

# **Demystifying Sensor Farming**

## **Final Report**

**KTIF Reference No: KTIF/037/2020**

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**Scottish Government**  
Riaghaltas na h-Alba  
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# 1. PROJECT PARTNERS

## SAOS

Scotland's experts on farmer co-operation and supply chain collaboration. SAOS provides a range of specialist information, development and consultancy services. Our work allows Scotland's farming, food and drink businesses to benefit from the commercial advantages that can be achieved by working together more effectively, enabling them to contribute to the success of Scotland's food and drink industry and its rural economy.

SAOS is itself a co-operative founded in 1905 and owned by 60 Agricultural co-ops who have a combined turnover of over £1.4bn and 26,000 members. Its work spans agriculture, aquaculture, forestry and their marketing chains with the aim of increasing competitiveness and responsiveness through 'smart' solutions and innovation. SAOS employs a team of 17 specialist project managers qualified, experienced and trained in co-op and collaborative development, delivering a range of strategic national projects as well as specialist co-op advice

The purpose of SAOS is to ensure that Scotland's farming, food and drink businesses and supply chains benefit from the commercial advantages that are achieved through co-operation and collaboration, enabling them to contribute sustainably to the success of Scotland's food and drink industry.

## SmartRural

SmartRural was established by SAOS in 2018. At present its legal status is a company limited by guarantee, but the intention is to convert over time to a farmer-controlled business. This mutual ownership strategy is essential to ensure that the data and the development of the intellectual property, software and the intelligence derived from the data resides within Scotland for the benefit of our agricultural and rural communities. To clarify, SmartRural is a non-profit business.

SmartRural's (SR) vision is to enable Scotland's rural communities and businesses to fully engage in, and to fully benefit from, the digital innovations available to them. Mutual ownership of SmartRural provides a cost-effective strategy for locating the base stations throughout our farming communities, as they will provide the connectivity from /to sensors for the monitoring of livestock, crop, social needs and security with computers and mobile phones.

## NatureScot

NatureScot (NS) is the lead public body responsible for Scotland's natural heritage, especially its natural, genetic and scenic diversity. It advises the Scottish Government and acts as a government agent in the delivery of conservation designations, i.e. national nature reserves, local nature reserves, long distance routes, national parks, Sites of Special Scientific Interest (SSSIs), Special Areas of Conservation, Special Protection Areas and the national scenic area. NS is committed to delivering a public service that meets its customers' 21st-century expectations and needs. Most of its funding comes from the Scottish Government's Environment and Forestry Directorate as 'grant in aid'. The organisation is a 'Non-Department Public Body' of the Scottish Government. Its headquarters are in Inverness, with a staff complement of circa 750 staff.

NatureScot's purpose is to:

- promote, care for and improve our natural heritage
- help people to enjoy nature responsibly
- enable greater understanding and awareness of nature
- promote the sustainable use of Scotland's natural heritage

NS also advise local authorities, and work with the Scottish Parliament and public, private and voluntary organisations towards shared aims. Working efficiently like this is part of its commitment to delivering a high-quality public service.

## **RSABI**

The Royal Scottish Agricultural Benevolent Institution (RSABI) was founded in 1897 to mark Queen Victoria's Diamond Jubilee and in recognition of the deep agricultural depression at the time. Many tenant farmers struggled on, often until they died, rather than give up their tenancies to retire at a reasonable age. There were no pensions and little, if any, support for those no longer able to work.

Today, RSABI is a thoroughly modern charity, with a corporate structure and a Board of Trustees who, whilst having their roots in the land, bring, on a voluntary basis, the necessary variety of skills required to govern the charity. RSABI provides financial and practical support and friendship to over 600 individuals and their families across a range of occupations with the common theme of working on the land in Scotland.

The service is available to those previously and currently involved in farming and crofting. This is a comprehensive service to clients who are experiencing difficult times to enable them to move forward. Emotional support is available through its helpline, case officers and volunteers, all of whom are mental health first aid trained. We listen, keep people safe and access professional support when required. Our helpline is open from 7am to 11pm 365 days of the year and offers a call out service for the lonely and vulnerable.

