Foresight Farming

Final Report

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Project Partners

Overview of the participating companies

Urban Foresight® is a multidisciplinary innovation consultancy that is dedicated to advancing the next generation of technologies, services and policy frameworks for cities. From our offices in Newcastle and Dundee, we work with ambitious organizations around the world on projects that improve lives, protect the environment and boost local economies.

Scottish Agronomy is a leading Scottish arable research and advice company. We undertake the most extensive trials work of any Scottish organisation. We then disseminate that market-leading information to our farmer members through a number of services

SAOS are Scotland's experts on co-operative and collaborative strategies, structures and management. We provide a comprehensive range of development and consultancy services, supported by The Scottish Government.

EQ Accountants LLP have built a strong reputation as one of the leading providers of accountancy, taxation and business advisory services to the Scottish agricultural sector. We act for a large number of successful rural businesses and have in-depth knowledge of the sector as a result of experience gained over many years. We understand farming and the issues which face farming families and their businesses.

Jane Craigie Marketing is a marketing, ideas and communications consultancy specialising in agriculture, food and the rural environment. Our team is skilled in communications strategy planning and implementation and is exceptionally well connected both nationally and internationally. We have a deep technical understanding of the farming industry and are involved in leadership roles within the wider rural sector.

Contents

Executive Summary

Foresight Farming was a one-year farmer-led benchmarking project which identified opportunities to deliver quality and economic benefits by applying ‘lean management’ principles to existing data sets. The project was funded by the Scottish Government and the European Union through the SRDP Knowledge Transfer and Innovation Fund. The project was led by a consortium of innovative project partners/facilitators: Scottish Agronomy Ltd, Urban Foresight, EQ Accountants, SAOS and Jane Craigie Marketing. The core operational group of Scottish arable farming members consisted of 4front Farming Co. Limited, Arable Ventures Ltd., Jas D Reid & Partners, P Chapman & Co., J. C. Bell Ltd. & Fairfield Farms.

The scope of farm data benchmarking was focussed on fixed costs, this included the principal areas of labour and machinery costing, which together make up around 50% of production costs. Using lean management techniques, a methodology originally derived from the car manufacturing company Toyota that focus on minimising waste within systems while simultaneously maximising productivity, project facilitators introduced the lean principles that help improve value to customers and deliver continuous improvement, providing members tools for a strategic business decision. The project facilitators also provided practical support through a series of communication channels, events and demonstrations to assist the members in understanding key benchmarking and financial concepts and their benefits to further develop the benchmarking group and tools.

The project engaged over 37 business group members in ten meetings across both the North and South of Scotland supported by two farm demonstrations. The outcome of the project has resulted in the collection figures from 23 farm businesses across 15 types of machinery data in the benchmarking exercise. This benchmarking study showed that there was no apparent relationship between the size of a farm/area of cultivation and its fixed costs. For example, plough cost was compared against 16 members, the highest plough cost is £78.81 per Ha and lowest is £23.74 per Ha. Similarly, for the combine harvester, the highest cost recorded is £132.60 per Ha and lowest is £46.35 per Ha. On closer examination on individual data, farms that were working towards to near-maximum capacity on individual items of equipment showed a reduction in fixed cost. This demonstrates that by maximising machinery output and working cohesively as one collaborative entity, reduction of fixed costs is facilitated. In one particular case study, comprising 1,214 Ha that previously were operated historically four separate independent units, a collaborative joint venture farming agreement enabled the rationalisation of management, labour and machinery which resulted in selling two tractors and purchase one tractor replacement. In addition, two combine harvesters were sold which were replaced with a single high capacity model. On the same unit, grain drying, and storage is now conducted at one centralised location. On another separate 3,400 Ha unit, one of the biggest decisions following the Foresight Farming machinery costing review was to change from tractors and trailers to lorries for grain carting. The farms being managed were many miles apart, with the additional complication of a motorway in between. Although lorries were expensive headline

figures, it was found that four lorries could be hired during harvest at less cost than the 12 tractors and trailers required for the same job.

The benchmarking exercise has prompted farm business owners to introduce a more effective means to collect labour cost such as work diary to accurately assign to different enterprise or crop. Using lean management principals and a better understanding of members' labour and machinery costs, some farm managers have begun the process of changing their business practice in areas such as justifying the decision to buy new machines, staff training and using contractors to work on their farms.

Improving operations on farm can be improved by applying lean management principles. Lean is a manufacturing model to maximise value through elimination of waste. The lean concept is a combination of cost and value the end customer is willing to pay. Ultimately contextualising the delivery of that value back to the primary producer. It is important not to view any process or input in isolation from the entire production system and its knock-on effects. It was found to be significant to rationalise the paradigm between lowering cost and improving effectiveness, together with achieving quality of output consistently over time. Ask the question; how this will affect my grain quality first and then yield, then cost targets. It was found to be important to check before making a system change to ensure that output and quality of work could be sustained whilst yield and quality can be maintained at the lowest achievable variable, fixed costs and labour costs. Focussing on machinery cost and work rate was central but it was also important to consider the management of people and potential unintended consequences.

The future of farming will rely on intelligent technology to give farmers new insights into more efficient and sustainable approaches to crop growing. The project lay the foundation for members to understand how data could lead to an optimised business operation. The next stage of innovation for the members is on the automation of data collection and the understanding of data ownership. This will enable farmers to react quickly with changes and threats such as drought and soil health. By combining low-cost smart sensors such as soil moisture sensor or fuel gauge sensor, this would empower farming that traditionally on intuition, to transition to sustainable farming optimised with data.

1. Project Description

Foresight Farming was a benchmarking project to identify opportunities to deliver quality and economic benefits by applying ‘lean management’ principles to existing data sets across a number of participating farm holdings. The project was a one-year pilot project funded by the Scottish Government and the European Union through the SRDP Knowledge Transfer and Innovation Fund.

The project introduced 'lean management' tools to promote resource efficiency to the participating farmers so that they could combine these with the findings of data benchmarking to help maximise the margins of their arable farming businesses. By comparing costs, work rates and farming techniques, members were able to understand and drive down cost per tonne of crop.

This report demonstrates the journey of the project, from inception to final output, identifying challenges in data collection, lessons learnt and recommendations that would enable continued support for the members.

1.1 Project Background

This project brought together two key approaches to help farming businesses in Scotland: 1. Fixed cost benchmarking and 2. Lean manufacturing tools. Benchmarking is a systematic approach to a business improvement where best practice is sought and implemented to improve the process beyond the benchmark. Lean Management or Lean Manufacturing is a methodology originally derived from the car manufacturing company Toyota, are principles that focus on minimising waste within manufacturing systems while simultaneously maximising productivity, improving value to customers and continuous improvement. These approaches provide important tools for a strategic business decision, enable knowledge and innovative solutions to be shared and discussed.

Accurately understanding farm costs enables businesses to make informed agronomic and economic decisions, to be better prepared for any shift in policies, regulations, subsidies, commodity prices and input costs, or threats such as weather changes, diseases and pests.

Production cost per tonne is the total combined cost of variable and fixed cost divided by the yield of a crop. Variable costs, also known as direct costs, relates to costs that vary with output. This cost can be “readily allocated” to an enterprise (e.g. oilseeds). Fixed costs, also known as indirect costs, cannot be readily assigned to a specific enterprise, however, this cost could account for more than 50% of crop production costs. Therefore, the scope of this project is to focus on fixed costs, which include two principal areas: labour and machinery cost.

