Value stream mapping for sustainable change at a

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Abstract: This case study increases our understanding of Lean implementation in which value stream mapping (VSM) is used to create an action plan at a small dairy and cattle farm in southwest Sweden. The researchers, the farmer-owner, and farm employees followed a step-by-step approach that resulted in ideas for operational improvements for the dairy activity. Data were collected in interviews with the farmer/owner, researcher participation in workshops, and researcher observations. The results reveal that VSM is an effective way to create a culture of collaboration among the farm staff and to better define their roles and responsibilities as well as improve routines, communications, and task completion. In the two-to-three year period following the VSM project, specific improvements were observed in milk production/quality and animal health. The results also reveal that while Lean principles are relevant given the repetitive nature of agriculture routines and tasks, the VSM element of lead-time reduction is less relevant owing to the unique value adding biological processes in the agriculture sector.

Keywords: lean; value stream mapping; agricultural production; productivity; farmers.

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1 Introduction

Two key global trends in agriculture today are the decrease in the number of farms and the increase in the size of farms. These trends are, in many cases, the result of fierce global competition that demands ever-increasing efficiency and productivity (Tell et al., 2016). The importance of technology challenges and production development have been proven to be an important aspect to consider, especially within agriculture. Cochrane (1958) suggest that farms need to increase production primarily through technological development, in order for the farmer to increase income, e.g., technological treadmills. However, when the farm invest in technology development, debt increase and also industry production increases subdue prices, which develops in to a continuous development pressure to increase production, e.g., treadmill analogy (Schewe and Stuart, 2017). We may ask whether these trends are consistent with sustainable innovation in agriculture. A literature review of sustainable business model innovation in the agri-food sector concludes that few published studies take a sustainable perspective (Barth et al., 2017). Although the focus on sustainability in this sector is still at an early stage, some evidence nevertheless suggests that sustainable innovation in agriculture can produce a competitive advantage.

An analysis of sustainable innovation in other sectors can be useful in examining how agriculture can implement sustainability tools and methods. One well-known method is Lean manufacturing or Lean production, or more simply, 'Lean'. The story of Lean production at Toyota (Womack et al., 1990), introduced revolutionary manufacturing principles to many Western industries. Initially, manufacturers adopted the Lean principles, but soon other sectors began to apply these principles as knowledge about Lean spread. In the 1990s, for example, 'Lean healthcare', 'Lean management', and 'Lean design' appeared (Björkman and Lundqvist, 2013). However, the use of Lean in agriculture has been limited, and no research is available on Lean implementation at the single farm-level.

It should also be mentioned that a number of other concepts have been used and studied within the agricultural setting. A comprehensive literature review by Urruty et al. (2016) highlights several differences and complementarities between the concepts stability, robustness, vulnerability and resilience. These concepts implies a shift from maximising outputs in a turbulent environment, to maintaining desired levels of outputs in a context of unpredictable disturbances (Urruty et al., 2016). Compared to these concepts, Lean focus on the customers view and include both tools and a philosophy to reduce waste in all activities. Basically, Lean focuses on increasing customer value by eliminating the non-value added activities or 'waste' that the customer views as unimportant. The major benefits of Lean for small and medium-sized organisations are increased productivity and efficiency, improved customer satisfaction, and reductions in production costs (Zhou, 2016). The five fundamental Lean principles, as identified by Womack and Jones (1996) are the following:

1 correct specification and enhancement of customer value

2 identification of the value stream and removal of wasteful activities

3 production flow without interruptions

4 a pull value system, e.g. work that starts only when there is an order, for reducing the waste of any production process

5 pursuit of perfection.

The agricultural sector has recently begun to recognise the possibilities of Lean principles in the manufacturing sector (Labajova et al., 2016). However, it is not clear how Lean is used in the agricultural sector. A number of Swedish farmers have begun to use Lean principles and methods to become more efficient (Melin and Barth, 2018). Based on a Lean Thinking framework, Melin and Barth (2018) address Lean implementation from a strategic and operational perspective. Conclusions drawn indicate that basic knowledge and tools can be implemented, but challenges exist when it comes to more strategic aspects such as continues changes and development, commitment of management, training of managers and employees (Melin and Barth, 2018).

