Digital Farm Project

Final Report

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1. PROJECT PARTNERS

The Operational Group created to deliver this exciting project involved four partners: SAOS, SmartRural, NatureScot and RSABI. Each partner brought distinct skills, experiences, resources, and networks to ensure the project's aims and objectives were successfully delivered.

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 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

NatureScot 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.

Focus Farms

Additionally, three family farm businesses agreed to be the Focus Farms in the project. These individuals were selected because of their interest in the project, their creditability with the wider farming community, their openness to change and having a "can do" attitude to make things happen. The involvement of these highly regarded, progressive farmers contributed to the project's success.

- Neil and Debbie McGowan, Inchoech Farm, Alyth, Perthshire – upland livestock cattle and sheep, and environmental schemes. 500ha.
- Russell and Robbie Brown, Inverdovat Farm, Newport-on-Tay, Fife – intensive lowground, ware potatoes and combinable crops. 1,000ha.
- Peter Robertson and Elaine Booth, Ednie Farms, St Fegus, Aberdeenshire – mixed farm, suckler cows, combinable crops, farm woodland and renewable energy. 566ha.

Further details on each Focus Farm is provided in Appendix 2, Case studies.

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.

The project worked with the three Focus Farms to demonstrate, monitor and evaluate the potential benefits of digital farming using LoRaWAN and sensor technology. The purpose of the work was not to innovate sensor technologies, but to deploy existing sensor technology, and to engage with the Scottish farming community in demonstrating how digital technology can improve profitability and sustainability.

The operational group comprised of four partners: SAOS, SmartRural, NatureScot and RSABI. The project operated from the beginning of November 2019 – to March 2021. Originally, the project was planned to last a year, but an extension was granted due to the impact of Covid-19 restrictions. The total project budget was £54,675, with the project being fully funded at 100%. In addition, SAOS also contributed in excess of £84,000 of its own resources to the project.

The key learnings for the project partners included:

- It took more time to do things than anticipated. The partners were all a bit naïve about what exactly was involved and under-estimated the level of complexity.
- A critical factor for success of the LoRoWAN gateway installation is the initial site survey.
- Another key learning was the considerable time required to integrate new sensors into the LoRaWAN system (TTI).
- The project was specifically designed not to be about sensor development, however, almost inevitably, there was a lot of development work done.
- One of the positive outcomes of the global pandemic has been the rapid adoption of online communication channels, which has greatly supported project management.

The project identified three key findings, namely:

1. **Solving practical problems.** The key to effective deployment on smart sensors 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 solve.
2. **Visualisation of data.** The visualisation of data was quickly identified as a key barrier for farmer engagement and the developed dashboards were a great success.
3. **Changing farmer mindset.** The application of smart sensor technology is at its heart a change management programme. The need to change the status quo and search for new solutions is well evidenced. The involvement of influential farmers in helping fellow farmers see the potential of sensor technology will be important.

The project has been a resounding success evidenced by the progress that has been made in terms of the improved understanding of smart sensors in farming and the experience gathered have been invaluable. The role and contribution of the three host focus farmers was unquestionably integral to the project's success. The project has proven that LoRaWAN gateways work, and that smart sensor offer a simple, cost-effective way for farmers to collect data and benefit from the digital revolution.

3. PROJECT DESCRIPTOR

Technological innovation is transforming the way we farm. Smart farming and the use of digital technology promises to equip farmers with the data and insights required to tackle the key challenges the industry face, issues such as: improving productivity, inefficiency and waste, improving environmental management, dealing with a shrinking labour force, extreme weather events, meeting climate change targets, and the lack of profitability.

This is an innovative project whose principal objective was to demonstrate and validate the practical benefits of digital farming technologies to farmers and supply chain actors, as a route to improve the sustainability of Scottish farms.

Already the UK lags behind other major agricultural economies (US, Europe, Australia, and New Zealand) in embracing the 'internet of things' (IoT) in agriculture, and risks being left further behind unless we ensure that our farmers and their associated supply chains understand the practical benefits to be gained from data driven farming and that they embrace these technologies. Fortunately, there is already a large variety of IoT sensors and devices available to purchase. The project's focus was on the rapid deployment of existing tools – devices and analytics – to deliver accelerated uptake and benefits.