Farm machinery costs can be divided into two categories: annual ownership costs, which occur regardless of machine use, and operating costs, which vary directly with the amount of machine use. Ownership costs can include the age of the machine, depreciation, interest, taxes, insurance, and maintenance. For modern farm businesses, capital and maintenance expenditure on machinery and equipment is a significant and ever-rising cost.

This is driven by ongoing technological evolution, which both places pressure to purchase new more efficient equipment and increases the servicing and repair costs of existing assets. Underpinning all of this is a broader rise in the costs of energy across all areas.

Making smart decisions about how to acquire machinery, when to trade existing assets and how much capacity to invest in, all these changes can reduce the overall cost of machinery and equipment. These decisions require accurate estimates and understanding of the costs such as farm machinery maintenance, purchase price, depreciation and fuel costs.

Analysing fixed cost of production costs has historically been complicated as most data comes from records which frequently do not contain sufficient detail at the point of recording. Fixed cost data is often taken from financial records that have a different year-end to the farming season. Collating this information and allocating the correct proportion of costs to the enterprises being benchmarked is complex, especially when done for the first time and where resources are shared across enterprises. The data gathering and analysis exercise could, therefore, be onerous without extensive support.

1.2 Project Partners and Members

The Operational Group is composed of arable crop triallists, an accountant, experts in collaborative working, data management and lean principles and arable farmers who are at the forefront of agri-tech. The project was led by Scottish Agronomy Ltd, project managed by Urban Foresight. Key project partners are Scottish Agricultural Organisation Society (SAOS), EQ Accountants and Jane Craigie Marketing. The consortium recruited an Operational Group of five farm members, which consisted of 4front Farming Co. Limited, Arable Ventures Ltd., Jas D Reid & Partners, P Chapman & Co., J. C. Bell Ltd. & Fairfield Farms. The operational group members formed the key project delivery facilitators to help with best practices and knowledge transfer.

Figure 1 Foresight Farming four project partners (from left George Nobel-SAOS, Lingsay Wong- Urban Foresight, Graeme Davidson-EQ Accountants and Eric Anderson- Scottish Agronomy Ltd).

2. Project aims and objectives

The project set out to identify opportunities to deliver quality and economic benefits by applying ‘lean management’ principles. The project aims and objectives were:

i. To create a group of progressive farmers who log and share their data with a view, through data analysis, to provide them with actionable outcomes to improve their own business.
ii. To benchmark physical and financial performance to help drive down cost per tonne of crops.
iii. To gather and analyse a broad data set associated with the fixed costs of farm equipment, machinery and labour cost.
iv. To introduce lean manufacturing principles to optimise business processes and decisions.
v. To exchange knowledge and ideas for the mutual benefit of all farming businesses involved.
vi. To have a commercial operation offering independent benchmarking to arable farmers across Scotland at the end of the project.

3. Project Outcomes

The Foresight Farming group have achieved all the project aims and outputs as described in Section 2. Key project outcomes achieved within the project are shown in Table 1. The overall project programme and milestones have been achieved on time and within budget, a summary of the milestones report can be found in Annex A: Milestone Summary.

Target	Outcome
1. A comprehensive benchmarking of fixed cost for 20 arable businesses across Scotland.	1. The project involved 23 farming businesses to participate in the final benchmarking exercise with 15 types of machinery costs collected.
2. A repeatable methodology for evaluating and valuing arable farm business data.	2. A replicable benchmarking methodology that included a costing spreadsheet and data management protocol was produced.
3. Comparison and assessment of participating farms of data holdings, cost, use and team skillsets.	3. Two members' meetings were held which discussed and compared data. Feedback was given by project facilitators to members regarding the cost differences, type of machinery, farm practises and skillsets.
4. Two on-farm open demonstration meetings on agri-tech and data management, one of which is to a production-focused business which is an exemplar of data-driven lean management.	4. Two on-farm demonstrations took place (see Section 3.4.1 and 3.4.3).
5. At least four Business Group meetings in two locations (eight meetings in all) between the participating farmers on best practice in data management.	5. All meetings took place within the project duration, see Annex A: Milestone Summary.
6. Four articles on the project progress, for an EU EIP audience, Scottish Government and media.	6. The project published over eight articles. See Press Releases in Section 5.1.

Table 1 Foresight Farming project outcome table.

The project targeted arable farmers located North and South of Scotland. Overall, we have engaged 37 farmers who participated in the project, who together manage a combined 20,303 Hectares of farmland. The map below demonstrates the number of Foresight Farming members in each Scottish region.

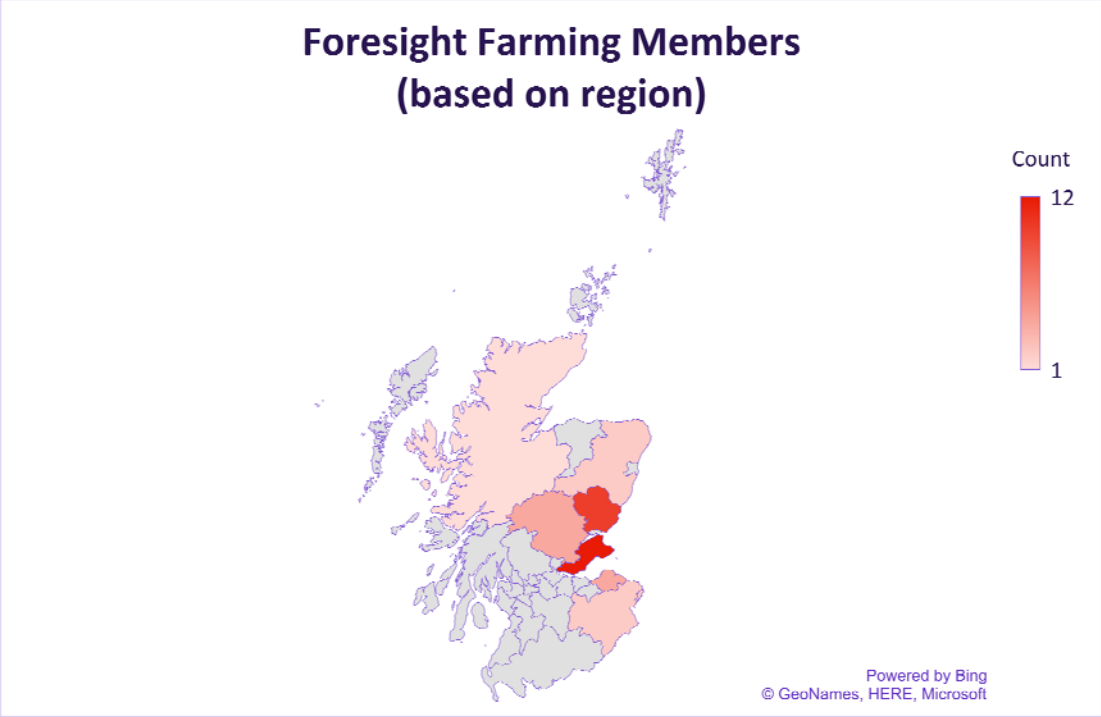


Figure 2 Foresight Farming members based on region.

3.1 Project Delivery

The benchmarking process involved the comparison of actual farm businesses fixed costs. The first step of the project was to define and agree on the scope of the costings to be assessed. A series of engagement events were conducted by project partners/facilitators prior to data gathering to ensure members fully understand each cost heading and its implication as well as the methodology of data gathering. This also allowed members sufficient time to collect the data, as much of the information was in the business' supplier invoices which can a lengthy process. The facilitators provided guidance of data gathering best practise, guided group discussions, stimulated ideas amongst members and sought innovative solutions. The facilitators also introduced lean principles and demonstrated success stories of adopting this best practice along with data gathering.