A commonly used Lean technique is value stream mapping (VSM). This technique, which takes a broader view of total value flow with less focus on the individual sub-processes, can be used to identify wasteful activities, reduce the length of process cycles, and make process improvements. VSM can also be used to identify the causes of waste and to illustrate the relationship between materials and information flow (Rother and Shook, 1998). Thus, VSM has three basic steps:

1 the generation of a current state map

2 the generation of a future state map

3 the development of an action plan.

VSM was first developed as a technique that manufacturers could use (Hines et al., 1998), but it has also been used in agri-food chains (Taylor, 2005). However, VSM has not yet been applied specifically in agricultural production on farms where the value streams are unique. A concern in the use of VSM on farms is that, if implemented incorrectly, it can lead to frustration and even inhibit the implementation of improvements (Dal Forno et al., 2014). It is therefore important to examine how VSM can be adapted to on-farm value streams and to analyse its advantages and disadvantages.

The agriculture sector has unique characteristics that may present problems when VSM is applied. Added value in agriculture is created when the sun's energy is captured and then transformed by biological processes into high-quality food products. In these biological processes, value increases continuously as animals grow in size and weight and as crops mature and ripen. Various operations that support the biological processes increase the value flow while operations with bad timing and bad performance decrease the value created in biological processes, which in the end will have a negative effect on product output and quality. Moreover, agriculture is associated with long production lead times. For example, in Sweden, the period from planting to harvesting is typically 20 weeks. The period from insemination of beef cattle to slaughter is typically 21 months. Given these conditions, where the link between supply and demand is also uncertain, the use of VSM poses particular challenges, similar to the challenges posed by the introduction of pull production systems such as the inventory-control system known as Kanban.

In addressing the gap in the research on VSM at the single farm-level, the purpose of this research is to examine how VSM, as developed in manufacturing sectors, can be implemented in the production chain at small farm in southwest Sweden that produces beef and milk.

Next we describe our research methodology followed by our presentation and discussion of our results. Thereafter, we present the conclusions of our research.

2 Methodology

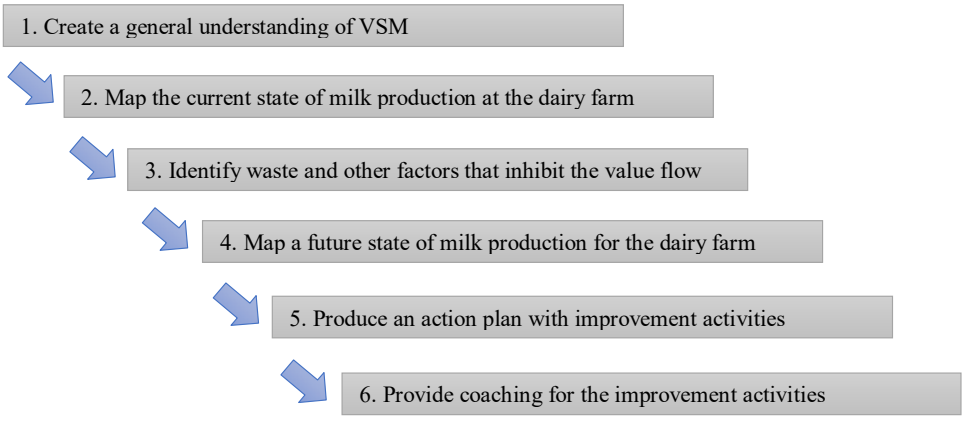
The VSM technique used in this research builds on the visual mapping approach (Rother and Shook, 1998). In addition, elements of Value Stream Management are applied in order to help the dairy farm achieve sustainable organisational development (Hines et al., 1998). Value stream management, which is a strategic and operational approach for use with Lean, is based on the VSM technique although it also takes an education and policy perspective.

The dairy activity (hereafter, the 'dairy farm') has 230 milk cows. The dairy farm had experienced production problems in recent years. The quality of the milk was inadequate, the milk yield had stagnated, and the calves had various health problems. In addition, as there was an over-production of milk globally, price competition for milk was severe.

The methodological approach have been action oriented research, which in this case address problem solving based on recurring cycles of action and reflection. Action research "should support a normative change in one way or another" [Nielsen and Svensson, (2006), p.5]. The project was initiated by the Rural Economy and Agricultural Society in Halland and our specific goal was to help the dairy farm become a more profitable and sustainable operation through the use of VSM.