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, low cost 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 8KM, serving several neighbouring farms. The sensors typically cost £60-£300 per device depending on their purpose. 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.

However, this opportunity will not be embraced if the farming and wide rural community are not aware of the potential benefits that LoRaWAN networks and sensor technology can provide. This was one of the main objectives of the project.

The project worked with the three Focus Farms to demonstrate, trial, monitor and evaluate the potential benefits of digital farming using LoRaWAN and sensor technology. The purpose of the work was not to innovate LoRaWAN and sensor technologies, but to deploy existing sensor technology, and to engage with the Scottish farming community in demonstrating how digital technology can improve profitability and sustainability.

The key opportunity for the project was in how LoRaWAN capability and sensor technology can be successfully harnessed to help support farmers /landowners in improving their management of the natural environment. Through SAOS' contact with *SemTech*, (the US based leaders in this field, global developer of LoRa technology) the project had ready access to a wide range of off-the-shelf sensors from around the world, meaning proven sensors can be quickly deployed. That said, the use case for sensors deployed to support and monitor the

management of the natural environment including wildlife monitoring and biodiversity protection is not so well developed.

Another aspect of the project was the opportunity to work with the respective supply chain partners from each of the Focus Farmers e.g. cattle, sheep, grain and potato processors and supply chain actors. There is universal agreement that there needs to be greater collaboration between farmers as primary producers, the processing sector, right through the supply chains to retailers and consumers. Digital farming allows compelling opportunities to improve the information data flows in a chain, to improve traceability, provenance, reduced waste, better transparency to improve trust with the benefits shared by all partners in the chain.

The view of the project partners is that digital farming, allied with super-fast broadband, is the 'game changer' necessary to meet the challenges concerning business and production efficiency, the climate emergency, environmental monitoring and social care through rural Scotland. If that is to be realised farmers need to be convinced that digital technology works and delivers the anticipated benefits.

4. FINANCE

4.1 Grant Award

To deliver the programme a grant application of £54,675 was made to the Knowledge Transfer and Innovation (KTIF) Fund – 100% 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 project was on budget at £54,675. The table below shows the expenditure across the various elements of the project. It also shows the estimated approved budget and the three claims.

	Budget	Claim1	Claim 2	Claim 3	TOTAL
Project Development	**44,180.00**	23,363.51	19,773.91	2,000.00	**45,137.42**
Project Management	**4,200.00**	1,620.00	1,200.00	1,800.00	**4,620.00**
Fees					**0.00**
Travel and Subs	**1,200.00**	163.35	95.79	0.00	**259.14**
Event/Venue Costs	**395.00**	395.00	0.00	0.00	**395.00**
Material Costs					**0.00**
Publicity	**1,200.00**	420.00	1,340.00	0.00	**1,760.00**
Other Approved Costs	**3,500.00**	0.00	2,544.56	0.00	**2,544.56**
	£54,675.00	**£25,961.86**	**£24,954.26**	**£3,800.00**	**£54,716.12**
Grant (100%)		25,961.86	24,954.26	3,758.88	**£54,675.00**

4.3 SAOS Project Support.

In addition to the KTIF funding, SAOS also contributed in excess of £84,000 from its own resources to the project. This is comprised of:

- Funding all the equipment, gateways and sensors - £24,000
- Developing a mobile 'phone App - £45,000
- Developing the dashboards - £7,000
- Additional time - £8,400

All the equipment and sensors were provided free of charge to the host farms, who provided the facilities to test the technology and their time. The infrastructure established will remain on farm as the hope is that follow-on work would continue in the coming year.

4.3 Major Change and Extension to the project

Originally the project was planned to end on the 31 October 2020. Due to C-19 pandemic restrictions however, project delivery was held up, so a major change was granted to extend the project until March 2021. The savings from being unable to deliver the open farmer meetings, reduced travelling costs, venue, catering and other costs totalled = £13,208. The

savings in project expenditure was used to fund the production of the 3 videos and some additional development work.

