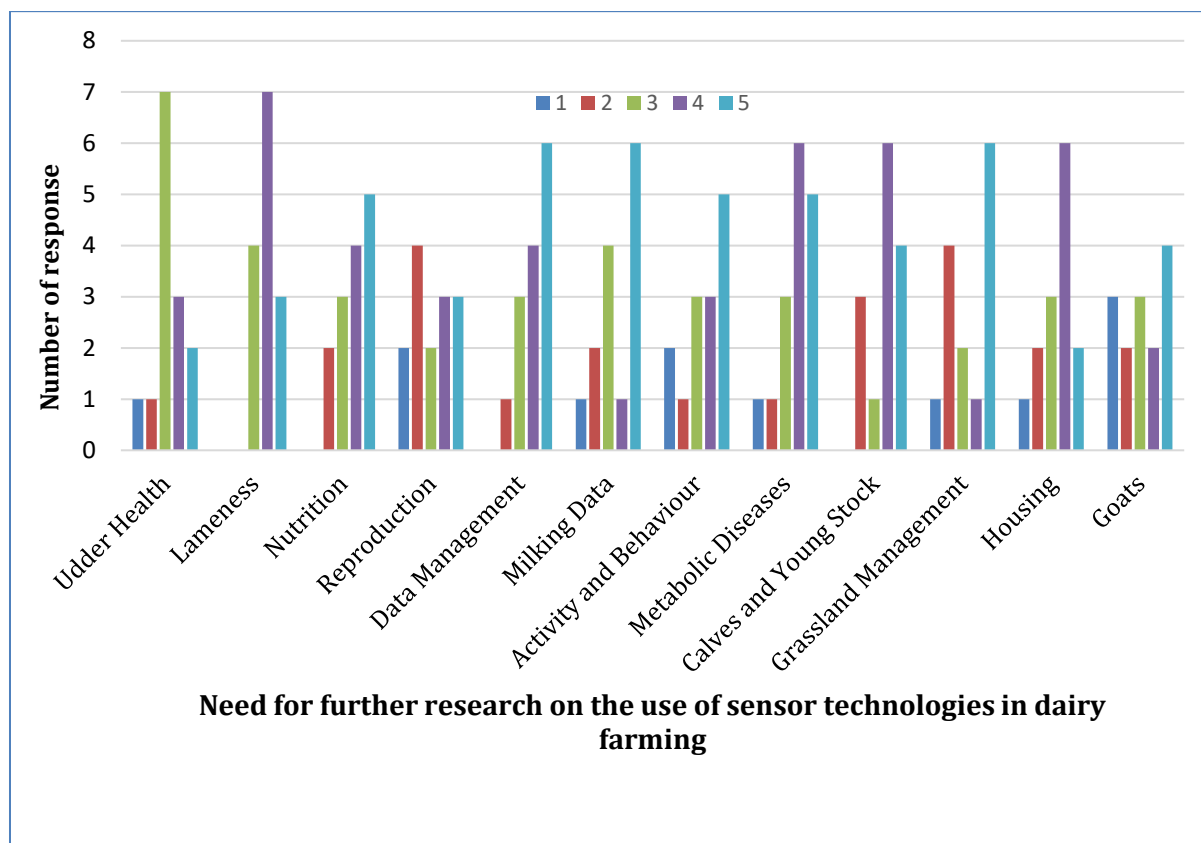


Figure 4: Veterinarians' responses on the availability of information on areas of dairy farming and the use of sensor technologies (1 = there is currently a large amount of information available on the topic and no research is needed, 5 = there is currently very limited information available on this topic and a lot of research is needed).

5.2.3 Problems identified on farms

Table 8 shows some of the problems identified by veterinarians on farms. The majority (6 out of 14) reported herd health issues such as udder health, lameness, and rumen acidosis. Areas of reproduction which included heat detection were also reported.

Table 8: Problems identified on farms

Problems at the farm	Number of response
Reading & interpreting data	3
Herd health issues	6
Housing	2
No issues reported	3
Total	14

5.2.4 Experience on sensor technologies

Table 9 show veterinarians experience on use the use of different sensor technologies. The majority of veterinarians are experienced in the use of movement sensors while none had any experience with pressure sensors.