## 2. EXECUTIVE SUMMARY

Developments in new technology to improve rural connectivity is gathering apace - allowing real time monitoring of crops, livestock, machinery, soils, stores, etc. The intelligence derived from farm sensor data allows farmers to improve their enterprise management, leading to improved productivity, efficiency, resilience and ultimately lower carbon emissions.

Long range wide area network (LoRaWAN) enabled sensor networks offer a simple, cost-effective way for farmers to collect data and benefit from the digital revolution. Although sensor technology provides multi benefits, one of the key lessons from the earlier KTIF funded “Digital Farming” project (KTIF/031/2019) is that the technology is at an early stage of understanding amongst the farming community.

The overall project objective was to increase the economic, environmental and social performance of Scottish farms through improved awareness and understanding of the practical application and benefits of smart sensor farming solutions.

The need for the project is a recognition that the barrier to the adoption of sensor technology is not the technology but farmers understanding. The project aimed to address that barrier by delivering a number of linked knowledge transfer (KT) activities, namely:

- Develop use cases to demonstrate the practical application of a range of sensors
- Produce short video clips to visually illustrate some of the key use cases
- Produce articles for a range of farming press and newsletters to promote the benefits of sensor technology
- Deliver a webinar on the benefits of the sensor technology and its application for farmers and crofters.
- Place all the developed materials on a range of web sites to ensure the project has a lasting legacy

The operational group comprised of four partners: SAOS, SmartRural, NatureScot and RSABI. This was a short five-month project, operating from the beginning of November 2020 – end March 2021. The total project budget was £33,800, at the 75% rate the total KTIF grant was £25,350. The grant was drawn down over two claims.

The project identified three key findings, namely:

1. **The power of Use Cases.** Practical use cases are a simple effective way to illustrate the value and benefits of deploying smart sensors. They give farmers tangible examples of how sensors can help their business.
2. **Development must be farmer-led.** The key to effective knowledge transfer amongst the farming community is peer-peer learning. Having a fellow farmer share their experience is very powerful and a great route to fast track innovation and share best practice.
3. **Webinars.** Webinars have become widely accepted and adopted by the farming community following covid-19 restrictions. They are an effective communication channel and popular amongst busy farmers.

The interest generated by the farming community from the project’s activity demonstrated that farmers are searching for new solutions and tools to help them manage their business. Funding should continue to support projects such as this so that Scottish agriculture harnesses the full potential of this exciting technology.

### 3. PROJECT DESCRIPTOR

This section in the report aims to provide an overview and context for the project.

Scottish agriculture has an urgent responsibility to proactively respond to the Climate Emergency and take a lead in supporting the Scottish Government's Climate Change plans and the drive towards net zero by 2045. While progress is being made this needs to be accelerated. Agriculture requires technical solutions for increasing productivity, while reducing the environmental impact by improving input efficiency and reducing waste. A benefit of this is the reduction of production costs and improved margins.

Technological innovation is transforming the way we farm. Developments in new technology to improve rural connectivity is gathering apace - allowing real time monitoring of crops, livestock, machinery, soils, stores, etc. The intelligence derived from farm sensor data allows farmers to improve their enterprise management, leading to improved productivity, efficiency, resilience and ultimately lower carbon emissions. There are also related marketing advantages through provenance, proof of high welfare, low waste and other positive traits.

At present broadband is limited to buildings and mobile phone signals follow people (with limited coverage) this leaves fields (green space) unconnected to the digital world. This is where 'long range, wide area networks' (LoRaWAN) come into their own. LoRaWAN is a form of low power, wireless communication developed to effectively allow whole farms to be digitally connected.