The planned open farmer meetings were replaced by the production of three videos, one each based on the Focus Farms. The aim of the videos was to cover as much as possible of what was planned for the open meetings. This included; a project overview, brief explanation of the technologies, introduction to each farm, the reasons for the respective farmers getting involved, the sensors deployed on each farm, the experiences and learning, and future plans.

The additional development work involved the integration of two new sensors. The two new sensors were; one for monitoring rotating motors which detect any faults preventing serious damage, the other is for monitoring livestock water troughs, which detect if there is a fault in the water system. Note, the capital cost of the sensors was paid by SAOS

The other activity was the trial on a Lone Worker alarm system. Personal safety was identified by all three focus farmers, and an earlier survey of farmers, as one of the key use cases for sensors technology. Knowing the location of lone workers, enabling them to raise an alarm if there is an accident, and being notified that a lone worker has returned safely 'to base' (or not) are key factors to helping with their safety. We identified a Scottish company (Safe Shores Monitoring) who converted their current system to become LoRaWAN enabled. There was no direct cost to the project, but it did involve additional time to organise, manage and monitor a pilot involving all 3 farms and 6 individuals.

5. PROJECT OBJECTIVES

5.1 Project Aim

The core aim of the project was to demonstrate and validate the benefits and practical application of digital farming to farmers, as a route to improve the sustainability of Scottish farms (Note, 'sustainability' here means economic, environmental and social sustainability).

At the onset it was acknowledged that we had to be realistic in terms of the project's aim and objectives. Ideally, this would be at least a three-year project, however, with a limited timeline we prioritised the install, test and monitoring of LoRaWAN base stations and a range of sensors on three typical Scottish farms. Further analysis of the data collected, the intelligence gathered and its influence on decision making were identified as being outside the scope of the project.

Specific Objectives

- To increase farmers awareness and confidence of the benefits of digital farming
- To trial how remote sensing technology can help farmers improve the sustainability of their farms
- To gather experience to evaluate if the technology works, identify the benefits, and better understand the limits of the technology
- To demonstrate the potential value of improved information flows and data accuracy in the food and drink supply chains
- To identify applications of sensor technology to better manage and monitor the natural environment
- To identify how sensor technology can help improve the health & safety record of Scottish agriculture
- To harness the combined resources and networks of the Operational Group to extend the reach of the project.

Timescale and Milestone Dates

The project ran from October 2019 and finished at the end March 2021. As highlighted previously, the project received an extension due to the impact of the C-19 restrictions.

Target Date	Key Milestones
Oct 2019	One of the planned Focus Farmers withdrew so recruitment of new Focus Farm (Ednie Farms, St Fergus)
13 Nov 2019	Project Planning meeting for All, Glenesk Hotel, Edzell
Nov 2019	Develop specific Action Plans for each Focus Farms
Nov-Dec 2019	Surveys conducted of all 3 Farms to identify base station Gateway sites.
Jan-Mar 2020	Installation of LoRaWAN bases stations on all 3 Focus Farms
23 Mar 2020	**C-19 Pandemic and Lockdown**
Summer 2020	Identification, specification, and installation of sensors
Ongoing	Monitoring and evaluation of the sensors and the data generated, with respect to the project objectives
Ongoing	Supporting the host Focus Farmers to use the data derived to help their decision-making
Autumn 2020	Integrated Land Management Plans and Carbon Audits carried on the 3 Focus Farms
Nov 2020	**Applied for major change of project and extension due to C-19**
Nov – Feb 2020	Regularly fortnightly online calls were held with the 3 Focus Farms and the Operational Group partners.

March 2021	Production of 3 on-farm videos to replace the planned Open Farm meetings
March 2021	Production of 3 case studies on each Focus Farm
Apr 2021	Project evaluation and reporting

Project Partners Meetings

Project planning between all the partners was important for the effective and successful execution of the project. Regular project partner meetings were held throughout the project's life. The table below shows when these meetings occurred. Agendas and summary reports were produced for each meeting.