Table 2 demonstrated topics were discussed with members, guided through project facilitators (also refer to Annex A: Milestone Summary):

Meeting	Presentation topics
First Operational Group Meeting	▪ Introduction to the project, aims and objectives (Urban Foresight).
Second Operational Group Meeting and First Business Group Meetings (North and South)	▪ Value of Agri Data to farm businesses (SAOS). ▪ Introduction of Foresight Farming benchmarking tool (Scottish Agronomy Ltd and EQ Accountants).
Third Operational Group Meeting 2 Second Business Group Meetings (North and South)	▪ Benchmarking and its benefits (All). ▪ Financial skills- Investment policy: leasing, hire purchase and finance (EQ Accountants).
Third Business Group Meeting and North Farm Demo (Hays Farm):	▪ Introduction to Lean Management (Urban Foresight) ▪ Skinny Milk Project- lesson learnt (SAOS) ▪ Key financial skills including the machinery costing spreadsheet created for the project and machinery register (EQ Accountants).
Lean business visit (South Farm Demo)	▪ Lean Principles in Practise- Value Stream Mapping exercise (Aidansfield, Urban Foresight and Scottish Agronomy Ltd).
Benchmarking meeting: Future planning for profit- data benchmarking results and discussion	▪ Business Group machinery data and costing received & analysed
Final meeting (Combined Business and Operational Group Meeting)	▪ Business Group machinery data and costing received & analysed. ▪ Future planning for profit- data benchmarking results and discussion.

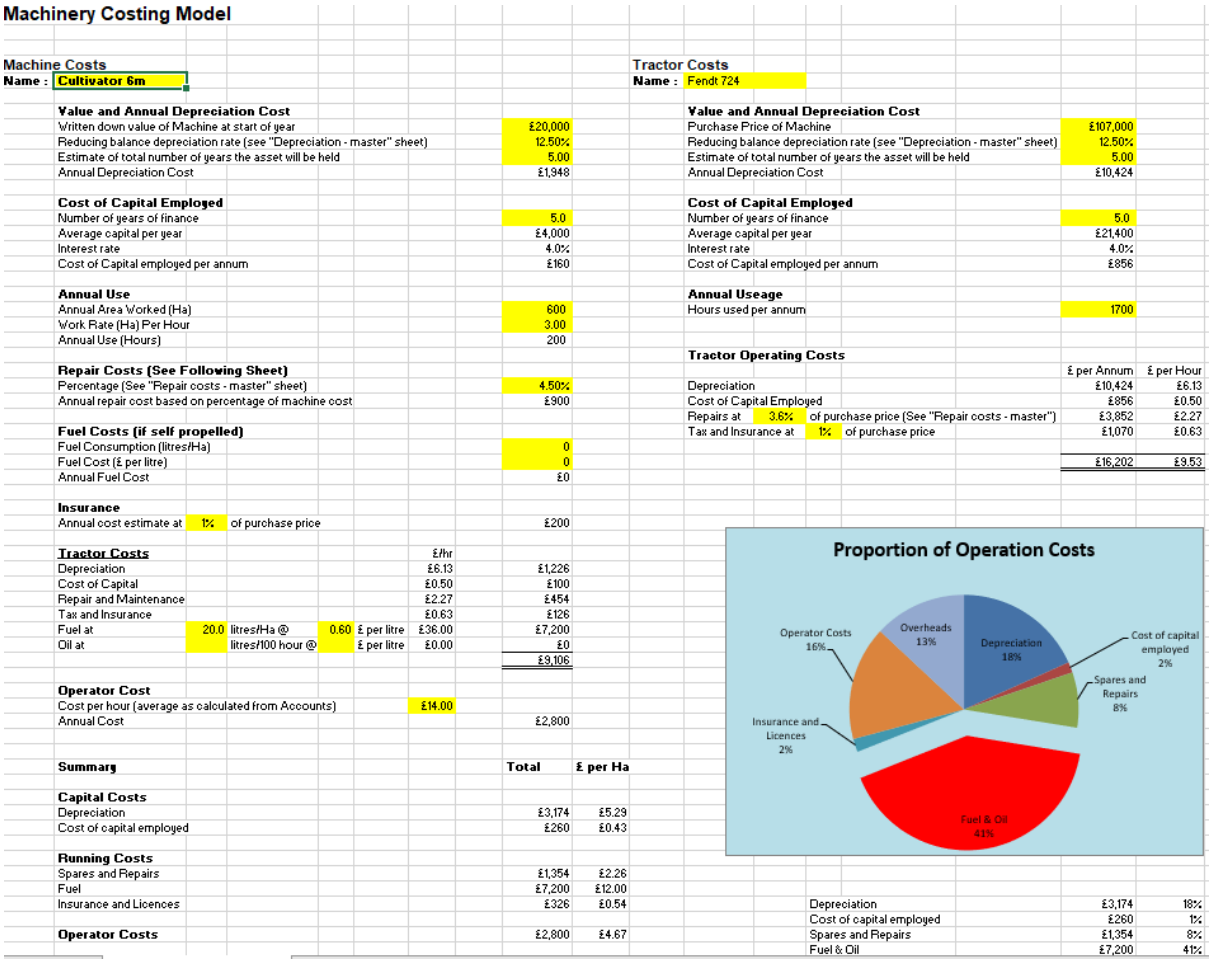
Table 2 Foresight Farming Project Programme

Figure 3 At one of the Foresight Farming meetings, George Noble of SAOS describing the benefit of data to members.

3.2 Foresight Farming Benchmarking Tool

Scottish Agronomy Ltd in conjunction with EQ Accountants developed an excel spreadsheet template to help members with their data-gathering exercise (see Figure 4). The scope of farm data benchmarking was focussed on data that was linked to the fixed costs of combinable crop and potato production. This included two principal areas: labour and machinery costing. The headings on the spreadsheet include:

i. Labour – A review of the labour profile of the business in terms of cost per hectare. This was calculated as Annual Area Worked (Ha), Work Rate (Ha Per Hour) and Annual Use (Hours).
ii. Power and machinery – A detailed breakdown of power and machinery costs including an accurate cost review for each machine and actual costs for each operation (i.e. ploughing, drilling and combine harvesting) to create an operational cost for each crop type. These included the depreciation of the machine, capital cost, repair and maintenance cost, tax and Insurance, fuel cost and oil cost.



