CASE STUDY

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Why try Lean? A Northumbrian Farm case study

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ABSTRACT

The purpose of this research paper is to evaluate the applicability and potential benefits of Lean Principles to a farm business. This research opted for a case study research strategy that is implemented through in-depth personal interviews with different actors along the supply chain. This is augmented by further data collection from experts in the field of Lean. Using the Five Principles of Lean, Value Stream Mapping and the Seven Wastes this study suggests that there are benefits from applying Lean Principles to a farm business in terms of reducing waste and improving the quality of food supply. The present study makes a contribution to the validity of Lean principles when applied to an agribusiness context.

KEYWORDS: Five Principles of Lean; Farm business; Value Stream Mapping; United Kingdom; Efficiency; Effectiveness

1. Introduction

Lean is a production practice that aims to minimise waste along entire Value Streams and create more value for customers (Womack and Jones, 2003).

''Working from the perspective of the customer who consumes a product or service, 'value' is defined as any action or process that a customer would be willing to pay for.'' (Wikipedia, 2013).

Therefore, any use of resources that does not deliver consumer value is a target for change or elimination. This management philosophy has mainly been applied in manufacturing, notably in Toyota, and the Toyota Production System, from where Lean originates. The core usefulness and uniqueness of Lean lies in the scope that it covers by examining in one map all factors of production (Womack and Jones, 2003). The core analytical tools of Lean have also been widely applied in non-manufacturing areas (e.g. the NHS). For a farm this includes land, labour, machinery, buildings, variable inputs, time, financial performance, degree of value creation and produce quality attainment.

Lean is now viewed as a way of looking at any activity by breaking it down into process steps and removing waste at each step. A key point is to see each process step as part of a Value Stream and look for the value generated by that process and optimise that value across the whole Value Stream, making sure not to review any individual process in isolation from the whole.

The Toyota Production System was crystallised into the Five Principles of Lean (Table 1), as a method to identify value and eliminate waste.

The above principles served as the overarching discipline, followed and deployed in this study.

The Food Chain Centre in 2003-2007 applied Lean concepts to agri-food chains. These studies used Value Stream Mapping, Value Chain Analysis and Benchmarking to explore the potential of these techniques/concepts in delivering commercial benefits for the milk, red meat, grain and fresh produce industries (FCC, 2007). However, none of these projects applied Value Stream Mapping to a working farm. Moreover, there has been limited research looking at the relationship of farm gate quality of produce to consumer values. This paper has addressed some of these gaps.

Economies of scale, better equipment and smaller work forces have allowed many farmers to become more efficient. Efficiency gains have traditionally been measured focusing on one or more aspects of a given system such as gross margin per hectare, kg daily live-weight gain or field operation efficiencies. Lean thinking, on the contrary, proposes a holistic approach that integrates many of these measures and combines them to evaluate the impact of each decision on the 'whole' enterprise. For example, while assessing the impact of buying fertilisers on the basis of price, Lean would not only look at cost issues but also at the effect on the rest of the Value Stream within the enterprise (Cunningham and Fiume, 2003). Consequently, a Lean approach would assess the effect of buying a low grade fertiliser on quality, cost and income. The focus of Lean methods is on assessing the value adding of a task or input. It argues that a continuous focus on the attainment of product (beef/grain/milk) quality is the true measure of an effective farm process and not that of efficiency or yield alone. Lean is therefore both a method to analyse process efficiency and process effectiveness in delivering products. In order to assess the potential of using Lean, this study applied, between 2009 and 2011, Value

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Table 1: Five Principles of Lean (Womack and Jones, 2003)

Value	Specify value as demanded and defined by the ultimate customer
Value Stream	Mapping all design, physical production and information actions involved in producing and delivering the product values identified. Identify any non-value adding activity to remove. Ideally should involve 'entire value chain' i.e. complete supply chain.
Flow	Make remaining value adding actions and processes flow continuously, (without hold-ups) towards end demand.
Pull	Produce only what is pulled (demanded) by the end customer, attempt to eliminate as much inventory stocks as possible.

Stream Mapping to all production activities carried out on a lowland combinable crop and beef breeding farm in the north of England.

2. The case study farm and method

This study applies the case study method as the main research tool to address the objectives of this research.

The selected case study is a family-owned lowland mixed farm in Northumberland. It has the following enterprises: winter cereals, oats for porridge, wheat for biscuit, oil seed rape for cooking oil and barley for malting and the beer market. It also has a pedigree Saler beef herd for breeding and beef. The land is ring fenced and the farm yard is centrally located. The land has high yield potential. In the beef enterprise all young stock are taken to beef and breeding purposes, males as bulls finished at 15 months and heifers taken to beef or sold as bulling animals. The arable machinery policy is self contained with almost all operations being conducted in-house. Agronomy management is guided by an Agronomist and the Farm Manager's experience. There is one full time member of staff alongside the Farm Manager and the Principal of the business. Part time staff are taken on by the farm for harvest and planting operations

To acquire financial information, a technique advised by Newcastle University was followed to allocate costs and income to the farm herd and crops and to identify fixed costs. Value Stream Mapping was applied at the whole profit centre (herd and crop) level to measure the value adding nature of processes on the farm. The maps included the time taken to perform each task, total cycle time, labour used, machinery used, land allocation, variable inputs, staff skill and produce yield and quality.