Project Partner Meetings

Date	Location
13 Nov 2019	Edzell
14 Feb 2020	Online Teams
27 March 2020	Online Zoom
15 May 2020	Online Zoom
26 June 2020	Online Zoom
25 Sept 2020	Online Zoom

Online Meetings with Focus Farmers and Partners

Date	Format
24 Nov 2020	Online Zoom
8 Dec 2020	Online Zoom
12 Jan 2020	Online Zoom
26 Jan 2020	Online Zoom
2 Feb 2020	Online Zoom

Targets

- Recruit 3 host Focus Farms
- Individual farm assessment and specification of an Action Plan
- Successfully install LoRaWAN base station and sensors on the 3 Focus Farms
- Produce 3 video clips - one per Focus Farm to replace the open farm meetings
- Write two or more press articles
- Attract 250 farmers to visit the Focus Farms – this had to be dropped, replaced by videos
- Develop 3 Case Studies (one per Focus Farm)
- Invitations to speak at 2 KT events
- Conduct a full evaluation of each Focus Farm
- Generate 1 final Report.

Measures of success

- Number of farmers attending the open farm events – Target 250
- Number of hits / reads of the short videos and case studies - Target 1,500
- Identification of a key role for sensor technology to support the management and monitoring of the natural environment
- The number of farms installing LoRaWAN and sensor technology on Scottish Farms in next 2-years – Target 20 farms
- The number of invites to speak at KT events – Target 2 events
- Continuation of work through the Operation Group (OG) following the project's completion.

6. PROJECT OUTCOMES

6.1 The project generated the following outputs as show in the table below.

TARGET	OUTCOME
1. Recruit 3 host Focus Farms	Completed
2. Assess each Focus Farm and specify an Action Plan	Completed
3. Install 3 LoRoWAN gateways and a range of sensors on each Focus Farms	Successfully installed 7 LoRoWAN gateways, including an off-grid pilot gateway at Inverdovat Farm. In total the project has deployed and tested a total of 48 sensors – see appendix 1 for the list of sensors deployed on each farm. Although many of the sensors were common on each Focus Farm, each had unique sensors applied to their situation demonstrating different use cases.
4. Produce 3 on-farm videos to replace the planned on-farm meetings	3 videos were produced to visually illustrate the key uses of on-farm sensors and to hear the experiences of the farmers involved. Ednie Farm – 10 minutes, 46 views to date https://youtu.be/2NCZqctb6cw Inverdovat Farm – 7 minutes, 36 views to date https://youtu.be/D8PwV1OV9as Incheoch Farm - 7 minutes, 34 views to date https://youtu.be/zYOP3XcQY9U The videos will be widely promoted and available through the FAS and project partners web sites. 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.
5. Produce 2 articles for a range of farming press and newsletters	The target of 2 press articles /newsletters was met, with 6 articles appearing – see section 8 for further details. The articles explained the potential benefits of smart digital farming, the project aims, the technology deployed, the project's progress and experiences.
6. Develop 3 case studies, one per Focus Farm	Three case studies were successfully completed – see Appendix 2. A two-page case study was produced for each Focus

	Farm. It introduced the farm, the enterprise mix and system, described the LoRaWAN and sensors deployed, their use on each farm, the benefits and experiences.
7. Invitation to speak at two KT events	Successfully completed. The project was promoted and described at 3 KT events – see section 8 for further details.
8. Produce Six or more Social Media feeds	Completed. Used to generate links to partners social media feeds to enable regular updates, to ensure the project is widely promoted and points of interest are shared.
9. Place materials on the FAS and project partners websites to ensure lasting legacy and open access	The materials are ready to be shared with the FAS website. They will also be available of the project partners websites.
10. Produce final report	A project report has been produced.