Machinery Costing Model

Machine Costs
Name : Cultivator 6m

Value and Annual Depreciation Cost	
Written down value of Machine at start of year	£20,000
Reducing balance depreciation rate (see "Depreciation - master" sheet)	12.50%
Estimate of total number of years the asset will be held	5.00
Annual Depreciation Cost	£1,948
Cost of Capital Employed	
Number of years of finance	5.0
Average capital per year	£4,000
Interest rate	4.0%
Cost of Capital employed per annum	£160
Annual Use	
Annual Area Worked (Ha)	600
Work Rate (Ha) Per Hour	3.00
Annual Use (Hours)	200
Repair Costs (See Following Sheet)	
Percentage (See "Repair costs - master" sheet)	4.50%
Annual repair cost based on percentage of machine cost	£900
Fuel Costs (if self propelled)	
Fuel Consumption (litres/Ha)	0
Fuel Cost (£ per litre)	0
Annual Fuel Cost	£0
Insurance	
Annual cost estimate at 1% of purchase price	£200

Tractor Costs				£/hr	
Depreciation				£6.13	£1,226
Cost of Capital				£0.50	£100
Repair and Maintenance				£2.27	£454
Tax and Insurance				£0.63	£126
Fuel at	20.0	litres/Ha @	0.60 £ per litre	£36.00	£7,200
Oil at		litres/100 hour @	£ per litre	£0.00	£0
					£9,106

Operator Cost	
Cost per hour (average as calculated from Accounts)	£14.00
Annual Cost	£2,800

Summary	**Total**	**£ per Ha**
Capital Costs		
Depreciation	£3,174	£5.29
Cost of capital employed	£260	£0.43
Running Costs		
Spares and Repairs	£1,354	£2.26
Fuel	£7,200	£12.00
Insurance and Licences	£326	£0.54
Operator Costs	£2,800	£4.67

Tractor Costs
Name : Fendt 724

Value and Annual Depreciation Cost	
Purchase Price of Machine	£107,000
Reducing balance depreciation rate (see "Depreciation - master" sheet)	12.50%
Estimate of total number of years the asset will be held	5.00
Annual Depreciation Cost	£10,424
Cost of Capital Employed	
Number of years of finance	5.0
Average capital per year	£21,400
Interest rate	4.0%
Cost of Capital employed per annum	£856
Annual Useage	
Hours used per annum	1700

Tractor Operating Costs				£ per Annum	£ per Hour
Depreciation				£10,424	£6.13
Cost of Capital Employed				£856	£0.50
Repairs at	3.6%	of purchase price (See "Repair costs - master")		£3,852	£2.27
Tax and Insurance at	1%	of purchase price		£1,070	£0.63
				£16,202	£9.53

Depreciation	£3,174	18%
Cost of capital employed	£260	1%
Spares and Repairs	£1,354	8%
Fuel & Oil	£7,200	41%

Figure 4 Foresight Farming benchmarking template

The data collected was then validated by Scottish Agronomy Ltd and EQ Accountants, followed by two review sessions to discuss the results with the members. Three members were selected to present their data and shared their lesson learnt.

3.3 Data Sharing Protocol

To ensure members' confidential information and data were safeguarded, transfer of data was covered by a Non-Disclosure Agreements (NDA) between individual farming businesses and Scottish Agronomy as well as a Non-disclosure Agreement between all the Partners. The protocol, led by Urban Foresight, was set up and discussed in the members' meeting, all parties were committed to doing this in full compliance with the General Data Protection Regulations (GDPR) as stated in the Data Protection Act 2018.

3.4 Collaboration with External Partners

In addition to the existing project facilitators, several other organisations were engaged to provide further expert input to gain practical insights.

3.4.1 Hays Farm

The Hays family are a fifth-generation farming and contracting business and winner of the House of Commons Food and Farming Industry Award. Over the last 126 years, the family business has progressively grown its farming operation, now covering 3,400 Ha across Perthshire on a mix of owned, rented and contract farmed land. The members had a unique opportunity to see first-hand how the business has transformed through sustainable and progressive farming techniques. An on-farm demonstration was held on Hays farm to allow members to discuss innovative techniques, data management and contribute to innovative initiatives.

Figure 5 Foresight Farming Group visiting Hays Farm.

3.4.2 Joint Venture Farming Group (JVFG)

The Joint Venture Farming Group is a Benchmarking group which was formed in 2003 to serve the needs of a growing number of farmers who are involved with some form of collaboration at the primary production level. The member businesses can compare their physical and financial data via the JVFG online data entry system giving a range of cost comparisons across operations and crops.

The Foresight Farming funding enabled the Operational Group members to join the JVFG, so they could benchmark their cost against wider businesses. By comparing costs, machinery, work rates and farming techniques, the operational groups could understand and drive down cost per tonne.

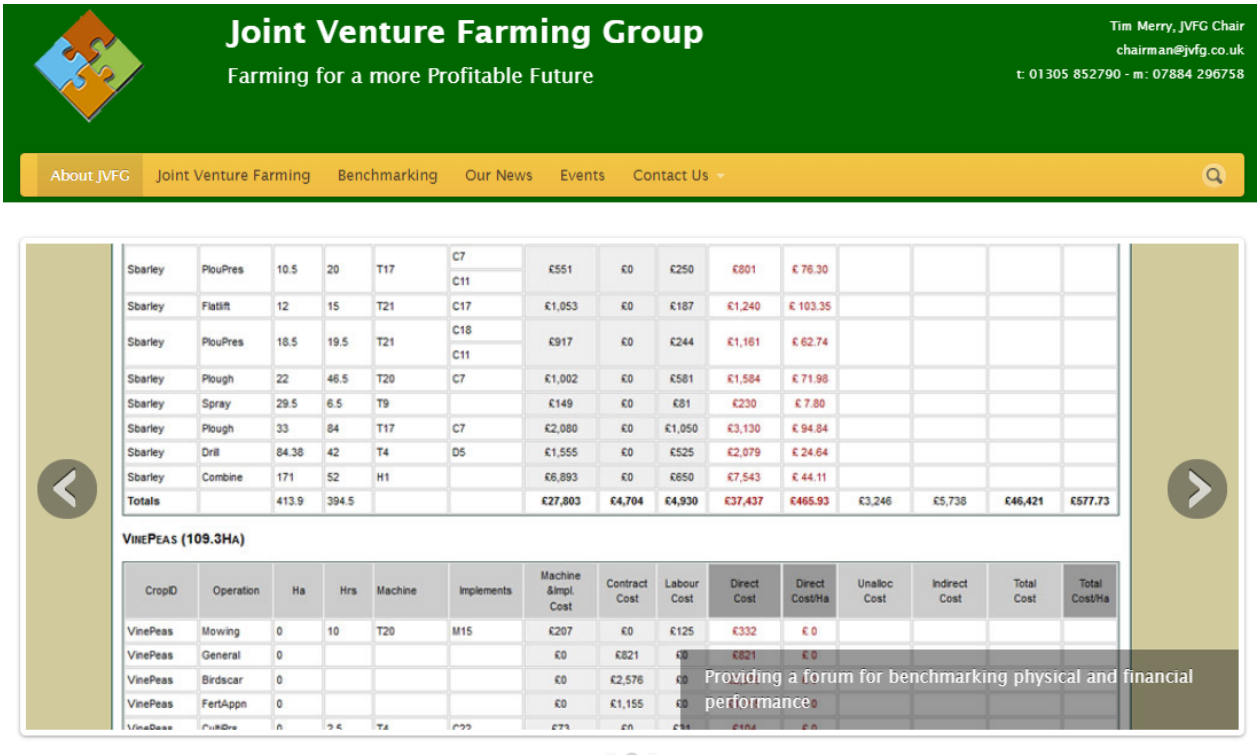


Figure 6 Example of the JVFG benchmarking database

3.4.3 Aidansfield's Farms

Aidansfield's comprises of 800 acres of prime Northumberland farmland growing 630 acres of combinable crops together with 120 pedigree high genetic merit Salers cows. Precision equipment and 'Lean' principles have been embedded at the heart of the operation, to ensure accurate data acquisition and interpretation of financial and environmental impacts on the farm.