Brainstorming with technical experts in the field of Lean, arable and beef was performed to identify the underlying drivers of value creation within the farm and provide perspective of the value adding nature of farm processes. Based on the results of the brainstorming sessions, areas for improvement were identified and plans proposed to improve enterprise performance. These plans were worked through to show the impact on process time, quality of output, cost and income and the feasibility of execution.

Lean asserts that all actions across the food supply chain should be focused on delivering consumer value. Consequently, the farmer as a supplier of agricultural raw material constitutes an important link in the food chain to achieve consumer value. This study has focused on quality parameters of grain and beef and their relationship with final consumer value demands. Walking of the Value Stream (Womack and Jones, 2003) was undertaken through interviewing all customers upstream and downstream from the business to identify if farm produce quality specifications demanded by each supply chain company were related to, and aligned with delivering a tangible final consumer value.

3. Current State Value Stream Mapping of the farm enterprise

The present study creates a Value Stream Map incorporating all tasks, inputs and processes for each profit centre on the farm. It is important to recognise that mapping the Value Stream must consider the crop or herd as a whole. This allows the Farmer to calculate the total processing time and cycle time for crop or herd and importantly the separation and allocation of fixed resources and labour to each farming activity. The 'Current-State-Map' (see Figure 3 in results) follows the manufacturing process from start (at the farm) to finish.

This study follows the methodology recommended by Womack and Jones (2003) to record all aspects within a business at the profit centre and process level to create the 'Current State Value Stream Map'.

Table 2 and Table 3 show the data that was recorded for this study.

From this data key measures used in Lean can be calculated (Table 4)

4. Identifying waste through the Value Adding analysis and the Seven Wastes

Each farm enterprise was analysed in terms of the Seven Wastes (Table 5), e.g. in terms of inaccurate resource allocation, the amount of farm product outside contract specification, or unnecessary conveyance. E.g. on the case study farm it was decided to relocate the fertiliser store to minimise conveyance and increase spreading output.

Value Stream Analysis argues that there are different actions occurring along the Value Stream and should be assessed in terms of their cost and value creation (Womack and Jones, 2003). For instance, there are steps such as planting the seed to grow a crop that are essential and Value Adding (VA). There are other processes that do not directly create value but are unavoidable. These are termed Necessary and Non Value Adding (NNVA.) An example of NNVA in agri-food chains would be multiple sampling of grain to

Table 2: Process Specific Data Collection

Name of process, e.g. feeding of bulls or T3 fungicide on wheat.
Labour, which member of staff involved.
Variable input quantity, i.e. seeds, fertiliser, sprays, feed used in the process.
Time taken from start of task to completion in hours.
Machinery used
Breakdowns or failures in process.
Amount of time in process not spent doing the task itself, e.g. transport fertiliser long distances before actually applying it. Conveyance time is calculated as separate to the application of the product.

Table 3: Profit Centre (Crop / Herd) Specific Data Collection

The amount of land used in the enterprise.
The total amount of processing time involved (by adding together task completion times)
The total cycle time, i.e. the time from the start of production to finish, e.g. ordering of seed to sale of harvested grain.
The total amount of seed, feed, fertiliser, fuel ordered and used.
Produce Quality inspection points.
The whole enterprise quality of product output against contract requirements in percentage terms.
Financial performance i.e. the gross margin of the enterprise.

Table 4: Key to Measures Used In Lean

Cycle Time (hr) = Total time from start of production cycle to point of sale and delivery.
Total Processing Time = Sum of all Individual process completion time.
Gross Margin per Hour = Enterprise Gross Margin / Total Processing Time (in hours)
Gross Margin after Labour = Gross Margin per Hour–Hourly Wage Rate

assess quality at each step of the chain, each handling the same information but common practice due to business structures and 'due-diligence' (FCC, 2003). Finally, a Non Value Adding (NVA) action is where a process or input is not required to make the product and therefore it should be eliminated.

5. Results of the case study

Identifying consumer value from supply chain interviews

The results of this study indicate that many grain quality parameters and beef carcase traits are primarily related to factory process efficiency and output. For example, high bushel weight and low ad-mix in grains allowed for higher factory yield and less waste in an oat processing facility. Similarly, optimum beef carcase conformation and fat grading ensures higher value cut quantity and minimises carcase trimming to efficiently suit pack size and beef fat level required by the final consumer. Therefore, these gains in processing efficiency could allow bringing cheaper products to the consumer. In order for this to happen, the savings in processing costs and higher factory yield must be passed on to the consumer.

Summarising, the application of Lean methods to the selected farm would allow for consumer value creation as Lean thinking would suggest (see Figure 1A/1B and Figure 2).

Consumer value knowledge is then used to appraise the efficiency and effectiveness of the farm business, systems, processes and inputs in delivering the consumer values identified.