6.2 The project outcomes included the following:

- Increased awareness and understanding amongst the farming community about the benefits of digital farming and the benefits it brings to the industry – leading to more rapid adoption.
- 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.
- Improved understanding of the role and application of sensor technology to support the natural environment management, biodiversity and soil health protection, real time monitoring, and identifying diffuse pollution events.
- Increased awareness of the potential contribution sensor technology can contribute to the reduction in the number of fatal accidents on farms.
- LoRaWAN and sensor technology has the potential to revolutionise agriculture with smart, data driven processes to improve efficiency and decision-making. Solving problems on farm and helping farmers meet the ever-increasing demands from consumers and processors, whilst protecting the natural environment.
- The Scottish Government's refreshed Digital Strategy emphasises the importance of network infrastructure in achieving the economic benefits offered by current and emerging digital applications, the application of LoRaWAN provides a low-cost practical solution.

7. LESSONS LEARNED

The project partners have learnt 8 key lessons over the life of the project, which are:

1 Improved technical understanding

It has taken more time to do things than we anticipated. The partners were all a bit naïve about what exactly is involved in the project and under-estimated the level of complexity. For example, the original plan was based on the installation of one LoRaWAN Gateway per farm (three in total). This had to be reviewed as most farms are neither compact nor have all their land farmed in a radius and many have grown through renting/buying bits of land often miles away from the home unit. As a result, the project installed seven gateways due to the scale of the farms involved and their geospatial layout to ensure the whole area farmed is LoRo enabled. Other neighbouring farms will doubtless fall under the coverage provided at the partner farms, but this is not something we tested during the programme.

2 Site Surveys

A critical factor for success of the LoRoWAN gateway installation is the initial site survey. We now have a better understanding of all the various variables that can influence the type of gateway required and where it should be located. Key to this is really understanding the farm's layout and boundaries, the farmer's needs, how and where they envisage sensors being deployed.

The laws of physics apply. Radio waves will get distorted by hills, trees, buildings and water. The agricultural land of Scotland is not all on level, flat plains. We have discovered 'not spots' where the radio coverage is not strong enough to be picked up inside some buildings. That said, we have developed tools (small-scale solutions) to resolve these issues.

3 Sensor Integration

Another key learning was the time required to integrate new sensors into the LoRaWAN system (TTI). We grossly under-estimated the time for this key technical element in the project. In practice, sensor integration varies depending on the complexity of the sensor and the level of support from the manufacturer/vendor - but typically it was 3-10 days. This significantly increased the technical days required for project development. Note, sensor integration is only done once, thereafter, any additional sensors of that model, can be deployed on any farm in the network.

4 Visualisation

The visualisation of data was quickly identified as a key barrier for farmer engagement with the data generated. Although not in the project plan, an App was developed by SAOS for mobile smart phone use. This permitted farmers to see the data generated by a specific sensor and allowed them to change the settings for the notification of any alert to signal an action. Later during the project, individual dashboards were also developed for each Focus Farm. Again, this was out with the project scope and funded by SAOS. This allowed farmers (and their advisers) to see all the data generated by the various sensors in a time series form. Both the App and the dashboard are required, as they serve different functions. The developed dashboards have been a great success and really helped with the visualisation of the data for farmers.

5 Sensor Capability

The project was specifically designed not to be about sensor development, however, almost inevitably, there has been a lot of development work done. The time taken to identify new potential sensors, sourcing them (largely out with the UK), integrating and deploying them on to a farm takes a cycle of approx. 8weeks. We deliberately set out to use off the shelf sensors which should have been ready to use but in fact many of the sensors have not achieved the

manufacturers claims or have been unreliable in the field. In total, the project has screened nearly 20, of which, probably 10-12 have been reliable enough for use in an agricultural setting. This proves the value of the project to screen and identify devices farmers would be happy to work with.

6 Farmer Support

The host farmers needed more support than expected, even though we are working with progressive, large-scale farmers. The experience has reinforced the importance of keeping things simple when it comes to engaging with farmers through the awareness raising activities. This includes a need to keep the technology explanation simple and to focus on the practical benefits of making users' lives simpler, providing piece of mind that there are no potential disasters happening, keeping their workers and families safe, and generating meaningful data to improve decision making. Farmers are increasingly time constrained, anything that adds complexity and is unreliable would quickly be discarded.