Farm owner and manager, Conor Colgan, is a pioneer in applying Lean principles to farming. He wrote a thesis on Lean management for his MBA in Advanced Farm Management and his mission for the farm and research centre is to optimise farming systems for best economic and environmental performance. An on-farm demonstration was held on Aidansfield's farm, where Conor provided practical examples implementing data-driven lean management in the farm processes from ploughing, spraying, harvesting, grain drying to the selling of the final products. During the farm demonstration, Conor also led an in-depth discussion and a step-by-step guide on how to derive a current state value stream map on wheat from seed to final product (see Section 6.1 for further information).

4. Lesson Learned

The Foresight Farming members have all agreed that they gained valuable knowledge transfer and information from the project (data benchmarking and the understanding of lean management). As the Operational Group consists of 10 members from different part of Scotland, it could be difficult for everyone to gather and discuss project details. To mitigate this, members were very co-operative in using online and telephone services to ensure information was communicated and shared. This shows that an effective engagement strategy is crucial in knowledge transfer.

To maximise the project values of benchmarking, this requires trust and honesty. All partners signed a Non-Disclosure Agreement, which enabled open and effective roundtable discussions over the project period. Face to face meetings and practical farm visits proved to be more effective in ideas generation, project feedback, benefits realisation and group analysis of best practises. At the final meeting, roundtable feedback was gathered from members, they agreed that Foresight Farming enabled the group to share ideas honestly. Unlike other benchmarking groups Foresight Farming provided a closed group and good data sharing protocol, enabled a sense of trust amongst members to allow them to share their operational practices, costs and practises openly.

4.1 Main benefits realised to date

The pilot project focused on data for decision making (labour, purchases and machinery use) on fixed farm costs in arable farming, the main benefits realised to date are:

4.1.1 Digital Transformation and Innovation

Quality data capture, data analysis and data use support and drive agri-tech and innovation in the arable sector. To drive digital transformation amongst the agriculture sector, the carefully curated programme by the facilitators has cultivated a culture of understanding in data-driven operations and how innovations can be derived from data. One of the most discussed topics amongst members was on the data collection for labour or work rate cost. The existing onerous timesheets collection systems resulted in a demand for a smart app amongst members, to accurately record time spent on different operational tasks, thereby enabling effective cost allocation.

One of the participating Foresight Farming members, Marc Skivington shared the context of being able to use existing platforms that were in development to capture timesheet data. A smart farming mobile-based App could be a way of demonstrating what was achievable in future through minimising double recording of data that makes it easy for farmers to use on the field. A platform that simultaneously manage pre-start safety and machinery checks as well as highlighting issues of the machine would be advantages. A discussion amongst Foresight Farming members showed demand in applying this type of interventions to their farm. The members collectively discussed what additional functions could be useful with a future plan to work with interested parties to have an integrated app.

The project has also fostered an environment for members to not only embracing new technology but also understanding the importance of processes and organisational culture change in digitisation. There is a need for organisations to address the change in business planning and innovate ways to quickly cater to these changing needs.

Members were also interested in employing LoRaWAN (Long Range Wide Area Network) and smart sensors for low-cost data collection. Smart sensors technologies have previously been employed in urban areas but use cases have not widely been discussed in the agriculture and rural setting due mainly to the lack of suitable infrastructure and investment. During the engagement meetings, SAOS and Smart Rural presented the use of LoRaWAN and low-cost sensor technology on farms to improve business operations. Examples of how this would work in the rural and agricultural context that will benefit the farming industry were shown to members. There was a good overall interest in the adoption of these products from the participating members.

These innovative dialogues and products would not be possible without the Foresight Farming group and the funding that supported the project. The project provided valuable opportunities for the most entrepreneurial agri-tech farm businesses to meet and share ideas to improve their farm business decisions.

4.1.2 Knowledge Transfer

The business-led, farmer centred Operational Group has an aim to 'foster knowledge transfer and co-operation' amongst members. They supported the members on innovation-led and agri-tech business discussion and ideas.

This project has created a protocol to allow farm businesses to calculate the value of their data holdings related to the cost of arable production. The baseline monitoring produced an initial value of data held, from 'without value' through to 'valuable' and an improve skillsets of the members. Following the project presentations and with the guidance from project facilitators using bespoke Excel spreadsheets based on members' data, Foresight Farming members were able to better understand their fixed cost. Members were able to develop key performance indicators based on data collected and a better understanding of their operational costs. This will be used to help with future business practices where they can apply lean principles and best principles gained from meeting, discussions and visits to other farming operations.

Operational group members were also given the opportunity to benchmark against other group members (JVFG), to identify areas of potential improvement. Practical learning skills were gained through the presentation on-farm demonstration as well as from a lean farm specialist, on-farm demonstration of lean principles and practical exercises for members to apply to their farms.

5. Communication & Engagement

To highlight the opportunity for members and the wider farming community to demonstrate the benefits of the Foresight Farming project, Jane Craigie Marketing, led by Susannah Pate, created a marketing strategy to disseminate and to promote the project via press releases and social media channels. The engagement was targeted at progressive farmers to demonstrate how drilling down into data could make savings, improve efficiencies and aid towards a lean management approach. The communication approach also promoted Foresight Farming as a leading provider of detailed benchmarking that can make a measurable difference to farm businesses.

The media activity was centred around the main elements of the project - the farm visits and the results. Main outputs of this communication strategy were:

- A press release to launch the project.
- Reporting key findings and messages from the two demo farm visits.
- Reporting key lean farming message.
- A press release to announce the findings of the project.

The consortium agreed at the start to create an identity for the project and nick-named the project 4Sight Farming. The 4Sight Farming Twitter (@4SightFarming) account has been active since February 2019.

5.1 Press Releases

Numerous press releases were published to engage the wider farming community and disseminate the results as below:

i. 4Sight Farming pilot project to drill down into data
ii. Government funds pilot project to drill down into data
iii. New scheme to give insight into true crop costs
iv. Project to analyse true costs per crop to give farmers accuracy
v. Cost saving aim from benchmarking project
vi. More profits from adopting a lean business approach?
vii. ‘Lean farming’ pioneer shares his knowledge
viii. Lean farming can make agricultural operations more effective: experts
ix. Arable farmers told to focus on fixed costs, rather than inputs

6. Key Findings & Recommendations

The project has successfully attracted 23 farming businesses to participate in the final benchmarking exercise. 15 types of machinery costs were collected across these members, which included machinery costing from Plough, Cultivator, Rollers, Drill, Sprayer, Spreader, Combine harvester, Grain trailer, Grain dryer, Separator, Deep ridger, Potato planter, Potato harvester, Carting and Forklift. Figure 7 shows the data count received from members for each type of machinery costing.