LoRaWAN enabled sensor networks offer a simple, cost-effective way for farmers to collect data and benefit from the digital revolution. For example, a LoRaWAN base station costs approx. £3,000 and can cover an area of up to 15KM, serving a number of neighbouring farms. The sensors typically cost £60-£300 per device depending on their purpose and complexity. This is not prohibitively expensive for the majority of farms and will allow the creation of bespoke 'farm specific' IoT solutions that can facilitate better business decision making and also provide solutions to non-economic challenges facing the farming sector, including health and safety and environmental protection.

LoRaWAN works by having a Base Station "listen" for the signals from sensors out in the field, in buildings or even on animals; and then relaying that message back through the internet and redelivering it to the user farmer. SmartRural have already successfully established 10 live LoRaWAN base stations, which are deployed throughout the farming community on agricultural buildings and land. This includes ones that have been explicitly designed as off-grid base station, to cover remote rural locations which have no immediate access to mains power.

Although sensor technology provides multi benefits, one of the key lessons from the earlier KTIF funded "Digital Farming" project (KTIF/031/2019) is that the technology is at an early stage of understanding amongst the farming community, even those we would consider as Early Adopters of technology. The experience has reinforced the importance of keeping the message simple and to focus on the practical benefits of making farmers' lives easier and freeing up time. Sensor technology provides an easy, low-cost route to help farmers manage their business more effectively.

The project is a recognition that the main barrier to the adoption of sensor technology is not the technology but farmers understanding. The project aims to address that barrier by delivering a number of linked KT activities.

## 4. FINANCE

### 4.1 Grant Award

To deliver the programme a grant application of £33,800 was made to the Knowledge Transfer and Innovation (KTIF) Fund – 75% funding was successfully secured. This grant source is jointly funded by the Scottish Government and the European Union.

### 4.2 Project Expenditure

The total spend on the 4-month project was on budget at £33,798.25. The table below shows the expenditure across the various elements of the project. It also shows the estimated approved budget and the two claims.

	Budget	Claim1	Claim 2	Total
<b>Project Development</b>	<b>27,600</b>	£26,866.88	2,709.00	<b>29,575.88</b>
<b>Project Management</b>	<b>1,200</b>	1,280.00	2,640.00	<b>3,920.00</b>
<b>Travel and Subs</b>	<b>600</b>	302.37	0.00	<b>302.37</b>
<b>Event/Venue Costs</b>	<b>0</b>	0.00	0.00	<b>0.00</b>
<b>Publicity</b>	<b>1,200</b>	0.00	0.00	<b>0.00</b>
<b>Other Approved Costs</b>	<b>3,200</b>	0.00	0.00	<b>0.00</b>
<b>TOTAL (100%)</b>	<b>£33,800.00</b>	£28,449.25	£5,349.00	<b>£33,798.25</b>
<b>CLAIM to date (75%)</b>	<b>£25,350.00</b>	<b>£21,336.94</b>	<b>£4,011.75</b>	<b>£25,348.69</b>

### 4.3 Reasons for variation from budget.

“Other Costs” was estimated at £3,200 in the approved budget. This was for the production of four videos by an external contractor. In the end this was done in-house by SAOS staff and included in the “Project Development” element. This explains why ‘Project Development’ was greater by £1,975.88 than the budgeted figure. Video production is evidenced through the time allocated to this activity by SAOS staff.

“Publicity” was budgeted at £1,200, which was for the production of an insert to be placed in the NFUS Newsletter which wasn’t completed. It was agreed by the project partners that this wouldn’t be good use of the resource. The effort and resource should focus on the planned press and newsletter activities.

“Project Management” was budgeted at 2-days (@ £600). This was an under-estimate, in reality it actually took a total of 6.5 days for project management. This included time for communications between the project partners, completing the two claims, and producing the final report. This is part of the learning from the project, it does require appropriate project management time to deliver a successful project and to complete all the necessary claims and reports. Although this was a relatively short and small project, the requirements for adequate project management is largely the same compared to a significantly larger project.

## **5. PROJECT OBJECTIVES**

The overall project objective was to increase the economic, environmental and social performance of Scottish farms through improved awareness and understanding of the practical application and benefits of smart sensor farming solutions.