Table 9: Veterinarians experience on sensor technologies

Type of sensor	Number of respondents
Movement Sensors	9
Milk Analysis	5
pH	3
Positioning	1
Cameras	2
Thermometer	5
Pressure	0

5.2.5 Areas for improvement on sensors

Table 10 show areas for sensor improvement as suggested by veterinarians where 50% reporting did not suggest any improvement while a few suggested the need for more training and having user friendly sensors.

Table 10: Areas for improvement on sensor technologies

Areas for improvement	Number of respondents
Cost	1
Training & user friendly	4
Wide spectrum	2
No response	7
Total	14

5.2.6 Top research priority areas

Table 11 summarise the research priorities suggested by veterinarians with the majority pointing out on the need to have sensors which target to issue early warning signs on many areas of dairy cow health. These areas were lameness, udder health and metabolic diseases.

Table 11: Top research priorities

Research priorities	Number of respondents
Herd health	12
Reproduction	1
Nutrition	1
Total	14

5.3 Researchers

5.3.1 Response on areas for profitability in dairy farming

Figure 5 shows researchers' responses with regards to areas for profitability in dairy farming. They identified 6 areas as the most important with regards to profitability in dairy farming. These were udder health, nutrition, reproduction, lameness, metabolic diseases and calves and young stock.

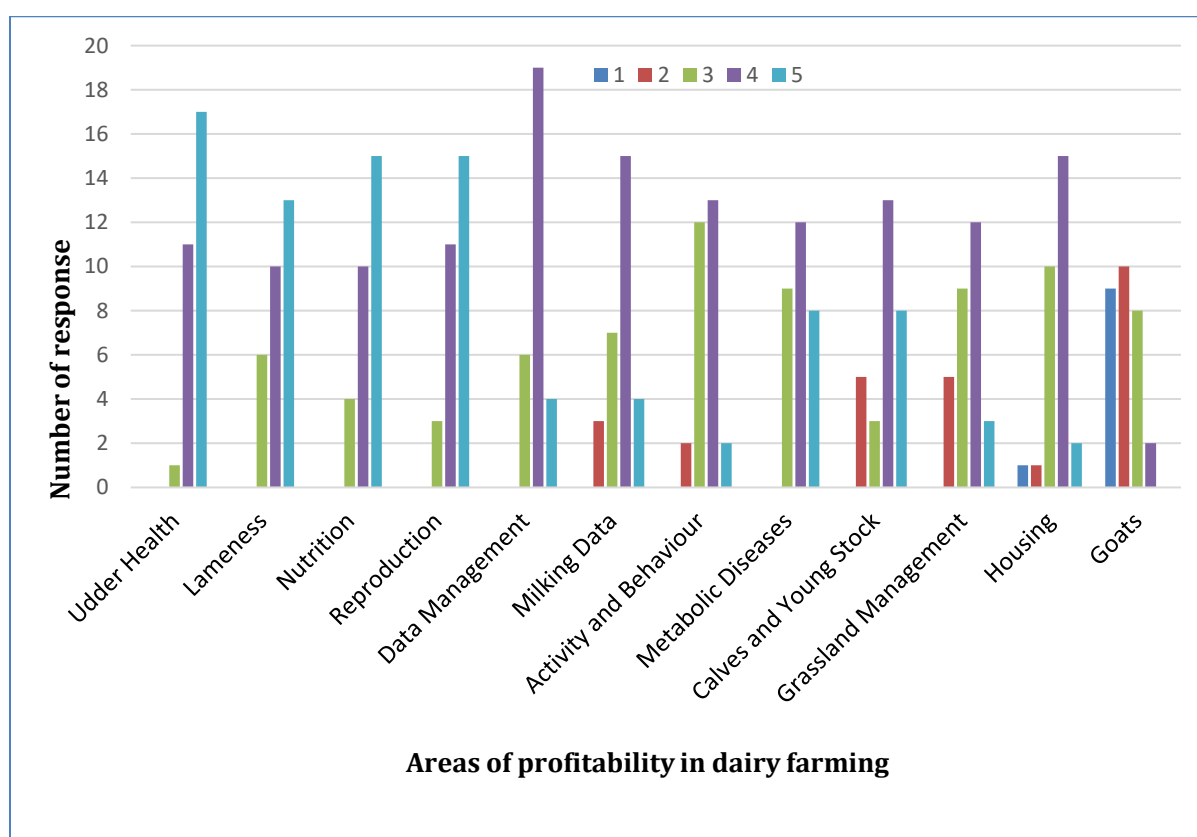


Figure 5: Researchers' responses in relation to areas of profitability in dairy farming (1 = the area has little importance, 5 = the area is of great importance).