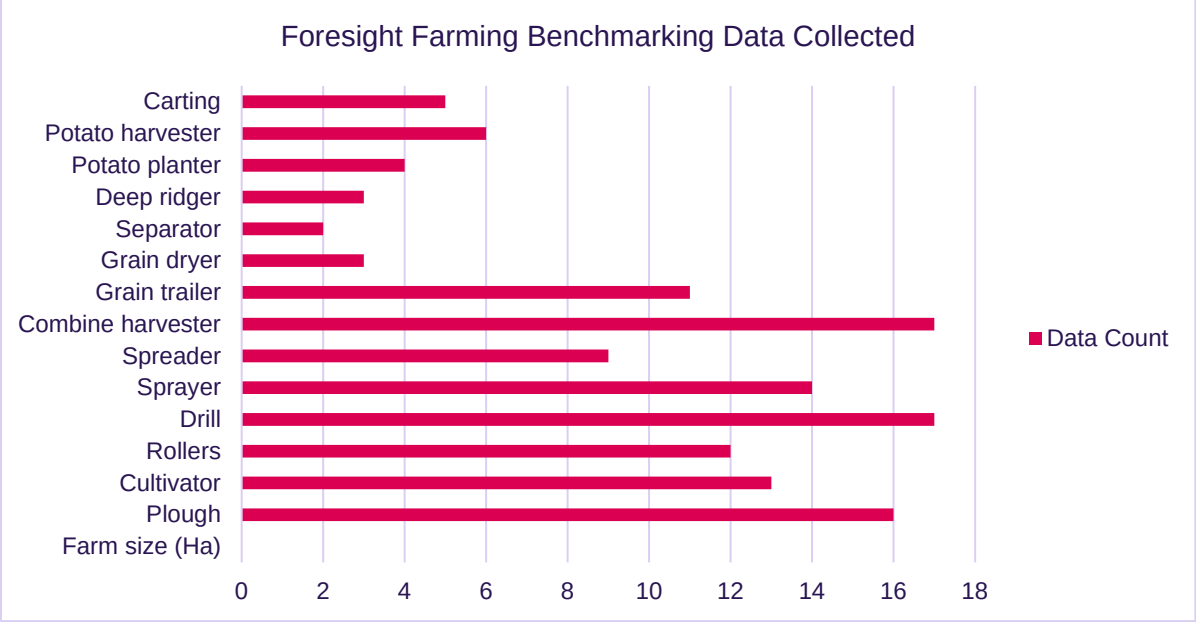
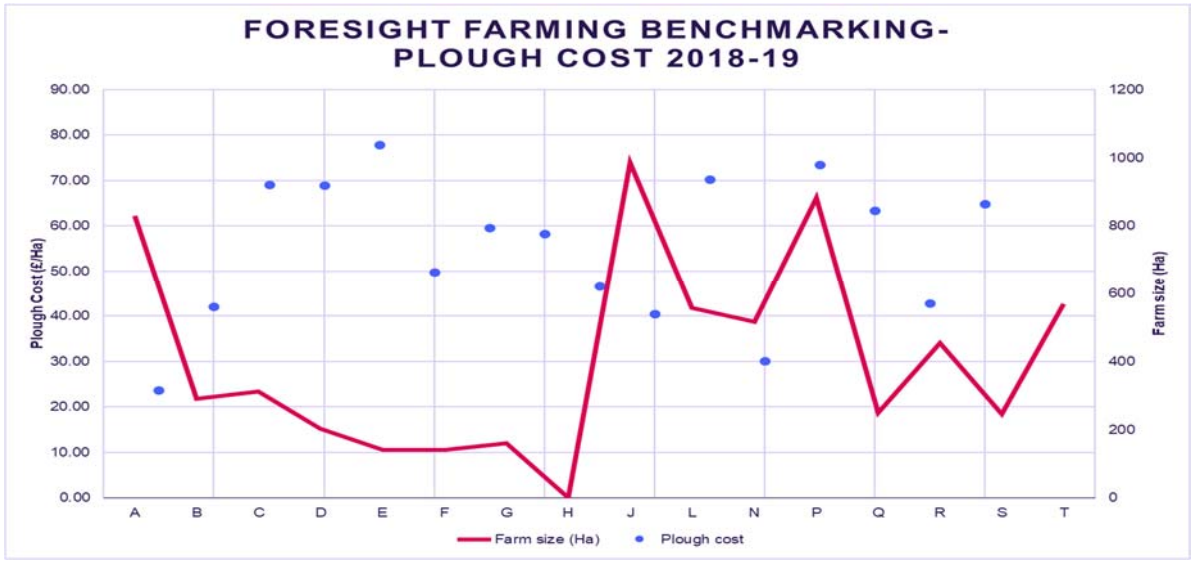


Figure 7 Foresight Farming data count for each machinery costing collected from participating members.

Figure 8 on the next page showed the two examples of the benchmarked costs: 1. Plough and 2. Combine harvester. 16 members submitted their plough cost for the benchmarking exercise, with an average cost of the plough at £56.14 per Ha. The highest plough cost is £77.81 per Ha and lowest is £23.74 per Ha. For the combine harvester, 17 data sets were collected, with an average cost of the plough at £47.93 per Ha. The highest combine harvester cost is £132.60 per Ha and lowest is £46.35 per Ha.

Our study showed that there was no obvious relationship between the size of a farm/area of cultivation and its fixed costs. Farms with a smaller footprint may still attract higher machinery cost per tonne of crop due to various reasons such as newly purchased machinery. However, the benchmarking exercise provided great opportunities for members to collect realistic or effective work rates including normal operational down-time, inefficient journeys, cultivation choice, labour use, fuel use and under-utilisation, which they can assess and compare along with assessments of residual machinery values and the benefits of regular maintenance.



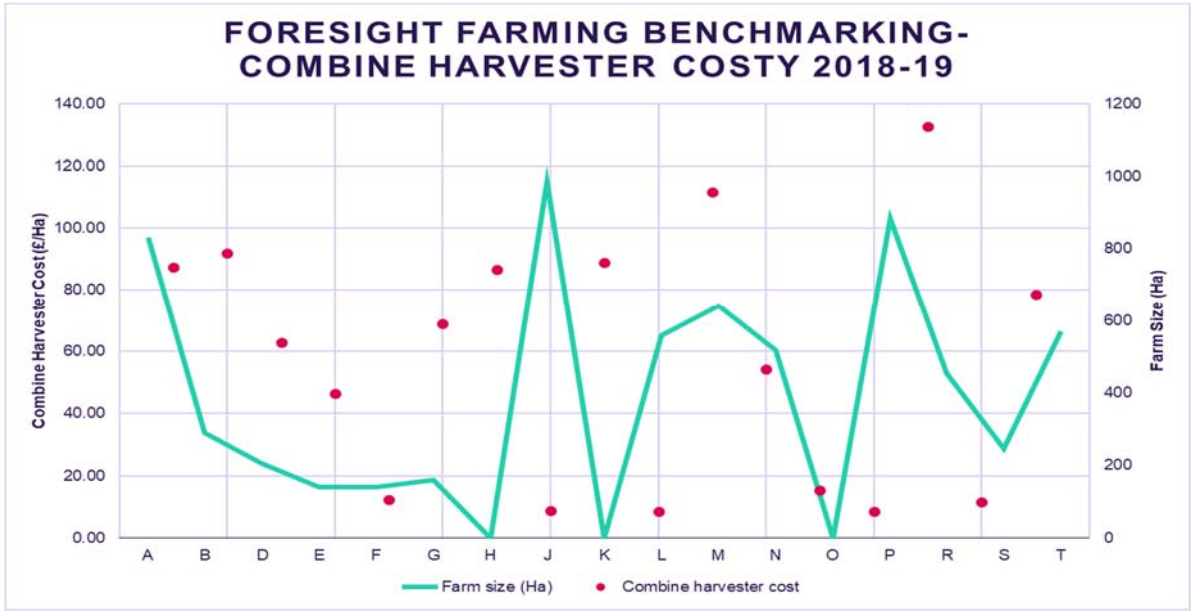


Figure 8 Foresight Farming- Machinery Cost Benchmarking

6.1 Lean Management

The lessons learned from lean farm best practices provided members with a basis for decision-making and useful tools to address day to day operational challenges. The factors affecting profitability were highlighted through the data collected by members through their farm businesses.