We collected our data in interviews with the farmer/owner, by participation in several workshops, and by observations at the dairy farm, e.g., personnel meetings. The VFA was performed in 2012 by three workshops on the farm where the farmer and the employees participated. In the following year we visited the farm 10 times to provide coaching and support, and the implementation of Lean was followed up by two telephone interviews in 2015 and 2017. Our focus in reporting on this research is the on-farm value chain for milk production. We developed a step-by-step approach using VSM with the intent of making operational improvements to the dairy farm's standard routines. See Figure 1.

Figure 1 The VSM steps for the diary farm (see online version for colours)



3 Results and discussion

At the initial workshop we presented information on change management, the objectives of our project, and a general description of Lean principles. These results were communicated in written form to the farmer/owner and the employees. Our intention in this step was to inform the farmer/owner and the employees that change recommendations would be forthcoming so they might be more willing to accept them. In the subsequent workshops the farmer/owner and the employees produced a company vision, a statement of long-term goals, and a listing of Lean principles.

Next, organised by the six VSM steps listed in Section 2, the results will be described and discussed at the dairy farm.

3.1 Create a general understanding of VSM

To achieve effective VSM in an organisation, people at various organisational levels, from senior managers to operations people, should be involved (Hines et al., 1998). An advantage of the micro-sized agricultural firm, such as the dairy farm of this research, is that it is relatively easy to gather all staff members in a meeting and engage them in the meeting's agenda. Moreover, in the workshops it is possible to explicitly link the VSM steps to the organisation's strategy and goals such that VSM is not conducted in isolation from the general organisational environment (Hines et al., 1998). In the group of staff were a foreman with an overall responsibility for the barn work, one person working with cows and calves, two persons working with crop production, mixing the mixed feed and maintenance of machinery and equipment, and two persons milking the cows in shift.

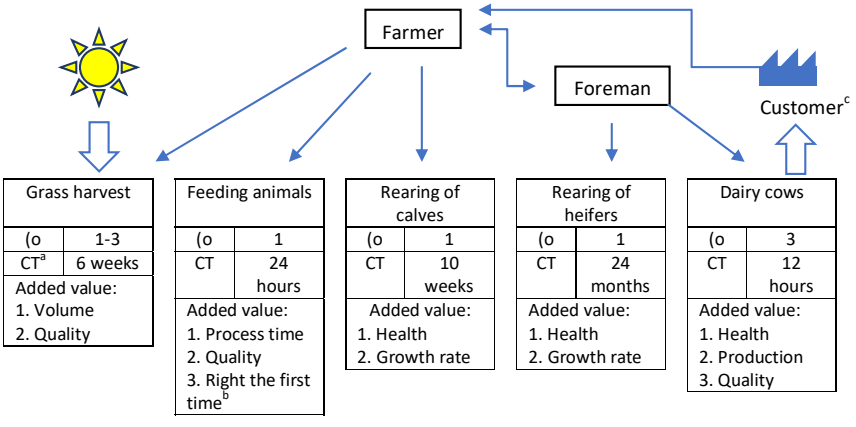
3.2 Map the current state of milk production at the dairy farm

The farmer/owner and some of his employees attended a workshop with a few representatives from other farms. At this workshop, they were shown how to map value flow in their main production processes. Because the goal of VSM is to improve the total value flow, it is necessary to understand the current state of an organisation's processes before improvement recommendations can be made for production systems (Rother and Shook, 1998). Although the dairy farm of this research is quite small relative to many manufacturers who have benefited from VSM, nevertheless the complexity of its operations is such that the employees may not have had a clear picture of its total structure. For this reason, a current state map of the farm's milk production was required.

For this mapping, the value adding processes and the non-value adding processes at the dairy farm were identified (Nielsen and Svensson, 2006). Additionally, the information flow needed to coordinate the various activities and to track consumer demand was documented. Interviews with the farmer/owner and his employees provided detailed information about these processes, which were then summarised and evaluated for their effect on the entire value chain. This information, which included details on process staffing, cycle times, production performance, and quality indicators, was used to map the current state of the on-farm value flow (i.e., the milk production). In VSM terms,

this step may be described as the 'learning to see' method (Rother and Shook, 1998). Figure 2 illustrates a simplified version of the current state map of the on-farm milk production process.