5.3.2 Availability of information on the use of sensor technologies in dairy farming

Figure 6 shows several areas for profitability in dairy farming by researchers. Areas identified to have scarce information with regards to use of sensor technologies in dairy farming were; data management, calves and young stock, metabolic diseases, udder health, lameness and nutrition.

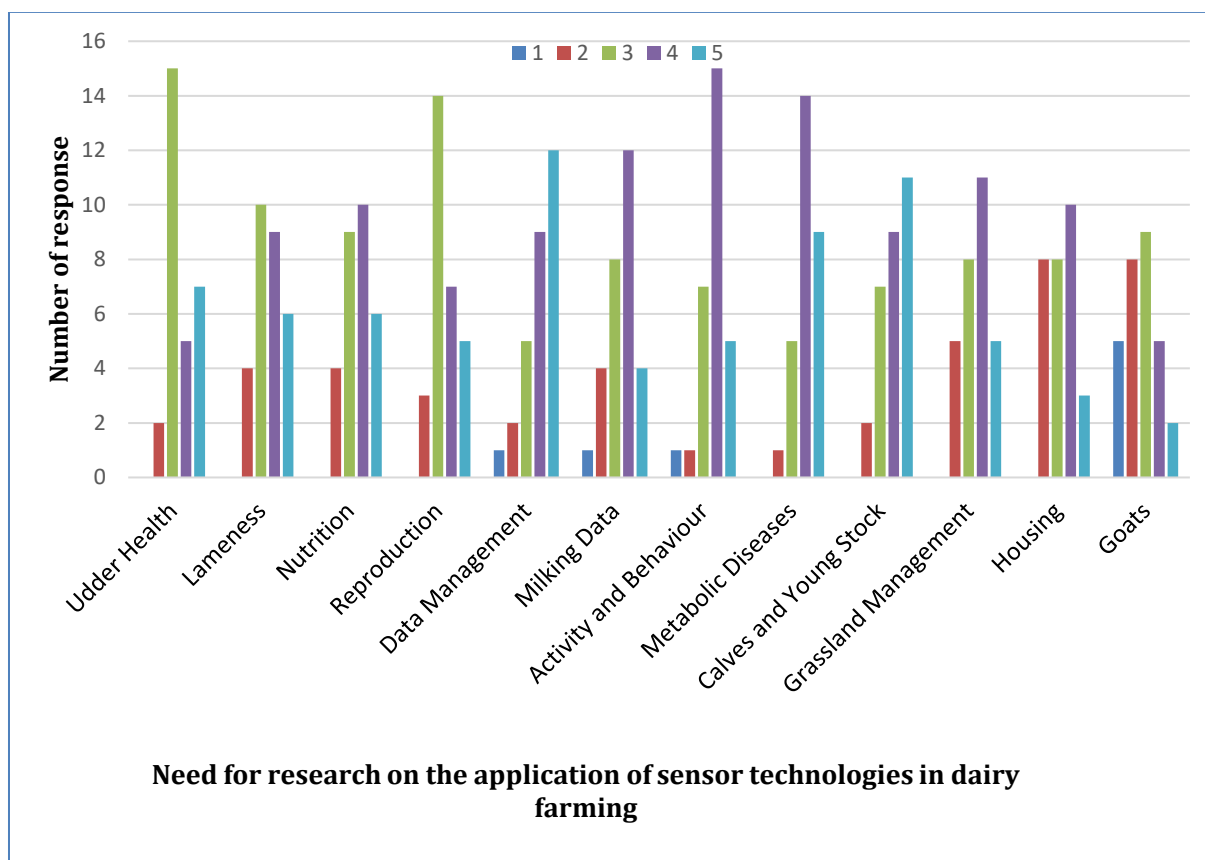


Figure 6: researchers' responses on availability of information on the application of sensor technologies in different areas of dairy farming. (1 = there is currently a large amount of information available on the topic and no research is needed, 5 = there is currently very limited information available on this topic and a lot of research is needed).

5.3.3 Problems identified on farms

11 out of 28 researchers identified health issues which included udder health and lameness. Areas of nutrition and reproduction were also raised. Equally, 11 researchers identified low specificity and sensitivity and lack of integration between sensor systems to be a common problem on farms. 6 researchers suggested that data should be integrated for better support (table 12).