Mapping the value stream, value adding and waste analysis

Overall profit centre value stream map

The crop or herd specific data gathered was used to create a 'Current State Value Stream Map'. All processes involved in the growing of the wheat crop (Figure 3) are shown alongside the total time taken to perform the process and the staff member involved. The quality of output is also shown. This map is the first step in analysing consumer value generation, namely to appraise the overall farming system deployed and to identify if process steps are complimentary to each other or in conflict to generating value. E.g. Drill output is limited by plough output, or seed order is too late to achieve early drilling, or labour assigned to a job could be improved through operator change or training. When

Table 5: The Seven Wastes of The TPS and an eighth waste (Liker, 2004)

1. Overproduction	Production for which there are no orders, wasting of resources and employees time.
2. Waiting (time on hand)	Employee down time due to delays in process. Capacity bottlenecks, processing delays, equipment downtime, lack of raw materials.
3. Unnecessary transport or conveyance	Carrying work in process (WIP) long distances, creating inefficient transport, or moving materials, parts or finished goods into or out of storage or between processes
4. Over processing or incorrect processing	Taking unneeded steps to process parts. Inefficiently processing causing unnecessary motion and producing defects. Waste is generated when providing higher-quality products than is necessary.
5. Excess inventory	Excess raw material, WIP, or finished goods causing longer lead times, obsolescence, damaged goods, transportation and storage costs, and delay. Also extra inventory hides problems such as production imbalances, late deliveries from suppliers, defects, equipment downtime, and long set-up times.
6. Unnecessary movement	Any wasted motion employees have to perform during the course of their work, such as looking for, reaching for, or stacking parts, tools etc. Also walking is waste.
7. Defects	Production of defective parts or correction. Repair or rework, scrap, replacement production, and inspection mean wasteful handling, time, and effort.
8. Unused employee creativity (Liker 2004)	Losing time, ideas, skills, improvements, and learning opportunities by not engaging or listening to your employees.

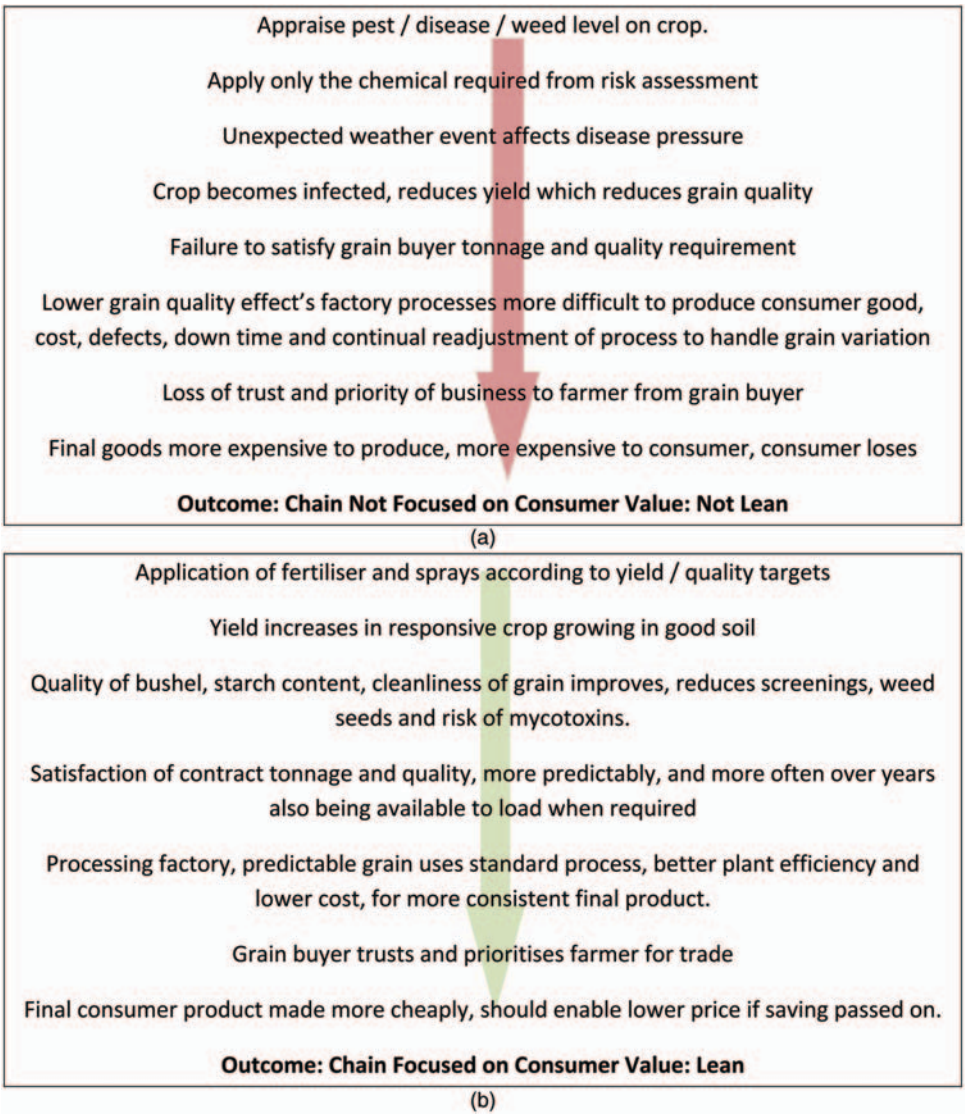

Figure 1A: Possible Chain Reaction of On-Farm Practice Effects on Consumer Value: Thresholds only to Guide Arable Inputs
Figure 1B: Possible Chain Reaction of on Farm Practice Effects on Consumer Value: Robust Programme