7 Changing Behaviour

As with all change programmes, encouraging the uptake of digital tools in Scottish Farming, is reliant on the relationship with the farmers being one of trust, such that they can share their pain points and problems so that the delivery provider can design a solution. Leading with technology will only work for a very small percentage of the farming community and to be effective across the sector, it has to be solution led and use case driven, with the pioneer farmers sharing their experiences.

8 Project communications

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 project partners and all the team 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. The use of these tools has really helped support effective communications across the team and improved project management. In addition, from November onwards, we moved from communicating individually with each Focus Farm, to holding regular joint online calls for all the farms every fortnight. This proved to be really popular with the farmers, improving communications and fast-tracking learning across the whole team.

8. COMMUNICATIONS AND ENGAGEMENT

As a means of highlighting the Digital Farm project to the agricultural community within Scotland a programme of marketing activity was undertaken that extended across a number of platforms and utilised the immediate and extended networks of the project partnership. Messaging was based on an honest appraisal of the technologies by the three focus farms and was very well received due to the 'farmer-centric' approach to the deployment of the technologies.

Twitter

A project Twitter account was created for the Digital Farm project and has been active since February 2020 - @digitalfarmscot. All project partners supported the social media feeds via their own Twitter/Facebook and LinkedIn accounts.

Press & PR

The project partnership has been active in pursuing communications coverage for the Digital Farm project. Activity has been a mix of stakeholder communications and press releases – principally in the agricultural press in Scotland. These included:

https://futurescot.com/three-farms-across-scotland-being-used-as-digital-farms-testbed/

https://www.thescottishfarmer.co.uk/news/18274793.scotlands-farms-future-focus-sensor-tech/

FAS Stakeholder Group

A presentation was provided on "Smart Sensor Farming" at the 11 Sept 2020 online meeting of stakeholders.

SAOS Quarterly Newsletter – Distributed to 670 SAOS Co-op farmer directors, co-op managers, and key industry stakeholders.

- Winter Update 2020 – Article mentioning Digital Farm trials of lone worker safety solution
- Summer Update 2020 – Article detailing the Digital Farm project
- Summer Update 2020 – Article reporting the progress of the Digital Farm project
- Spring Update 2021 – Article reporting the Digital Farm webinar

SAOS Annual Conference

The Digital Farm project was presented as part of a session on data within the SAOS Annual Conference on the 28th January 2021 which was delivered on line and attracted over 240 attendees. This reached a broad cross section of the agricultural community within Scotland and elements of this were picked up in the agricultural press.

Videos

Three videos were produced at the end of the project – one for each of the family farms that were supported over the course of the project. The videos will be widely promoted and circulated to ensure as wide a coverage as possible across the farming community and their advisers. This would include placing all materials on the FAS web page.

9. KEY FINDINGS AND RECOMMENDATIONS

The project identified three key findings, namely:

9.1 Solving practical problems

It is important to stress from the onset that the technology works. 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 it is 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.

Key to understanding the pain points and potential uses for smart sensors was a survey SAOS conducted prior to the commencement of the project. This was gathered during the SAOS Annual Conference and involved feedback from 47 farmers and crofters. The key potential uses for sensors were (in order of priority):

- Lone worker safety
- What is happening when I'm not on site?
- Gathering weather data
- Identifying abnormal behaviour in livestock
- Saving time – just in case checks
- Farm security and theft of assets
- Demonstrating regulatory compliance
- Preventing catastrophes e.g. is the farm gate shut, is my grain store at the right temp?
- Knowing what my fixed costs are?
- Monitoring soil temp.

The project has contributed greatly to an improved understanding of the potential of smart sensors, its limitations, and its role in helping farmers improve their performance and profitability. The experience gained has been invaluable. The earlier section on lessons, also identified 8 key learnings resulting from the project.