Table 12: Farm problems identified by researchers

Areas identified	Number of respondents
Health issues	11
Sensor specificity	11
Integrate data for better support	6
No reply	1
Total	29

5.3.4 Experience with sensor technologies

The majority of researchers were experienced in more than one sensor technology, in particular, movement sensors followed by milk analysis while 3 had no experience with any of the sensor technologies (table 13).

Table 13: Researchers experience with sensor technologies

Type of sensor	Researchers with experience
Movement sensor	18
Milk analysis	14
pH	3
Positioning	4
Cameras	3
Thermometer	5
Pressure	0
No experience	3

5.3.5 Areas for improvement/adoption

Six out of sixteen researchers felt that sensors should be adopted for multiple use and be made user friendly. Thirteen researchers did not respond to this question (table 14).

Table 14: Areas for improvement

Area for improvement	Number of respondents
Cost	1
Training and advise	3
Adopt sensors for multiple use	6
User friendly	6
No response	13
Total	29

5.3.6 Top research priorities

Researchers indicated health and integration of information as the two main areas to be given priority for future research. Looking at health, in particular, udder health, lameness, including related areas such as nutrition (measuring individual feed intake and digestibility), and reproduction (heat detection) were pointed out to be key for future research (table 15).

Table 15: Top research priorities

Area for research	Number of respondents
Wide spec sensors	8
Integrating information	10
Health	11
Total	29

5.4 Advisors

5.4.1 Areas of farm profitability

Advisors identified the following areas to be the important with regards to profitability in dairy farming. These were nutrition, udder health, metabolic diseases, reproduction, lameness, data management and calves and young stock (figure 7).