In particular, the role of sensor farming in helping Scottish farmers meet their climate change obligations, in supporting the improved management of the natural environment, biodiversity and soil health protection.

### **Specific Objectives**

1. To increase farmers awareness and understanding of the benefits of digital farming and sensor technology
2. To develop a range of practical use cases for the application of low-cost sensor technology
3. Help place Scottish farmers at the forefront of the AgriTech revolution and the journey to become sensor enabled
4. To identify how sensor technology can help improve the health & safety record of Scottish agriculture
5. To showcase applications of sensor technology to better manage and monitor the natural environment, protect biodiversity and support sustainable farm practices.

### **Timescale.**

The project ran for a 5-month period from the 1st Nov to the end of March 2021. This allowed sufficient time for the linked activities to be properly planned and implemented to ensure successful outcomes. The Covid-19 lock down restrictions did delay the shooting of the on-farm videos. In the end to get the project completed, we went ahead and followed all the necessary guidelines to minimise the risk of spreading the virus.

### **Targets /measures of Success**

1. Develop and produce 20 practical on-farm Use cases
2. Produce 4 short on-farm video clips to visually illustrate the key Use cases
3. Write appropriate articles for a range of farming press and newsletters
4. Plan and deliver an open webinar (online live audience 100 participants)
5. Record the webinar and edit into shorter videos sections
6. Place materials on the FAS and project partners websites to ensure a lasting legacy and open access (target hits over a 3-year period 3,000)
7. Produce a final report.

## 6. PROJECT OUTCOMES

### 6.1 Project Outcomes

The approach used to deliver the project involved a series of 4 linked stages, each of which were delivered in a sequence building to the launch of the materials which was achieved through the live webinar on the 24<sup>th</sup> February 2021.

Key project outcomes achieved are shown in the following the table.

TARGET	OUTCOME
<p>1. Produce 20 practical farm Use Cases for the deployment of smart sensors</p>	<p>The project produced 22 Use Cases. These were written in farmer friendly language and restricted to one page in length. The uses cases are applicable to a range of farm types; livestock and cropping systems.</p> <p>The completed 22 Use Cases titles are provide in Appendix 1. The use cases are grouped across four farm enterprises; environmental, livestock, crop and general - for convenience of locating and sign-posting. All the developed Use Cases are contained in a separate pdf file.</p> <p>Having a bank of practical on-farm sensor use cases will be a real asset and help interested farmers and crofters better understand what low-cost sensors could potentially do for them.</p>
<p>2. Produce 4 short on-farm video to visually illustrate the key Use Cases</p>	<p>4 short videos were produced to visually illustrate some of the key uses of on-farm sensors to make the topic come alive.</p> <p>Introduction to sensor farming - <a href="https://youtu.be/vLgR9qk6QqE">https://youtu.be/vLgR9qk6QqE</a></p> <p>Sensors to support environmental outcomes: <a href="https://youtu.be/GwC9mSfcpsE">https://youtu.be/GwC9mSfcpsE</a></p> <p>Sensors for the Scottish Livestock sector: <a href="https://youtu.be/Jt6_TPrgZmw">https://youtu.be/Jt6_TPrgZmw</a></p> <p>Sensors for the Scottish arable sector: <a href="https://youtu.be/RBZo1xUyoag">https://youtu.be/RBZo1xUyoag</a></p> <p>key to success is showing real on-farm examples and hearing from the farmers involved. The videos will be widely promoted and available through the FAS and project partners web sites.</p> <p>Effective promotion and easy access though a range of routes will ensure the videos are seen by the target audience (farmers and crofters) and those who advise and influence the farming community.</p>
<p>3. Produce 4 articles for a range of farming press and newsletters</p>	<p>The target of 4 press articles /newsletters was met, with 6 articles appearing – see section 8 for further details.</p>