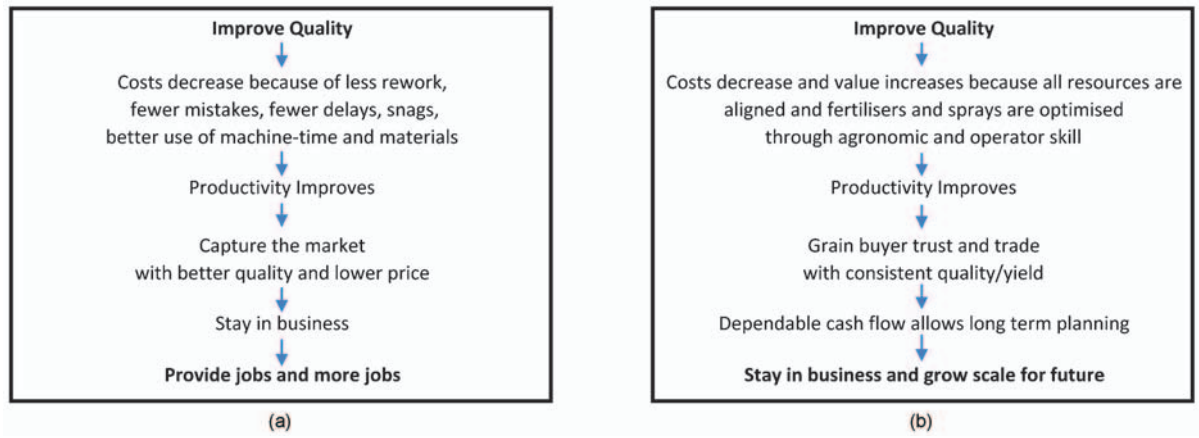

Figure 2A: Japanese Manufacturing (Deming, 1982)
Figure 2B: Lean Farm Philosophy

this map is used in conjunction with the gross margin and process specific data, the detailed 'Value Adding' analysis can take place.

Furthermore, mapping at the level of one crop or herd within the business allows the farmer to question the suitability of capital item allocation such as land, labour (men / skill), machinery and buildings, in order to evaluate efficiency and effectiveness by asking;

1. Is the produce quality and yield meeting consumer demand and value requirements? (Value as defined through customer interview and market intelligence). If not should the business cease or change?
2. Should there be a change of market outlet to increase product value?
3. Has there been accurate budgeting of fixed resources to the business?
4. Has the mix of capital deployed been successful in delivering consistent quality / value / yield?
5. Should there be a change in machinery policy to achieve better crops?