9.2 Visualisation of the data

The visualisation of data generated was identified as a key barrier for farmer engagement. Connecting the technology to the people is the key. Interestingly, once the farms had their dashboards, they were much more able to engage with the other farms and share thoughts and impressions – not just on the technology itself, but on the wider implications of their farming practices – evidenced by them sharing their Carbon Audits and data on slurry spreading, etc. Once the dashboards were developed, farmer involvement and engagement quickly progressed. Data could be easily seen over time and presented in timeseries graphs for easy interpretation. This allowed the focus farmers to review their data at their convenience, and facilitate analysis and interpretation to explain past events or support decision-making in real time. Sensor are designed to measure things at regular periods over a day andthat in itself is of limited value. The real value is the presentation of the readings taken, in a format that is easily accessible and readily usable by farmers. This backend functionality is arguably the most important function of a sensor.

9.3 Changing the mindset of farmers

The application of smart sensor technology is at its heart a change management programme. Changing farmer behaviour has long been recognised as a challenge. If farmers do not

perceive there is a benefit or value in adopting new approaches, they simply will continue with the status quo. The report by the Scottish Government's Agricultural Champions (May 2018), highlighted the need to change farmer mindset to deliver the transformational change required. The need to change the status quo and search for new solutions is well evidenced. The involvement of influential farmers in helping fellow farmers see the potential of sensor technology will be important. As mentioned previously, it's about ensuring smart sensors make farmers lives easier, tackle real issues, are reliable, and deliver real value on farm. This can only happen through continuous support, awareness raising and demonstration activities. The involvement of influential farmer and their endorsement will be critical to future success.

9.1 Recommendations

The project group make the following two 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 Scottish Government funding support to showcase both the innovation and best practice aspects 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

The project has been a resounding success. The progress that has been made, the improved understanding of the potential of smart sensors and the experience gathered have been invaluable. What the project team have delivered in a year largely under lockdown, has been nothing short of remarkable and a credit to everyone involved. The commitment and support of the four partner organisations has been critical to the success of the project. SAOS itself has committed considerable resources to the project, in excess of £84,000. The knowledge and experience gathered in just over a year could have easily taken over 3-years to accumulate.

The role and contribution of the three host focus farmers has also been integral to the project's success. Not only did they open up their business and willingly allow themselves to be the test bed for the project, but their role changed over time, so that they became part of the project management team and decision-making. That is great credit to the three family businesses involved.

The main project aim was to test and demonstrate the practical benefits of LoRaWAN enabled smart sensor networks. The project has proven that LoRaWAN gateways work, and that smart sensor 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 addressing the climate emergency, improving health and safety and building communities.

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.

A key conclusion is that smart sensor farming 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 itself 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.

In summary, the benefits of smart sensor farming 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
- Tool to help tackle the climate emergency. Using the technology to improve productivity, input efficiency and reduced waste will help farmers reduce their GHG emissions
- 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.

APPENDIX 1

Table of sensors deployed on the Project.

Use Case	Sensor	Incheoch	Inverdovat	Ednie	Notes
Weather station	Metos Lorain (*)	√	√	√	
Vehicle Tracking	Digital Matter Oyster	√	√	√	two each
Soil temp & humidity	Netvox R718PB	√	√	√	two each
Electric Fence testing	Adeunis Analog	√	√		
Crop Store temp	Netvox R718AB / RS1xx		√	√	
Vaccine Fridge monitor	Laird Sentrius RG1XX	√		√	
Livestock shed monitor	Netvox R718AB	√		√	Plus at Middelton of Rora
River Level	RadioBridge RBS306	√			
Bree Tank Level	Elsys ELT2 / RBS306	√			
Grain store temp	Tektellic Mul8		√	√	
Soil Moisture	Sensoterra		√		6 sensors
Personnel Beacon	Safe Shores Monitoring	√	√	√	2 beacons each per farm
Light Sensor	Netvox R311G			√	
Water trough monitor	Various			√	
Rotating motor monitor	Eolane Bob		√	√	

APPENDIX 2

Case Studies produced – a separate pdf file has been provided of each case study.