4. Deliver an open webinar on smart sensor farming	<p>A webinar was successfully delivered on 24<sup>th</sup> Feb 2021 at 7pm. Effective promotion of the webinar was achieved through the co-operation of wider stakeholders, including NFUS, QMS, AHDB, Scottish Land and Estates, Scottish Association of Young Farmers, amongst others.</p> <p>To ensure effective knowledge exchange (KE) it is important to recognise the important role trusted advisers play in influencing farmers and encouraging the adoption of new thinking. Trusted advisers come from a large sphere (friends, family, advisors, the trade, financial professionals, amongst others). Although the main target audience are farmers and crofters, it is important the webinar and developed materials is also accessible to advisers and influencers of farmers.</p>
5. Record the webinar and making it widely available	<p>The webinar was recorded, edited into chapters for convenience of viewing and widely promoted.</p> <p>To date the webinar has had 320 views.  <a href="https://www.youtube.com/watch?v=Fj3j9USRQIY">https://www.youtube.com/watch?v=Fj3j9USRQIY</a></p>
6. Place materials on the FAS and project partners websites to ensure lasting legacy and open access	<p>The materials are ready to be shared with the FAS website.</p> <p>They will also be available of the project partners websites.</p>
7. Produce final report	A project report has been produced.

## 6.2 Wider Project Impact

### The wider project outcomes include the following:

- Increased awareness and understanding amongst the farming community about the benefits of low-cost sensor farming and the benefits it brings to the industry – leading to more rapid adoption.
- Improved understanding of the role and application of sensor technology to support the management of natural environment, biodiversity and soil health protection, real time monitoring, and identifying diffuse pollution events.
- Help place Scottish farmers at the forefront of the AgriTech revolution and the journey to become sensor enabled.
- Increased awareness of the potential contribution sensor technology can contribute to the reduction in the number of fatal accidents on farms.
- Increased awareness of the potential contribution sensor technology can contribute to improved information and data flows between farmers and processors /supply chain partners, leading to greater trust, transparency and traceability, all contributing to more collaborative supply chains.

## 7. LESSONS LEARNED

One of the positive outcomes of the global pandemic has been the rapid adoption of online communication channels such as Zoom and MS Teams. This has allowed the Operational Group comprising of four organisations and eight individuals to meet regularly to discuss project development. Prior to the wide adoption of online communication channels, it would have been difficult and costly for staff from different parts of the country to physically meet. This has really helped support effective communications across the team and improved project management.

This was the first time anyone in the Operational Group had delivered an online webinar so the team learned a lot from the experience. There are certainly pitfalls to avoid! You can't do it alone, you need a team particularly if you are both the host of the event and chair. There are technical issues to manage on top of trying to facilitate an effective event.

It is important to recognise online meetings and webinars are different communication events. It is important you choose the right one for your needs and situation. For example, webinars are great for one-way communications, but participation is limited to written questions through the chat and Q&A functions. Choice is driven by numbers and the style of the event. As this project had such a high number of registrations, we had to use the webinar functionality rather than simply a large meeting. We wanted to ensure there was no disruption to the webinar from the attendees inadvertently leaving speakers for example.

Preparation is essential. The team held a practice session with all the speakers one evening three days prior to the webinar. This quickly exposed the issues in terms of unreliable broadband connectivity, presentations being too long, and nerves amongst some of the presenters. As a result of that experience, the decision was taken to pre-record most of the presentations prior to the event. The webinar introductions and panel discussion, however, were live on the evening, giving the whole event an authentic feel. Pre-recording the farmer presentation was a great success and ensured the event went as planned and was professionally delivered.

Although the event had 364 attendees registered, the audience peaked at 231. This is quite normal, individuals register for an event but for a host of reasons are then unable to actually attend. Most people now expect a webinar to be recorded so if they can't attend live, they can catch up later providing they have registered.

Having the ability to record the whole webinar is really important. It means the webinar can have a lasting legacy. It can be viewed again by those who attended the event and who wanted to follow-up on certain aspects, as well as those who missed the live webinar. Potentially the material can be available for a number of years.