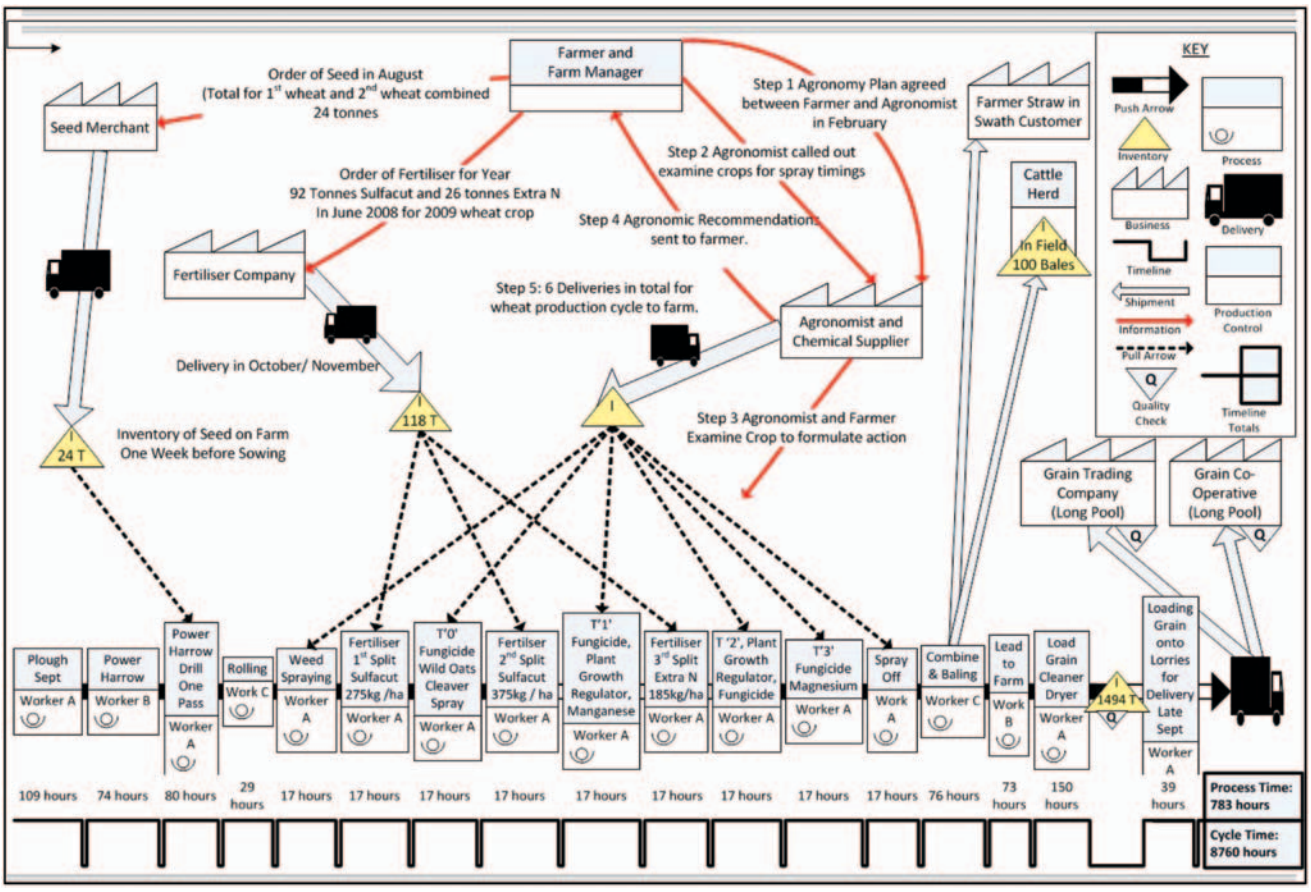

Figure 3: Value Stream Current State Map for Wheat Crop 2009, 100% biscuit quality

Table 6: Wheat Enterprise Process Waste and Value Appraisal from Brainstorm Example

Raw Material Inputs	Rate	Purpose	Growth Stage	VA	NVA	NNVA	Comment
Consort Seed	1st wheat 173kg/ha	Plant seed for new crop	1st-2nd week September	✓			no seed no crop is needed, rates could maybe be reduced
Consort Seed	2nd Wheat 183kg/ha	Plant seed for new crop (latitude treatment)	Last few days Sept / start Oct	✓			no seed no crop is needed, rates could maybe be reduced
Alpha Pendimethalin	3 l/ha	grass and broadleaf weed control	12 (2 leaves)			✓	reduced value adding if low weeds could rely on grain cleaner instead of weed killer
Moddus	0.1 l/ha	plant growth regulator	20/25 (tillering) (T0)		✓		high plant count from seed rate used = no need for Moddus tillering
Topik	0.075 l/ha	wild oat herbicide	20/25 (tillering) (T0)	✓			wild oat control essential for yield and quality high crop equivalent
Abacus	0.5 l/ha	non-ionic wetter	20/25 (tillering) (T0)	✓			needed to make best use of Topik

6. Are employee ability / skill suitable for the task?
7. Is there a bottleneck to flow of product through the system? (E.g. machinery work-rates)
8. Can there be a reduction in cycle and process time while maintaining product quality?

Analysing at this overarching business level addresses the first four of the Five Principles of Lean; Value, Value Stream, Flow and Pull and begins the perfection process.

Perfection can also be addressed by changing the overall system simply by optimising the first Four Principles to ensure maximum value potential is embedded to the farm.

However, ongoing Perfection through continuous process improvement is maintained and achieved by setting of efficiency and effectiveness Key Performance Indicators (KPIs) at the process level on a job by job or daily basis to maximise value delivery. This belongs more closely at the process, chemical or feed input level itself. This is because it entails 'perfecting' an existing farm system. The overall farming system itself has to be right in the first instance and is achieved by examining the business model closely through the first four principles contained within Value Stream Mapping.

Process specific data

The Value Stream map is accompanied by Data Sheets containing the 'Process Specific Data', Value Adding Assessments and crop or herd Gross Margin (Tables 6 and 7).

The method used to initially appraise the Value Adding nature of farm resources and inputs was performed by brainstorming with technical experts in beef, arable and Lean. The appropriate Value Adding Status (VA, NNVA or NVA) was then granted to the specific process, resource, technique or input. This accompanied by a comment to show justification for the Value Adding status granted, (Table 6 and 7).

At this point the farmer can calculate the gross margin per labour hour by taking the total gross margin from the data sheet and dividing by the total number of process hours (Process Time) from the 'Value Stream Map'.

Areas of waste and value issues identified from the value stream maps and data sheets

Results indicate that there is scope for Lean improvement centred on changing market outlets and more efficient allocation and utilisation of fixed cost resources, such as land, labour skill, machinery and buildings to add value, I.e. changes to the overall farming system.

The study experts also identified that variable inputs such as fertiliser, sprays and feeding are crucial to realise the yield and quality potential of land and genetics i.e. consistent value adding (VA). This is not to approve the overuse of chemicals and fertilisers, rather the more judicious value orientated use, as environmental protection is also a consumer value that the farmer has to balance and provide.