Figure 2 The current state map of the milk production process at the dairy farm (see online version for colours)



Notes: [a]CT = Cycle time, i.e., the time elapsed from start to end of the process.
[b]Avoid extra work from having to do the same thing twice.
[c]The customer is a processing industry in this case.

3.3 Identify waste and other factors that inhibit the value flow

The inclusion of the employees, with their various roles and responsibilities, in the mapping activity facilitated the identification of the waste and other factors that created problems in the value flow. A number of organisational and managerial problems were identified. The main problems were the following:

1 the existence of non-value adding activities at the operations level

2 the lack of a system for collection of employees' ideas for improvements

3 health problems among the dairy cows, decreasing milk production

4 the lack of standardised routines for important work tasks; this deficiency reduced product quality and contributed to the inconsistency/instability in the performance of such tasks

5 insufficient delegation of tasks by the farmer/owner to his employees

6 job descriptions and responsibilities not sufficiently defined and communicated

7 key performance indicators not monitored with the result that production problems are not identified.

Table 1 Key performance indicators monitored for the farm at the time of the value stream mapping (VSM) and three years later

Key performance indicator	*At the time of the VSM*	*Three years after the VSM*
Milk yield (kg energy corrected milk per cow/year)	9,600	11,000
Age a fist calving (months)	26	24
Milk quality (somatic cell count, cells/ml of milk)	275,000	150,000
Calf mortality (%)	6	2
Mil fat (%)	4.4	3.9
Milk Protein (%)	3.4	3.3
Calf growth rate (kg body weight at weaning)	70	90

3.4 Map a future state of milk production at the dairy farm

Based on the previous steps, the researchers, the farmer/owner, and the employees prepared a future state map for the dairy farm in the workshops. The point of departure in this process was a workshop where a long-term vision was created for the farm and where the company values were discussed by the members of the staff. In the next step a process map for the milk production was co-created and the wastes were identified. In a workshop with the farmer and the whole team of staff, a number of goals and improvement activities were produced that would take the company from the current state towards the vision. The researchers' roles were to present an unbiased, external perspective on the milk production activities and to show the employees how to picture the operational structure, and its problems, and to help set goals. The future state map listed the following long-term goals:

1 increased milk production

2 new health routines for the cows

3 new routines for calf-rearing

4 improved communication among all employees

5 initiation of a continuous improvement work system.

3.5 Produce an action plan with improvement activities

Based on the long-term goals an action plan with improvement activities was produced. The action plan used the Lean principles presented at the initial workshop. A PICK chart (possible, implement, challenge, kill) was used a systemic tool to identify improvement activities (Bicheno, 2004). Next we list and describe the action plan's eight improvement activities for the dairy farm.

1 Standardised routines for important work tasks in the production processes were documented and visualised. These standard operational procedures were translated into several languages, printed, water proofed, and posted near the various workplace sites.

> With the standard operation procedures, all employees know how to feed the calves and how to handle a new-born calf properly. These procedures have improved the calves' health. We used to have an unacceptable calf mortality rate, but nowadays it is very low. (Farmer/Owner)

2 The farmer made an investment in a new equipment for feeding calves with raw milk. The old equipment led to mistakes and made the feeding routine very time-consuming.

3 Employees were educated on Ohno's[1] seven areas of waste in mass production: transport, inventory, movement, waiting and delays, over-processing, over-production, and defects. The employees were also educated on two additional types of waste: waste of energy and waste of human potential (Hines et al., 1998). In addition, the waste caused by poor work environments and workplace accidents was addressed. An external coach led employees on waste walks at the dairy farm.

4 The Japanese organisation method, 5S, was introduced as a way to organise the barn tools and equipment and the workshop machinery. Translated into English, the five elements of the 5S method are sort, set in order, shine/sweeping, standardise, and sustain. These elements describe how to efficiently and effectively organise the workplace. The 5S method was also used to address health/accident risks and water/electricity waste.

5 Key performance indicators were identified and listed on a whiteboard. This display helped employees become aware of the dairy farm's operational goals.

6 A simple system for monitoring daily routines was introduced. Sheets of paper (enclosed in plastic), one sheet for each day of the week, were posted in the barn. The sheets are red on one side and green on the other side. The employees check off completion of their daily tasks on the red side. When all tasks are completed, the sheet is turned to its green side. This is the signal that the daily work goals have been achieved.