Webinars are very inclusive and popular, as reported the event had 364 registered attendees. Participants from Ireland, Wales, England and all over Scotland. Apart from the core group of farmers and crofters, it also included; Local Authorities, Academia, Innovation Centres, and 21 participants from Scottish Government and RPID. The project could have never reached that breadth and variety of people with a traditional physical meeting.

## 8. COMMUNICATIONS AND ENGAGEMENT

As a means of highlighting the Demystifying Sensor Farming project to the agricultural community within Scotland a comprehensive communications programme was undertaken. This extended across a number of platforms and utilised the immediate and extended networks of the project partnership.

### Videos

Four videos were produced at the end of the project that highlighted key use case examples within Scottish agriculture. These underpin and reinforce the validity of LoRaWAN technology in enabling innovative IoT solutions on Scottish farms.

### Webinar

A key delivery component of the project was the 'Demystifying Sensor Farming' webinar which was delivered on the 24<sup>th</sup> Feb 2021.

Interest in the webinar exceeded expectations, with 361 registrants and a peak attendance on the evening of over 260. The webinar, which provided practical insights into farmer experiences was also recorded and made available on YouTube, as well as the Farm Advisory Service (FAS) website.

### Press & PR

The target of 4 newsletter/press articles was met, with articles appearing as follows:

<https://www.pressandjournal.co.uk/fp/business/farming/2952154/family-firms-hail-agri-tech-trials-success/>

<https://www.scotsman.com/country-and-farming/comms-technology-can-play-a-big-role-in-farming-safety-3147230>

*"Family firms hail agri-tech trial success"* appeared Dundee Courier, March 6 2021

SAOS Winter Update 2020 – Article mentioning Digital Farm trials of lone worker safety solution – "Lone worker safety beyond mobile phone coverage". Distributed to 670 SAOS Co-op Directors, managers and wider stakeholders, plus available on the SAOS website.

<https://www.scotsman.com/country-and-farming/farming-for-the-future-with-the-internet-of-things-3149594>

SAOS Spring Update 2021 – Article reporting on the success of the webinar with quotes from the three demonstration farmers involved in the project - "Digital Farming webinar draws great interest". Distributed to 670 SAOS Co-op Directors, managers and wider stakeholders, plus available on the SAOS website.

## **9. KEY FINDINGS AND RECOMMENDATIONS**

The project has identified three key findings, namely:

### **9.1 The power of Use Cases.**

Although digital smart sensors are widely used across various industries around the world, they are at an early stage of understanding amongst Scottish farmers. Key to effective deployment on Scottish farmers is not about simply installing LoRaWAN Gateways but for farmers to identify their pain points, the things that frustrate them, that they wish technology could help remove /solve for them. It is not about installing the technology because its available and works, it's about each farm thinking how sensors can help their business, to improve their decision making, saving them time and making their lives easier.

Practical use cases are a simple effective way to illustrate the value and benefits of deploying smart sensors. They give farmers practical examples of how sensors can potentially help their business. We are only scratching the surface in terms of use cases. In agriculture there are hundreds of potential use cases and each farm will need something specific that fits them. Once farmers engage with the technology and realise the power of the data sensors generate, they quickly think of new applications and questions to address.

### **9.2 Development must be farmer-led.**

The key to effective knowledge transfer amongst the farming community is peer-peer learning. It is a well proven technique which is widely used. Having a fellow farmer share their experience is very powerful and a great route to fast track innovation and share best practice. It is important farmers are at the heart of the development and roll out of smart sensor technology. If not, the risk is the uptake of the technology will be slower and the impact will be less. Smart sensor technology allows farmers to address the key challenges facing the industry including responding to the climate challenge, improving profitability, maintaining productivity, improving resource efficiency and protecting biodiversity.

Changing farmer behaviour has long been recognised as a challenge. If farmers do not perceive there is a benefit and value in adopting new technology, then they simply will not adopt it. On-farm demonstrations, hearing from fellow farmers is a key part of changing farmer behaviour. We have had direct feedback from the three demonstration farmers that farming is complex and demanding so any new innovation must be easy to use.