Maximising the degree of value generation of fertiliser, feed, seeds and sprays are important to realise the value potential by any farming system and are managed through accurate budgeting, cost / benefit risk

Table 7: Labour, Machinery Use, Total Task Completion Rate, Waste and Value Appraisal

Staff	Tractor	Implement	Total Time Rate	VA	NVA	NNVA	Comment
Worker B	JD 6910	New Holland 650 Round Baler	1.6 ha/ha	✓			value adding, fertiliser value and straw price trade off however
Farmer	JCB Loadall	Drying limited by dryer flow and outlet	10 tonnes /hr			✓	separate grain quality, reduce overtime work with larger hopper
Any Staff	JCB Loadall	Loading Lorries for Delivery of Grain to off-farm	29 tonnes/ 45 mins			✓	bigger bucket, more automation, possibly conveyer fill lorries

assessments, proficient application methods and setting KPIs to plan work timings and techniques to monitor performance.

Pedigree Saler beef herd

The data collected in this process suggested that:

1. Opportunity to sell more heifers for breeding not beef, (Bulling Heifer Customer Interview).
2. Change in market outlet gives an opportunity to sell more heifers as bulling animals at 15 months of age as opposed to 18 months for beef. This policy shortens the keep (cycle) time of the females at a competitive pricing point, compared to keeping longer and selling for beef. Shortening the cycle time will free up grazing, fodder and shed capacity to keep more breeding cows, or, reduce grassland requirements by 5%. This has the potential to increase gross margin per labour hour and per hectare.
3. There is excess capacity in terms of too much grassland allocated to the herd. Potential to plough up 30% of grassland for the arable enterprise. This will align resources more accurately and further increase gross margin per hectare.
4. There is a need to focus on maintaining and improving genetics through considering the use of Estimated Breeding Value's or using cattle weighing records linked to dam to assist in replacement selection and to ensure feed resources are efficiently processed through the animal to achieve target selling dates and maximum gross margin.
5. There is an opportunity to finish bulls 1-2 months faster at 13-14 months to the same slaughter weight by introducing full meal diet earlier after weaning. Therefore reducing meal demands by 9 ton.

Arable

The data collected in this process suggested that:

1. Marketing was an area in need of improvement based on Benchmark data. Short term grain storage limited autonomy by the farmer to make independent grain marketing choices. Grain is end user ready at the farm level, so end user sale options could be explored. Therefore consumer market intelligence for beer, porridge, biscuit and cooking oil should be obtained and frequently updated.
2. Grain quality assessment post-harvest in shed occurred too late to segregate and allocate more effectively to end user requirements.
3. BASIS and FACTs agronomy training would be needed by the Farm Manager to better understand integrated crop management techniques to protect crop quality and yield against variable weather and agronomic conditions and to maximise value.
4. Inefficiencies were identified in the drying, grain conditioning and combining process. These were generated by bottle necks arising from: the intake due to a small hopper, too small a grain bucket and insufficient combine capacity.

6. Future state mapping business improvements and effect of implementing Lean

In order to address identified areas for improvement a plan was drawn up to show the net effect of implementation, in terms of cost, time (process and cycle time) and income. Tables 8 and 9 show the livestock Lean plan.

Note that use of time in Value Stream Mapping allows for the calculation of Gross Margin per Labour Hour. Examples of Lean implementation effect within the arable crops are also listed.

Example of arable results

1. Land freed up from the herd allocation has increased the arable area by 7%.
2. More automated drying plant, larger bucket and intake hopper has delivered 48 hours of labour time saving per harvest.
3. Relocation of fertiliser store has realised 20 hours of process time saving through avoiding unnecessary conveyance.
4. Planned storage of 900t grain in freed-up building (due to reduced cattle housing needs) will deliver storage charge savings. The upgrading of building and plant cost show the potential to be paid back through storage charge savings alone in 4 years.
5. Earlier biscuit wheat quality assessment is being examined in conjunction with research partners. The aim to have combine mounted protein sensors for harvest segregation of grain according to protein for

Table 8: Potential Financial and Time Effects of Plans on Beef Herd Current State

	Cycle Time (hrs)	Process Time (hrs)	Total Variable Cost as % to show change	Total Output Sales as % to show change
Current State	Heifer 13,800 Bull 10,920	1,198	100%	100%
Quad / in shed		0	+0.6%	
Improve stocking density calculations and plough up 30% grassland for arable				Creates greater beef output per hectare through intensification
Diet (introduce meal earlier to bulls)		- 16 hours	- 8%	
Selling heifers sooner bulling, not beef	minus 5,040	-44 hours	-2.6%	Releases 5% grass and one shed for arable
Selling bulls sooner	minus 720	-20 hours		
Future State	Heifer 8,760 Bull10,200	1,118	90%	100%
Net Change	Heifer -5,040 Bull- 720	-80	- 10%	

Table 9: Potential future state beef herd gross margin increases (in % terms)

Potential % Increases in Beef Herd Gross Margins			
Total Herd	Per hectare	Per process hour	Per hour after labour cost
24%	116%	23%	60%

segregated storage and drying. This will allow consistent delivery of quality to buyers. Ultimately the field protein maps to help guide nitrogen policy to improve the consistency of delivering the desired grain quality parameters in a field by field basis.

6. Staff training has allowed each member to be skilled in all tasks, so preventing over reliance on any one person in particular. FACTS and BASIS training has allowed the farm manager to more precisely manage the agronomy and ensure greater focus on value adding and waste reduction.