Value Stream Mapping (VSM) is a lean management tool that helps visualise the steps needed to go from product creation through to delivering it to the end customer. The purpose of value-stream mapping is to identify and remove or reduce "waste" in value streams, thereby increasing efficiency. This is intended to increase productivity by creating leaner operations which in turn makes quality problems easier to identify. Conor Colgan of Aidansfield farm demonstrated to Foresight Farming members the lean management techniques, in particular how he used value stream mapping for his whole farming process, sharing his capacity alignment of all machines and grain drying handling facilities, as well as findings from his MBA thesis with the members (see Figure 9). Members also learned how to use their enterprise cost data (fixed and variable and sales, yield and quality) to embed - at the enterprise level - onto a current state value stream map.

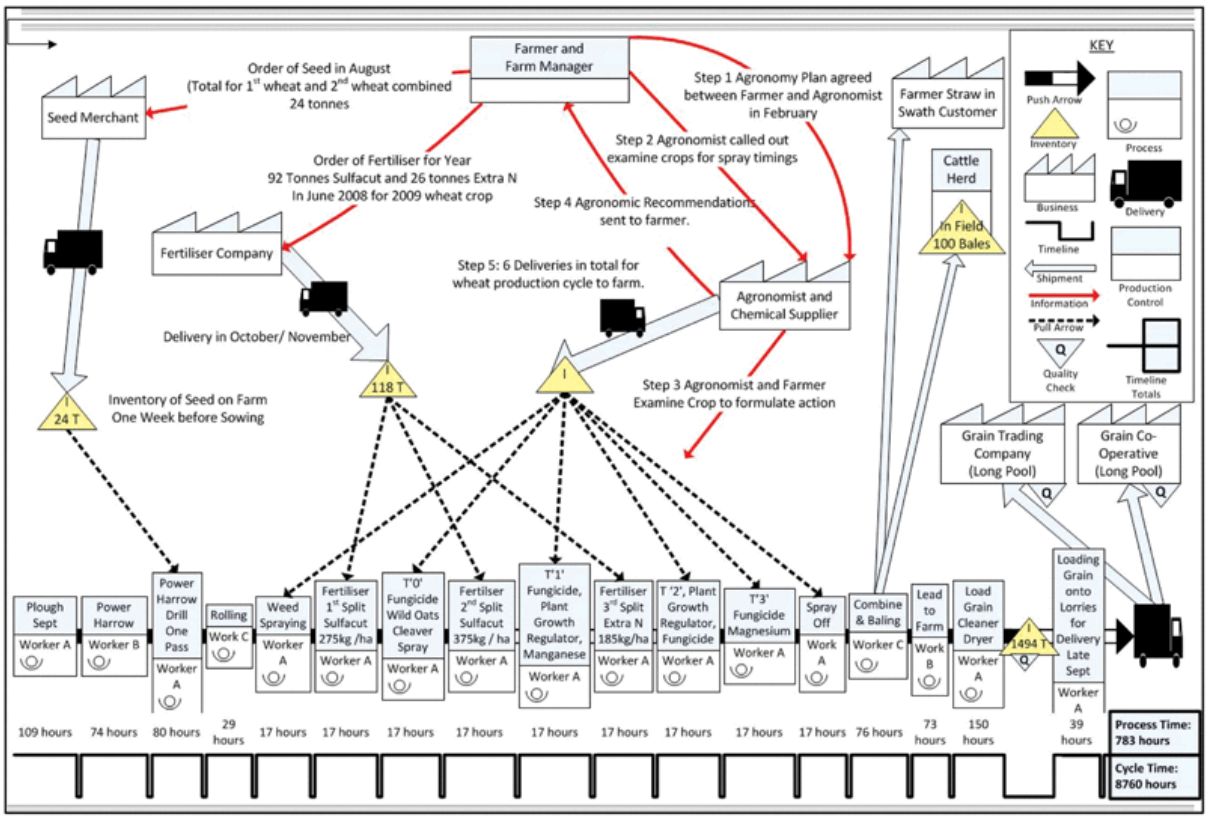


Figure 9 Value Stream Mapping and methodology to review processes (Reference: Conor Colgan; George Adam; Federico Topolansky, International Farm Management Association and Institute of Agricultural Management, Volume 2, Issue 3, pages 170-181.)

At the final meeting, Conor also led a discussion on cost versus value, providing key examples using his VSM practises to demonstrate the importance of consumer value, which are all the activities that contributed to delivering the quality that the customers require. Conor reiterated to members that lower cost does not necessarily mean the process is more effective. Therefore, it is imperative to conduct a thorough analysis of total value and cost. To obtain value, businesses can investigate their final product quality, yield, cost, effectiveness and any complimentary items required to make the product valuable to the customer.

6.2 Recommendations

All the participating members understood the benefits of the project. However, to maximise the project values of benchmarking, this requires trust and honesty. All partners signed a Non-Disclosure Agreement, which enables open and effective roundtable discussions over the project period. Face to face meetings and practical farm visits have proven to be more effective in innovative ideas generation, project feedback, benefits realisation and group analysis of best practises. This shows that a clear communication strategy is critical to making the leap to digital transformation.

Benchmarking is a continual improvement process as shown in Figure 10. Once process changes have been implemented, businesses have been encouraged to conduct another benchmarking exercise to measure performance improvement in future.

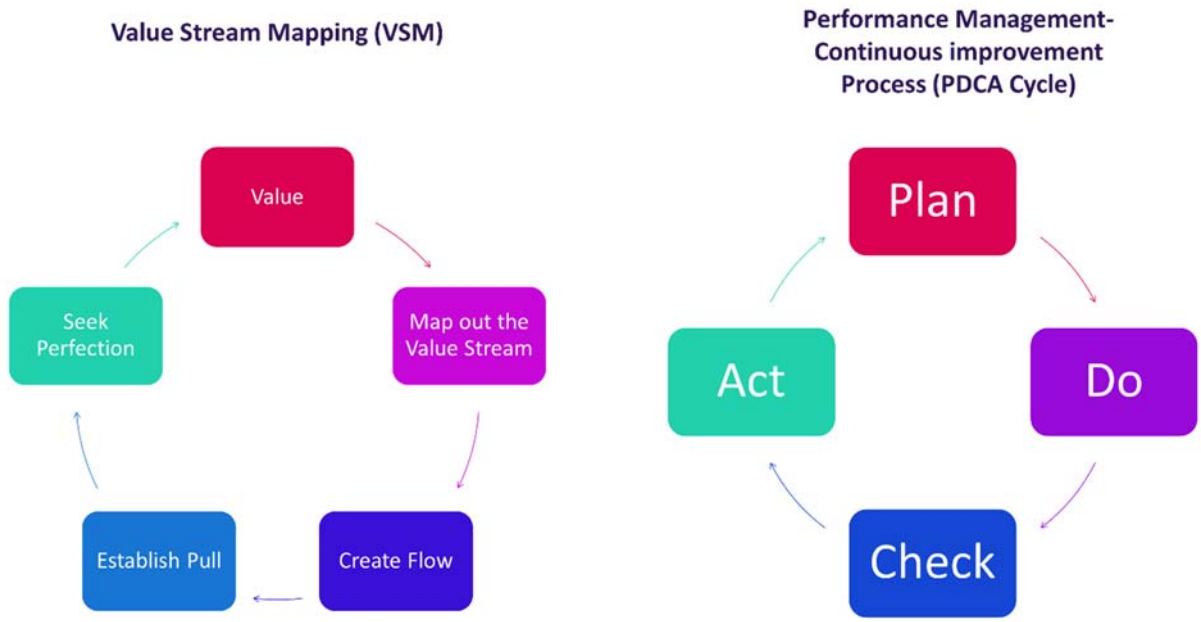


Figure 10 Value Stream Mapping (VSM), key principles of lean management coupled with continuous improvement principles to optimise business process.