### **9.3 The value of Webinars**

Webinars have quickly become widely accepted and adopted by the farming community following covid-19 restrictions. They are an effective communication channel and popular amongst busy farmers. They are very inclusive, with the only requirement being access to adequate broadband. Whilst webinars may not have the full impact of on-farm meetings they are an effective communication tool and should be continued to be used in the future.

### **9.4 Recommendations**

The project group make the following recommendations:

#### **Continued Support.**

Smart sensor technology offers huge potential benefits to Scottish farmers but needs continued support to demonstrate the benefits and value to the farming community. In order to make a real difference, demonstration projects must continue to receive ScotGov funding support to showcase innovation and best practice implemented on real farms.

**Continued Communications.**

A one-off project is not sufficient to make lasting change. A communication plan is needed to continually keep the topic at the forefront of mainstream farmers and their advisers. The project has reinforced the importance of keeping the message simple and to focus on the practical benefits of making farmers' lives easier and freeing up time. Sensor technology provides an easy, low-cost route to help farmers manage their business more effectively. Research has shown that farmers respond better to positive or gain messages as compared to negative or loss messaging. Communications should concentrate on the benefits and value of adopting smart sensors. Additional use case, case studies, press articles and further webinars would all contribute to continual improve awareness and understanding amongst the farming community.

## 10. CONCLUSIONS

Technological innovation is transforming the way we farm. Developments in new technology to improve rural connectivity is gathering apace, allowing real time monitoring of crops, livestock, machinery, soils, stores and people. The intelligence derived from farm sensor data allows farmers to improve their enterprise management, leading to improved productivity, efficiency, resilience and ultimately lower carbon emissions. There are also related marketing advantages through provenance, proof of high welfare, low waste and other positive traits.

LoRaWAN enabled sensor networks offer a simple, cost-effective way for farmers to collect data and benefit from the digital revolution. The application of smart sensor technology allows bespoke 'farm specific' IoT solutions that can facilitate better business decision making and also provide solutions to non-economic challenges facing the farming sector, including health and safety and environmental protection.

**In summary, the benefits of smart sensor technology are:**

- Improved information flow leading to more informed decision-making
- Timely alerts to actual and impending negative events – preventing any potential disasters
- Improved efficiency across all resources – leading to reduced waste
- Using the technology to improve productivity, input efficiency and reduced waste will help farmers reduce their emissions and contribute to the climate emergency
- Improved monitoring and protection of the natural environment
- Improved collaboration with supply chain partners
- Use of aggregated data for the benefit of the whole agricultural industry.

Sensor technology is at an early stage of understanding amongst the farming community, the project validated that the main barrier to the adoption of sensor technology is not the technology but farmers understanding. The interest generated by the farming community from the project's activities demonstrate that farmers are searching for new solutions and tools to help them manage their business. Funding should continue to support projects such as this so that Scottish agriculture harnesses the full potential of this exciting technology.

## **APPENDIX 1**

### **Index of 22 Use Cases**

#### **Environmental**

1. Improving environmental outcomes using smart sensor technology
2. Monitoring river level – flood warning
3. Monitoring tree growth, quantifying carbon sequestration
4. Soil temp – timing fertiliser application
5. Avoiding silage effluent overflow

#### **Livestock**

6. Livestock tracking /abnormal behaviour
7. Livestock health – monitoring cattle buildings
8. Are your Vaccines stored properly?
9. Detecting Electric Fence failure
10. Avoiding Livestock stress from water supply failure
11. Monitoring NH3 levels with real data

#### **Crops**

12. Protecting stored grain
13. Monitoring Irrigation equipment
14. Monitoring potato stores
15. GPS tracking equipment
16. Soil Temp: timing Spring N application
17. QA schemes – making assurance recording easier

#### **General**

18. Demystifying LoRoWan and Sensors – an overview
19. Keeping Lone Workers safe
20. Asset Security and equipment location
21. Monitoring rotating motors
22. Monitoring Diesel tanks and other liquid stores

All the developed Use Cases are contained in a sperate pdf file.