> If you don't have a system in which the routines are visualised and followed up on, there is an obvious risk that the routine work will fail. (Farmer/Owner)

7 To prevent mistakes, visualisations of different kinds were used. For example, information signs related to feeding the animals were placed in the bunker silos and beside the feeding trough in the barn.

8 Systematic improvement work routines following the PDCA model (plan, do, check, act) were introduced. Employees were encouraged to write improvement suggestions on a whiteboard located centrally in the barn. These suggestions were discussed at weekly meetings.

3.6 Provide coaching for the improvement activities

Sustainable change requires that people in an organisation are open to improvement suggestions. The farmer/owner and the employees jointly created the current state map, identified wasteful activities, and developed the action plan (goals, sub-tasks, and routines) for improvement. The employees were coached on the Lean principles and the VSM technique at an introductory presentation and during the project. Because implementation of the action plan requires the full commitment of the farmer/owner, he

received leadership coaching at a two-day seminar that the researchers organised. Furthermore, a Lean coach, who visited the farm regularly for a year during the Lean start-up phase, continued to provide support.

In brief, the VSM project at the dairy farm accomplished the following three specific results:

1 Three years after the VSM project, milk production had increased by 15%, mainly because of the improved work routines (see Table 1).

2 Three years after the VSM project, the health of the cows had improved significantly. Measured by milk somatic cell count, the cells per millilitre of milk[2] had decreased from an average of 275,000 to an average of 150,000 (Table 1).

3 Three years after the VSM project, the body weight of calves at 8 weeks of age (at weaning) had increased by 28%. The increase of growth rate was followed by an improved health, and the rate of calf mortality had decreased from 6 to 2% (table 1).

4 Conclusions

VSM is an effective way of initiating a culture of collaboration among members of an organisation. When people in an organisation receive information on the organisation's problems and guidance on its goals, they are better able to understand how, in their individual roles and responsibilities, they can help solve these problems, focus on these goals, and offer improvement suggestions. Using VSM, they can develop an action plan that gives them the opportunity to participate in implementing improvement activities in the workplace.

Because animal husbandry and crop production follow more or less fixed cycles, one adaptation to the VSM technique was required. These agricultural activities have biological processes in which value is added continuously as animals grow and crops mature. Therefore, minimisation of lead times between the beginning of a process and its completion was a poor performance indicator at the dairy farm. During these biological processes at the dairy farm, various managerial activities are performed that require just-in-time intervention. Just-in-time activities support the biological processes and increase the value flow. For this reason, indicators related to production efficiency and product quality (e.g., calf growth rate or animal health) are better measures of added value than reductions in lead times.

Previous research has highlighted the problems in the use of VSM when the organisation has the continuous added value flows and long process wait times (Dal Forno et al., 2014) that are characteristic of on-farm production. Research suggests that the focus in animal husbandry should be on the value adding activities (e.g., nourishment routines and veterinary visits) that promote animal growth and health.

Our dairy farm project confirms this difficulty in defining value adding and non-value adding activities when using the VSM technique in the agricultural sector. Because of this difficulty, we claim the focus should be on the biological processes – the flow of energy from the sun to the growth of grass and grains to the transformation into milk and meat. The farmer's production flow is very different from the manufacturer's assembly line for trucks or the refiner's conversion of crude oil into petrol. However, using the VSM technique, it is possible to identify the critical points in agricultural production

processes where systemic improvements can be made. Using efficiency and quality indicators, added value can be measured at these points.

Our dairy project shows that several Lean principles apply to the farm environment. For example, because of the highly repetitive nature of farm tasks, especially when only two products are produced (in our case, milk and meat), standardisation of work routines is quite possible as well as practical. The pull production system and Kanban are less applicable in the agricultural sector. In this study we have shown that the VSM is a useful tool for developing the work organisation at a dairy farm. The paper can serve as a practical guideline for farmers and consultants who wish to introduce lean in a farm business. Although the study is based on only one case, we have shown what results might be expected after three years of Lean work.

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Notes

1 Taiichi Ohno is credited as the father of the Toyota production system (TPS) in which waste is categorised according to unproductive manufacturing practices.

2 The number of somatic cells increases as a response to pathogenic bacteria, leading to poorer milk quality and even mastitis in a cow's udder. A decrease in the somatic cell count is an indication of improvements in animal health.