Managing processes for consumer value effectiveness and efficient resource utilisation

The following are some examples of management that have been implemented at the process level to ensure daily operations realise the value potential of the new farming system. A key benefit is it empowers management with a simple method to ensure the new Lean farm system is on track.

Pedigree Saler beef herd

1. Forward purchasing of feed to achieve target daily feed cost, if necessary.

2. Use of efficiency KPIs in the weighing of cattle to identify if daily live weight gains are on target to meet target weights for heifers and bulls at weaning, mid winter, spring and selling age.

3. Use of efficiency KPIs for target feed intakes, accurate weighing of feed over winter, reduce feed losses in feeding process e.g. spillages. This data then works out the actual cost per kg of live weight gain, against target cost.

4. An effectiveness KPI for systematic inspection of bulling heifers with alternating vehicles; quad, land-rover and on foot to optimise temperament post sale for the customer in a new farm environment. To make the heifers 'Hill Farm Ready' and increase customer satisfaction.

5. Bulling period 6 weeks for heifers, 9 weeks for cows.

6. Semen test and trim bulls feet 1-2 months before each mating season.

7. In tightening stocking rates, sward improvement and more frequent applications of fertiliser adopted to maintain grass supply.

8. Rotational grazing in three blocks to extract extra grassland utilisation.

9. All bulling heifers and fat bulls to be sold by end of May every year, to ensure that the grass budget is met.

Arable

1. Quality assessments of grain before movement off farm and for every load off farm, linked to the field where it was grown.

2. Consideration of other inputs in the Value Stream for example, timings of fertiliser, soil fertility and plant density from seed rate before deciding on the need for growth regulators. (Hence the benefit of Value Stream Mapping)

3. Use of agronomic response curves (cost/benefit), crop equivalence, and timing for weeds and thresholds for pests are used to guide product need, choice and quantity.

4. An effectiveness lead purchase policy for pesticides based on budget price and quality of ingredients, i.e. brand names that ensure robust chemical suspension in mixture (i.e. chemical not settling out). This ensures

correct crop coverage, reduces scorch and increases yield value adding potential.

5. Attempt to apply inputs in optimum weather and soil conditions e.g. fertilizer to reduce losses through the nitrogen cycle, and pesticides to optimise crop coverage, reduce drift and evaporation or run off. To avoid the 'not-as-value adding' application days.

6. Use of efficiency KPIs to maintain target daily harvesting and cultivation work rates to meet target drilling dates.

7. All straw, except for beef herd need, incorporated to the soil, reduces cycle and process time and ensure more-timely drilling.

8. Matching of fertiliser and fungicide rates to fulfil the genetic yield and quality potential of varieties and the yield potential of the soil.

9. Soil maintenance of indices, organic matter and use of low compaction equipment.

Five principles of Lean in context of the case study farm

The majority of tangible effects on the case study farm that made the largest step change in output and time benefits arose from correctly implementing the first Four Principles of Lean

7. Conclusions

Lean may offer an opportunity for British farmers to increase their level of competitiveness by reducing waste and improving the quality of food supply. This strategy may certainly allow farmers to differentiate their produce within the supply chain. However, for Lean to be successfully applied farmers need to be acquainted with the principles of Lean. Farmers may be able to bring in the required skills through a new manager or consultants although this would also represent an extra cost for them.

Table 10: Five Principles of Lean in a Farming Context

Principle	On Farm Case Study Example	Tangible Effect on Case Study Farm
Value	• Change of selling technique through grain forward selling. • Selling heifers for breeding not beef.	Selling forward embeds value (hence the degree of value that can be added by the inputs). Breeding heifer selling increased sale price 25% per animal compared to beef (2012)
Value Stream	• Removal of duplication and shortening cycle times. • Accurate budgeting of land, labour, machinery and buildings. • Focus on ensuring complimentary effect of process steps, e.g. effect of seed rate on crop canopy therefore need for growth regulator.	More accurate grass budgeting and change of heifer market destination has released 30% of grassland to arable cropping with no reduction in cow numbers. Saving of 9 tonnes of concentrates through earlier bull finishing. Reduction in beef herd cycle time of 5000 hours.
Flow	• Aligning machinery capacities to reduce processing time. • Matching labour skill to a task to achieve 'right first time' and reduce rework, and therefore process time. (e.g. re-drilling a crop). • Shortening cycle times also reduces process times.	Saving in whole farm process time of over 200 hours per year, equivalent to 25- working days of 8 hours. Saving in process time has reduced overtime hours and facilitated improved timeliness of crop and herd processes to underpin optimum value generation.
Pull	• Keep in touch with supply demand forecasts for each value stream. Reports of the ultimate consumer market intelligence are e-mailed, e.g. Dunhumby Data, or Trade Journals. • Farmer has established key network contacts in product value stream. • In order change crop grown to meet a predicted shortage, or delay signing a contract to maximize grain price, or when to store or sell.	Avoided low prices e.g. for oat crop added 40% to the price per tonne, through taking notice of final customer supply and demand market intelligence and taking the decision not to sell and wait.
Perfection	• Reviewing and implementing of the previous four principles. • Maximise crop value generation effectiveness by pesticide and fertilizer inputs by using response curves in conjunction with spreading technique and weather / soil conditions to aid timeliness and choice of chemical applications. • Set effectiveness KPIs for produce quality attainment e.g. heifer temperament or grain protein and efficiency KPIs for target growth rates/feed intake or field work rates.	All crop harvested and planted in 2012 in adverse weather conditions through benefits of reduced processing time demands and maintaining target daily work rates. 100% of all bulling heifers last year on spec on time for early sale and sold from 50% 80% of bulls in U /R grade in at target slaughter age / weight from 60%.