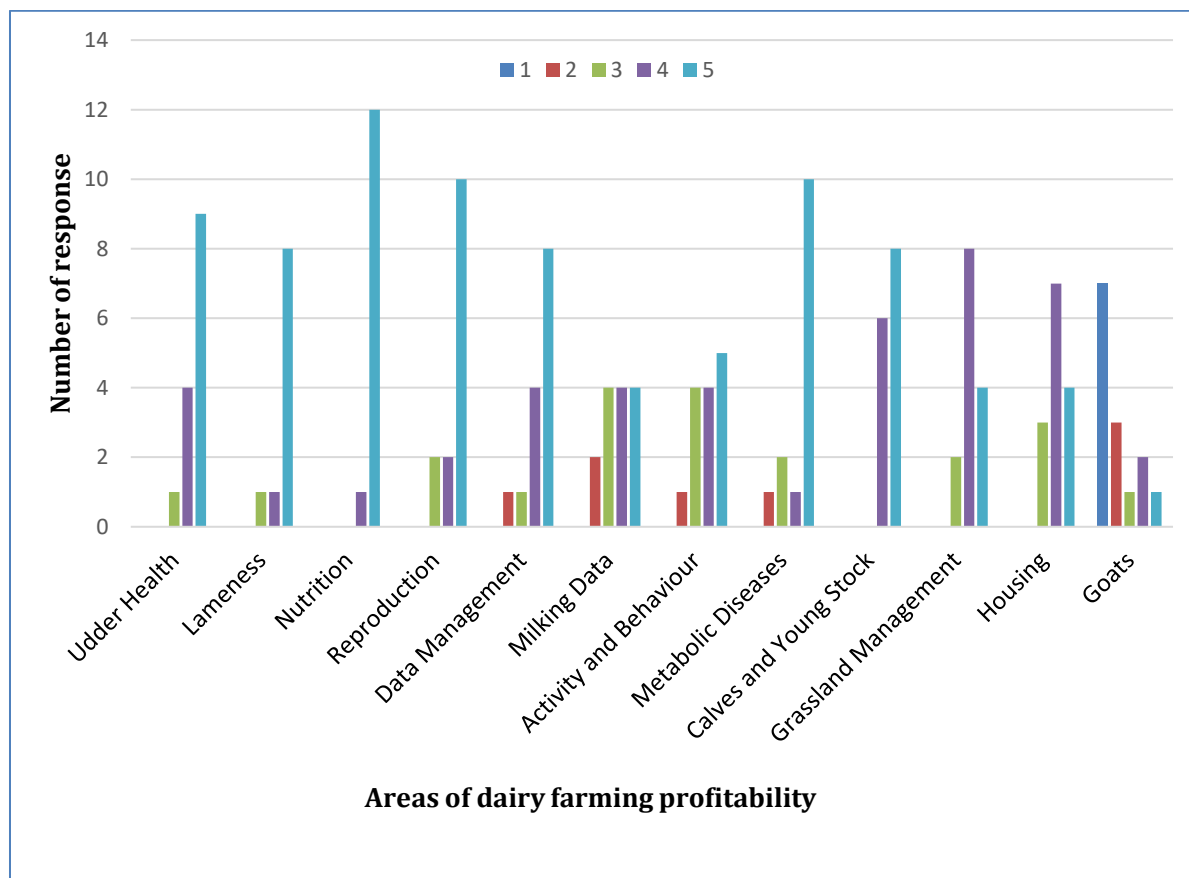


Figure 7: Response from advisors on areas of dairy farming profitability (1 = the area has little importance, 5 = the area is of great importance).

5.4.2 Availability of information on the use of sensor technologies in dairy farming

Advisors identified the following areas to have very scarce information with regards to the use of sensor technologies in dairy farming; milking data, metabolic diseases, nutrition, reproduction, data management, calves and young stock, udder health, lameness and housing.

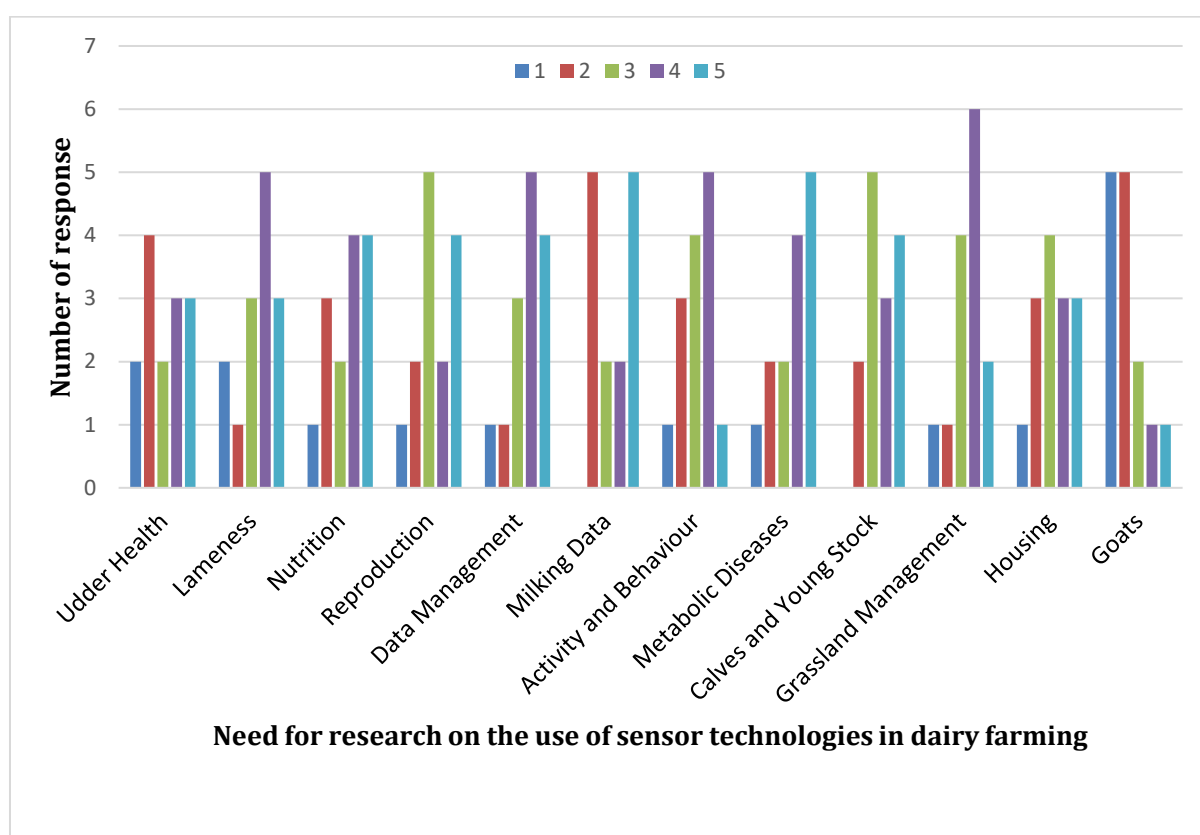


Figure 8: Advisors' responses in relation to availability of information on areas of dairy farming and use of sensor technologies. (1 = there is currently a large amount of information available on the topic and no research is needed, 5 = there is currently very limited information available on this topic and a lot of research is needed).