The project engagement process has proven that collaboration is important to learn new skills and generate ideas. Peer discussion allows partnership and establishes new business links. Through the project, Foresight Farming members have formed a strong network and have asked to continue with this benchmarking exercise,

Scottish Agronomy Ltd is currently evaluating possible funding opportunity and collaboration such as with AHDB to continue the initiatives.

To maximise the benefits realised in this project, the facilitators recommended next step for the members is the use of the knowledge gained in the project to optimise farm process such as implementing the VSM model of the lean management, understanding customer value and adjusting their process. Additionally, many types of machinery have existing data collection tools and telematics, members could employ simple feature to automate data collection such as labour and work rates. Smart sensors can also be used to help members monitor their operation and crop, which will enable farmers to react quickly with changes. By combining low-cost smart sensors such as soil moisture sensor or fuel gauge sensor, this would enable farming that traditionally on intuition, to sustainable farming optimised with data.

7. Conclusion

The overall objective of the project was to assess the use of benchmarking as a tool to improve business operations for arable farmers. Our project showed that with the support from facilitators, members found that this a worthwhile exercise. Innovation ideas for new products, services and ideas can be generated and refined through facilitated group discussions.

As U.K. agriculture faces another period of significant change, there has never been a better time to scrutinise production costs. Accurately understanding farm costs enables businesses to make informed agronomic and economic decisions, to be better prepared for any change in policies, regulations, commodity prices or threats such as weather changes, diseases and pests.

The future of farming will rely on smart technology and data to give farmers new insights into more efficient and sustainable approaches to crop growing. This project laid the foundation for members to understand how data could lead to an optimised business operation. Although the recommendations made to the members cannot be measured immediately, the mechanism for change has been demonstrated to them.

The lean management process needs to be sustained over the long-term and requires continuous effort to be successful. Further benchmarking will demonstrate to members whether their performance is stronger or weaker and can also be compared with other members. It will give members a clear understanding of where improvements are needed and how to increase profits.

The next stage of implementation is on the automation of data collection such as machinery and work rates. Smart sensors can also be used to help members monitor their operation and crop, which will enable farmers to react quickly with changes and threats such as drought and soil health. By combining low-cost smart sensors such as soil moisture sensor or fuel gauge sensor, this would empower farming that traditionally on intuition, to sustainable farming optimised with data.

8. Case Studies

Three case studies and lessons learnt from within the Business Group were discussed and evaluated with other members in the final meeting. All three farming businesses have different geographic location, structure and organisation, crop types and practices.

Farm A, Fife

Farm size: 1,214 Ha

Type of Crop: winter wheat, feed winter barley, winter oilseed rape, spring malting barley, winter and spring oats, along with temporary grass, spring-sown green cover crops and let ground for ware potatoes and vegetables.

This a family farm with a complex role as the farm owner manages four other large arable farms, as well as contracting. The operation comprises more than 150 fields. The farms are operated within a collaborative venture. In-hand farming is characterised by direct control of the activities on the land, either through contracting arrangements or by farming with direct labour.

The farm owner also has a pedigree herd of cattle and produces up to 4,500 tonnes of cereal. The farm owner is progressive and has been embracing regenerative agricultural practices, focusing on topsoil regeneration and increasing biodiversity.

With this benchmarking practise (see Figure 8), Farm A's operating cost is relatively low. Maximising machinery output was achieved by rationalisation and selling surplus machinery. This was possible by the units working cohesively as one collaborative venture, with a single workforce rather than as separate entities. The objective is to use equipment to near-maximum capacity, to facilitate reducing fixed costs e.g. selling two tractors and purchase one tractor replacement. Sold two combine harvesters which were replaced with one high capacity model.

Farm R, Angus

- Farm size: 246 Ha
- Type of Crop: Crops combined with animals, mixed farms

Farm R is a traditional family-run business. Before joining Foresight Farming group, the business had no formal way of recording the work rate for each crop. The business has been relying on intuition and estimation, therefore there could be a high level of inaccuracy in estimating cost. The business owner recognises the benefits of the benchmarking process, using the projects bespoke spreadsheet has been a useful practice for the business. They also have no machinery replacement policy, i.e. the replacement of the machine will depend on the machine lifetime. Invoices on repairs, fuels and oils were collected and examined.

The business owner has now introduced a work diary as a starting point to estimate the work rate, and they hope to adopt a more automated process to collect this data (possibly through the installation of sensors and LoRaWan). Work duration was collected from the time the personnel leave the yard to their return. Lean best practice will also continue to be more actively applied to other farm processes.

Farm H, Scottish Borders

- Farm size: 800 Ha
- Type of Crop: cropping wheat, winter/spring barley, oilseed rape, vining peas and potato lets.

The farm is all arable, work rate is about 1.5 Ha/hour, task docking and 12 hours work per day. The farm tractor is one of the oldest (Fendt 722), more than 6,000 hours were clocked for the machine as it must work hard to get drilling completed in a short space of time. Cost of ploughing is circa £63.48/Ha. During the feedback session, the farm manager was surprised with the costing, and on evaluation, this led to a discussion on whether contracting on Farm H would be more cost-effective. This benchmarking exercise has prompted the farm manager to think through their business practise and change their business plan in areas such as justifying the decision to buy new machines. One of the key learning points is that there is better engagement from farm staff by demonstrating the benchmarking costs to them and showing them the benefit in having a more efficient farm process.

Annex A: Milestone Summary

Dates	Title	Venue	Status
20th November 2018	Project initiation meeting	EQ Accountants, Forfar	Completed
20th November 2018	First Operational Group Meeting	EQ Accountants, Forfar	Completed
8th February 2019	Preparation and signing of Memorandum of Understanding (MoU) and Non-Disclosure Agreement (NDA) M1: Operational Group/Farm Business Group constituted		Completed
22nd February 2019	Second Operational Group Meeting and First Business Group Meeting (North)	EQ Accountants, Forfar	Completed
25th February 2019	First Business Group Meeting (South Farm Demo)	SAOS, Rural Centre, Islington	Completed
24th April 2019	Third Operational Group Meeting 2 (Software and benchmarking training)	DoubleTree by Hilton, Dundee	Completed
24th and 26th April 2019	Second Business Group Meetings Data quality, ownership, security and value (South Farm Demo-1)	Dundee and Haddington	Completed
31st May 2019	Third Business Group Meeting and North Farm Demo-2: Introduction to Lean Manufacturing and application in Agriculture, data and finance skills.	Hay Farms	Completed
17th July 2019	Lean business visit (South Farm Demo-3) M4: 3 farm business demonstrations	Conor Colgan, Aidansfield Farm, Lowick	Completed
31st October 2019	Business Group machinery data and costing received & analysed		Completed

4th November 2019	Benchmarking meeting: Future planning for profit- data benchmarking results and discussion	Eassie & Nevay Hall	Completed
29th November 2019	Final meeting (Combined Business and Operational Group Meeting) M2 and M3: All Operational Group and Business Group meetings completed. M5: Innovative Project Proposal, data benchmarking results and discussion	Eassie & Nevay Hall	Completed
7th February 2020	M6 and M7: Project reporting, case studies and final project claim.		Completed