Summary of the benefits of Lean and Value Stream Mapping to a working farm

1. Value Stream Mapping offers a step by step method for a farmer to review his/her business in its current functional reality, to identify value generation and waste.

2. Correctly implementing the first Four Principles of Lean to improve the overall farming system deployed in line with the most profitable market outlets can provide a step change in efficiency, farm output and the consistency of product quality.

3. Value Stream Mapping focuses on the generation and delivery of consumer value by all production factors this aids root cause analysis of poor product quality by guiding the farmer to identify links between farm process and product quality. Customer interviews explore the link between farm produce qualities to consumer value. This serves to align farm activity to consumer satisfaction across the supply chain.

4. All enterprise factors of production, physical, financial and human resource are encompassed in one map for ease of visual analysis. It offers a gross margin per labour hour, assists in the reviewing and budgeting of fixed resource allocation and helps identify bottlenecks to flow of farm operations, such as machinery capacities.

5. Shortening the Cycle and Process time of an enterprise reduces resource demand and cost and this has potential to improve profitability. This facilitates the releasing of resources for further enterprise intensification or alternative use. The resulting savings in labour time reduce the overtime hours and improve staff quality of work through less fatigue.

6. Once the farming system has been structured for optimum value through the first Four Principles of Lean. The Fifth Principle Perfection can be managed through the use of efficiency and effectiveness process techniques which help the farmer to optimise the conditions for maximum value generation of each farm process. In turn, using KPIs offer a pro-active daily management method to measure the delivery of consistent product quality and the utilisation of resources allocated to ensure targets are being met.

Value Stream Mapping also serves as a method to appraise the introduction and potential impact of a new system to a farm. E.g. A farmer may decide to trial minimum tillage equipment; the Value Stream Map will help calculate the extra fixed costs, savings in time and fuel, cost of extra herbicide, effectiveness of crop establishment and staff training incurred by switching from a plough based system. This demonstrates the all encompassing nature of Value Stream Mapping and therefore the value of Lean techniques in strategic farm planning as well as for farm business review.

Difficulties encountered in applying Lean to farming

A central problem with the implementation of Lean is in calculating the financial value that is being added by a process or input. For example, yield increase from fertiliser is influenced by other practices such as the use of fungicides which enhance yield. The method used–in this study - to understand the value adding nature of inputs was to engage with industry experts who looked at each input step by step and assisted in the allocation of appropriate VA, NVA or NNVA status.

However, maximising the value generation potential by each agronomic or feed input is addressed by following precise process management using KPIs to monitor process success for each enterprise, such as understanding the cost benefit response curves for inputs or measuring the cost per kg of daily live weight gain.

Therefore, it is the cumulative value generation of the whole system in terms of optimum market orientation, consumer satisfaction, resource allocation, and lastly utilisation through using KPIs that is important.

Staff training is critical to drive home the importance of careful working practice, which can ensure produce quality and minimise breakdowns. As described on the case study farm, the Farm Manager has worked with staff to perfect working practices by focusing on the relationship to enterprise performance with a 'right first time' discipline while introducing more refined process management.

Other farms, sustainable intensification and food waste

'Feeding 9 billion people by 2050 with less resources' (Beddington, 2009) is a topic of concern for the farming community and society in general. Although Lean is not the sole answer to this challenge, it can ensure a focus on efficient resource utilisation while protecting product quality. Improving consistency of product quality delivery by agriculture can also give considerable efficiency savings to the supply chain and ultimately the consumer, through greater grain or meat processing factory yield and less logistical waste: For example, less grain lorries being re-directed back to the farm or alternative buyers because grain is not up to specification at the factory or grain store. Farmers therefore need to focus more closely on knowing the quality of produce before it leaves the farm.

Combining the Lean efficiency and quality effectiveness gains as demonstrated on the case study farm in beef and cereals could be extended to good effect to other similar farms as a model to analyse and improve farm performance.

Furthermore as a postscript, the recent report (Global Food: Waste Not, Want Not) by the Institute of Mechanical Engineers (IME) states that

''It is Estimated that 30-50% (or 1.2-2 billion tonnes of all food produced on the planet is lost before reaching a human stomach'' (IME 2013)

Particularly waste at the value stream business interface level, (30% loss between food supply chain companies (Institute of Grocery Distribution (IGD) 2011) calls for efficient and effective utilisation of natural resources and focus on solutions to minimise whole chain food losses alongside better flow rate of produce in aligning supply and demand along the value stream.

If 2 billion tonnes of food could be utilised to feed people, this could help cap rises in food inflation.

Lean principles are certainly equipped in part to address this challenge, if implemented across supply

chain companies and consumers in a co-ordinated fashion.

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