5.4.3 Problems identified on farms

Like the rest of the respondents, advisors identified low specificity, sensitivity and integration of sensors to help in decision making with regards to health (lameness in particular) and other associated issues; feeding, nutrition and lack of measurement for grassland management as a problem. Additionally, they pointed out a need for more sensors for early warning signs and individual cow monitoring across many areas of dairy farming (table 16).

Table 16: Problems identified on farms by advisors

Areas for solution	Number of respondents
Nutrition	3
Sensor precision/early warning	3
Health issues	5
System integration	3
Total	14

5.4.4 Experience on sensor technologies

The majority of advisors have experience on movement sensors and those that are used for milk analysis. Similarly to the veterinarians, none was experienced on pressure sensors (table 17).

Table 17: Advisors experience on sensor technologies

Type of sensor	Number of advisors with experience
Movement sensors	6
Milk Analysis	6
pH	1
Positioning	2
Cameras	1
Thermometer	0
Pressure	0

5.4.5 Areas for improvement/adoption

Only 4 advisors replied to this question where they identified the need for training workers on the use of sensors and simplifying sensors to make them more attractive to farmers/users. Additionally, they suggested sensors could be improved with making sure they have improved links/connections.

5.4.6 Top research priorities

In agreement with the other groups, advisors felt that there is need for more research on animal health areas, especially, lameness and udder health. Areas of reproduction, specifically heat detection and the need for sensors measuring dry matter intake and the like so increasing their ability to make real time decisions were additional areas pointed out by the advisors.

6. DISCUSSION

This study has focused on use of sensor technologies to improve profitability and sustainability on dairy farms within 8 project partner countries with a view to identifying top future research priorities. The discussion summarises these findings.

It was clear from the outset that feedback provided by participants identified common areas which were of importance in dairy farming. There was also a dearth of information concerning research on sensor technologies on most important areas of dairy farming. The key areas identified by the respondents from various occupations were; lameness, udder health, metabolic diseases, nutrition, reproduction and calves and young stock. The feeling that some of the sensor technologies are non-user friendly, have low battery life and more complex, especially when it comes to reading the data to convert this to a possible solution have also been expressed. It is therefore of great importance to promote further research in these areas, not only to simplify and make the sensors to be more user friendly, but also to come up with sensors which are less costly with long term use in the dairy farm environment.

It is interesting to note that there was agreement between all groups on the most significant areas of dairy farm productivity. Furthermore, farmers pointed out grassland as another area of significance importance, opposite to all other categories, while veterinarians and farm advisors felt that areas of metabolic disease and data management were also important and had very limited information.

On the area of experience with sensor technologies, the majority of occupations were experienced in the use of different types of sensors, in particular, movement and milk analysis sensors. Interestingly, only farmers had experience on the use of pressure techniques. These findings highlight the need for training on the use of sensor technologies. From the response, it is evident that there is need to formulate a set of step-by-step instructions to help those involved in the dairy farming industry in one way or the other carry out routine operations using sensors with a more simpler action protocol. This will help increase efficiency, quality and uniformity, while reducing some of the failures associated with the lack of standard operation procedures.

The respondents in the various occupations surveyed cited herd health as one of the top research priority. In particular, lameness, rumen acidosis and udder health were thought to be important areas of dairy farming business. Research on sensors with specific action alerts to help address issues on cow foot health would be important in order to obtain a sustainable production, both from an animal welfare and an economical aspect. Hoof problems are possible to prevent by early detection of affected animals where sensors would play an important part in the busy farming environment. Research on sensor technologies in early warning signs of hoof problems is therefore beneficial animal welfare. Likewise, udder health has been linked to milk yield and milk quality, in particular poor udder health can have a negative effect not only on the overall farm business profitability, but also general cow health and welfare. The findings suggest a more robust research on more sensor technologies with early warning signs, better algorithms for health and other system monitoring for individual animals which will address these important areas of dairy farming productivity and sustainability.

On the area of reproduction, the respondents felt that further research is needed to have sensors which will help with timing of insemination for improved conception and increased productivity. Automatic oestrus detection and proper timing of artificial insemination will result in efficient and profitable and reproductive performance of a dairy herd. More so, the precision approach will minimise on the use of hormones thus improved product quality among others. It is worthwhile to note that the majority of the respondents were also in agreement that sensor research should include those that integrate data from different sensors, improvements on accuracy and developments of other types of sensors to support management.

7. CONCLUSION

In summary, respondents felt that use of sensor technologies offers a number of benefits which may help in the improvement of animal health and welfare and ultimately increased farm business profitability. The problems of limited research on the various areas of dairy farming health issues, training, and developing and refining sensors which not only can have wide spectrum but also a much more finer precision still remains a big obstacle if farmers are to invest further on precision livestock technologies. It is therefore of great importance that research be implemented in the different areas identified in this report to ensure that we have the appropriate sensor technologies available for the dairy farming sector for it to be sustainable and even continue in the future generations.

8. RECOMMENDATIONS

This study has identified a number of areas in which further research is required in the use of sensor technologies in dairy farming. The top recommendations for further research are listed below:

- Research on refining sensors which can provide rapid information on health issues, reproduction, nutrition. Precisely on the following areas; lameness, mastitis, and metabolic diseases. In particular, the sensors ought to have better algorithms for health. More research in the area of integration of information was stressed by researchers.
- Further research on wide spectrum sensors i.e. those which can capture multiple dairy cow health issues.
- Simplifying the data so that it would be easy to understand in order to enable prompt action with regards to areas of dairy farm productivity.

9. REFERENCES

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10. APPENDICES

This is a questionnaire into the use of sensor technologies to improve productivity and sustainability on dairy farms.

Your answers will be used by the 4D4F project on dairy sensors to produce a report prioritising areas for further research.

Name:

Email address:

Occupation?

Farmer	
Vet	
Researcher	
Farm advisor	
Other (please specify)	

1. On a scale of 1 to 5, rate the importance of the following areas of dairy farming:

1 = This area has little importance in the dairy farming industry

5 = This area is of great importance in the dairy farming industry

Place a mark in the appropriate box;

	1	2	3	4	5
Udder Health					
Lameness					
Nutrition					
Reproduction					
Data Management					
Milking Data					
Activity and Behaviour					
Metabolic Diseases					
Calves and Young Stock					
Grassland Management					
Housing					
Goats					



2. On a scale of 1 to 5, rate the need for further research into the following areas of dairy farming:

1 = There is currently a large amount of information available on the topic and no research is needed.

5 = There is currently very limited information available on this topic and a lot of research is needed.

Place a mark in the appropriate box;

	1	2	3	4	5
Udder Health					
Lameness					
Nutrition					
Reproduction					
Data Management					
Milking Data					
Activity and Behaviour					
Metabolic Diseases					
Calves and Young Stock					
Grassland Management					
Housing					
Goats					

Sensor technologies are used in dairy farming to electronically monitor livestock, their environment, and to collect real-time data to make more informed decisions.

Examples of sensor technologies include:

Type of Sensor	Measuring	Alerts
Movement Sensors	<ul style="list-style-type: none"> Activity Rumination Eating time Resting time Lying time Walking time 	<ul style="list-style-type: none"> Heat Health Calving
Milk Analysis	<ul style="list-style-type: none"> Progesterone Ketones Lactate Dehydrogenase Fat and Protein Colour Somatic cell count Conductivity 	<ul style="list-style-type: none"> Heat Ketosis Mastitis
pH	<ul style="list-style-type: none"> Rumen pH 	<ul style="list-style-type: none"> Rumen health Acidosis
Positioning	<ul style="list-style-type: none"> Cow behaviour 	<ul style="list-style-type: none"> Heat Location Health
Cameras	<ul style="list-style-type: none"> Heat 	<ul style="list-style-type: none"> Mastitis



	<ul style="list-style-type: none">• Body form• Movement	<ul style="list-style-type: none">• Lameness• Body condition
Thermometer	<ul style="list-style-type: none">• Temperature	<ul style="list-style-type: none">• Health• Calving
Pressure	<ul style="list-style-type: none">• Locomotion	<ul style="list-style-type: none">• Lameness

3. What problems have you identified on farm that require a solution?
4. Which sensor technologies do you have experience of?
5. In which ways can current sensor technologies be improved or adapted to address other management areas?

In relation to this subject, what would you consider your top 3 research priorities and why

Priority 1:

Why:

Priority 2:

Why:

Priority 3:

Why: