Northern Periphery and Arctic Programme

Northern Cereals – New Markets for a Changing Environment

# Þorvaldseyri sustainability model

## Collection and compilation of data. Framework of LCA

Deliverable T2.3.1


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**February 2016**

Northern Periphery and Arctic Programme
Northern Cereals – New Markets for a Changing Environment
NPA CAV Diary Number 304-8673-2014

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# Contents

1. Introduction ........ 4
2. Methodology ........ 5
2.1. Goal and Scope ........ 6
2.1.1. Þorvaldseyri sustainability model ........ 7
2.2. Functional unit and allocations ........ 7
2.3. Impact categories ........ 7
2.4. Data and farm processes ........ 8
3. References ........ 12

# 1. Introduction

Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs. Despite unprecedented advances in sciences, serious terrestrial issues regarding food production show that conventional agriculture struggles to produce and preserve ecosystems at the same time. Sustainable agriculture is an alternative for solving fundamental and applied issues related to food production in an ecological way. It integrates biological, chemical, physical, ecological, economic and social sciences in a comprehensive way to develop new farming practices that are safe and do not degrade our environment (Lichtfouse et al., 2009).

Worldwide concern about the environmental burdens and resource use efficiency of food production has been increasing, and there is special focus on the environmental impacts from animal husbandry based on ruminants and other plant derived agriculture (Roer et al., 2013). In order to quantify the resource use and emissions of this sector and to highlight goal conflicts when improvements are sought, a holistic analytical approach should be undertaken. Life Cycle Assessment (LCA) is the prevailing framework for environmental assessment of products and production systems that is widely used for this purpose.

These concerns continue to make their mark resulting in new legislation and large research programs. However, despite a huge amount of published material and many available techniques, doubts over the success of national and European initiatives remain. Uptake of the more cost- effective and environmentally-friendly farming methods (such as dietary control, building design and good manure management) is already widespread but unlikely to be enough in itself to ensure that current environmental targets are fully met (Loyon et al., 2015). Industrial crops are in many cases produced on huge monocrop farms, which rely extensively on chemical pesticides, synthetic fertilizers and genetically modified crop varieties.

In this project, sustainability is of importance, involving other aspects than environmental impacts. Sustainable agriculture is the act of farming based on an understanding of ecosystem services, the study of relationships between organisms and their environment. In the FAO report *What is Sustainable Agriculture? i*t has been defined as *an integrated system of plant and animal production practices having a site-specific application that will last over the long term*, for example: Satisfy human food and fiber needs, enhance environmental quality and the natural resource base upon which the agricultural economy depends, make the most efficient use of non-renewable resources and on-farm resources and integrate, where appropriate, natural biological cycles and controls, sustain the economic viability of farm operations, enhance the quality of life for farmers and society as a whole (Gold, 2009).

Task 4.3 in this work package focuses on the cereal and dairy farm Þorvaldseyri, located at the south coast of Iceland. Conditions at Þorvaldseyri are special and have already been placed far towards sustainability. Therefore, it is possible to create a sustainability model based on the situation at Þorvaldseyri, a model that can become a blueprint for others both domestically in Iceland and in other Nordic countries where conditions might be similar.

## 2. Methodology

One aspect of achieving sustainability is to measure and compare the environmental impacts of production and supply of goods and services in order to minimize impacts. The life of every product starts with the design/product development, and from that point adoption of resources and raw materials, production, use and end of life activities. Life cycle assessment (LCA) is a methodology used to estimate and evaluate the environmental impacts of a product's life cycle. Traditional life cycle assessment is measured from cradle to grave. That means that the life cycle is registered from the extraction of raw materials to the use and disposal of the product. From cradle to gate means that the life cycle is registered from the extraction of raw materials to a so called gate or farm-gate, which is usually some sort of product process, before it is sent for use.

Life cycle assessment is based on four steps, as standardized by the ISO standard 14040 series (ISO 14040:2006(E)) and presented in figure 1. In addition to these steps it is necessary to determine the functional unit. Definition of the functional unit is the foundation of life cycle assessment because the functional unit sets the standard in order to compare two or more products and for improvement analysis. All data collected during the project will be put in context with the functional unit. When comparing different products that fulfill the same function, the definition of the functional unit is very important. One primary purpose of the functional unit is to provide a reference to which input- and output data can comply with.

System boundaries define process/activity (e.g. manufacturing, transport and waste), and the input and output materials that shall be included in the analysis. Definition of system boundaries vary between research projects as they define what is included in the assessment. As the choice if system boundaries can certainly affect the results, it is important to encourage a transparent working process, and report every assumption made.

This task will focus on material and energy flow of the farm of Þorvaldseyri, using a cradle-to-gate perspective of the farms operations and processes.

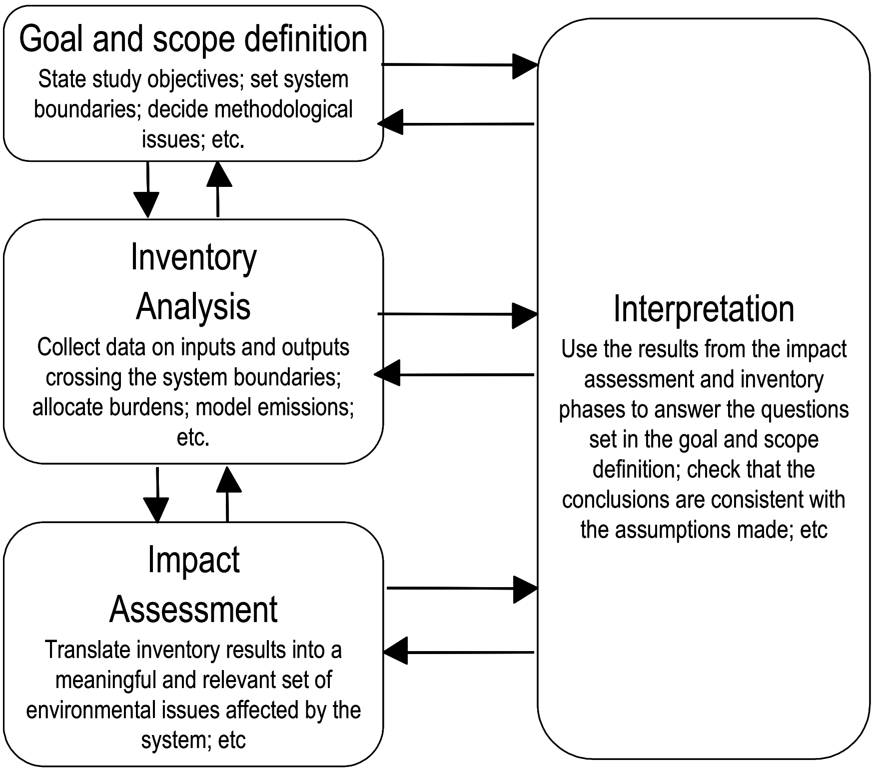



*Figure 1. The 4 steps in conducting Life Cycle Assessment as standardized in ISO 14040 and 14044 (ISO 14040:2006(E)).*

## 2.1.Goal and Scope

The LCA methodology will be used to identify environmental impacts and material and energy use of the farm Þorvaldseyri. The results will be used to refine guidelines and demonstrate how local sustainability can be improved and how knowledge can be transfered. The aim of this activity is to identify the main environmental impacts, energy and material use and flow within the systems of milk and cereal production at Þrovaldseyri, compare the results to the same system with imported raw materials for feed and external energy, and identify potentials for improvements.

Þorvaldseyri has sometimes been called a sustainability model for its utilization of products and co-products from the farm's milk and cereal production. It produces its own feed for livestock, made from cereal and various co-products, fuel from rapeseed oil, electricity from the local river and even a large portion of food for the residence. It is therefore an interesting case for LCA, to demonstrate the benefits of local production and utilization. It should be noted that this task will not undertake a full scale LCA, rather a sustainability assessment besed on the LCA methodology.

Minimizing resource use, carbon footprint and environmental impacts in general, associated with the provision of agricultural products can make a potentially important contribution to climate change control and resource efficiency. Favouring low impact methods and transportation can lead to reduction in greenhouse gas emissions and increase the sustainability of production.

#### 2.1.1. Þorvaldseyri sustainability model

Conditions at Þorvaldseyri are very specific where a lot of resources and energy are produced on the farm. The farm should be able to become self-sufficient in energy with a small power plant located nearby and hot water which is pumped up from a borehole. The energy can be used for drying grain, dairy production, which is the farm's core activity, and house heating. The feed is almost entirely produced on the farm: hay, grain and rapeseed-products. Rapeseed can provide both biodiesel, used on tractors and other vehicles, and cooking oil. All manure from the farm is used on cultivated land, thus reducing the need for synthetic fertilizer.

The intention is to define the conditions and processes at cereal- and dairy farm Þorvaldseyri located at the south coast of Iceland. Conditions at Þorvaldseyri are special and have already been placed far towards sustainability. Therefore, it is possible to create a sustainability model based on the situation at Þorvaldseyri, a model that can become a blueprint for others both domestically in Iceland and in other Nordic countries.

### 2.2.Functional unit and allocations

This activity will follow the ISO 14040:2006 and 14044:2066 standards on LCA, although it will not be a full scale LCA. The functional unit will be 1 kg of product and the system boundaries cradle to grave, explained in chapter 2.4.

Mass allocation will be used to partition the environmental impacts in all systems yielding co-product ingredients, i.e. allocating co-products based on their mass. Other allocation methods will be considered such as economic- and/or energy and nutritional value for comparison. The use of mass allocation provides stability and encourages the food industry to make use of by-products because high environmental burden is allocated to them. Economic allocation for example, is affected by high variability in prices, making this method reasonably unstable over time.

### 2.3.Impact categories

The impact categories chosen for this study reflect the most common and important categories used in aquaculture LCA studies. In a study by de Vries and de Boer (2010), they compared assessments of the environmental impact of livestock products. Twenty-five peer-reviewed studies were found that assessed the impact of production of pork, chicken, beef, milk, and eggs using life cycle assessment. In the studies reviewed, climate change, acidification, eutrophication and land use were the most commonly used impacat categories.

The environmental impact categories quantified in this analysis will be global warming potential (GWP), acidification potential (ACD), eutrophication potential (EUT), and energy use (CED). By including multiple impact categories, the results provide a broader understanding of the environmental impacts and helps identifying trade-offs between impacts.

## 2.4.Data and farm processes

The life cycle inventory analysis is the fundamental basis of every LCA study. It involves the collection and compilation of all the data required to quantify the relevant input and output data associated with the functional unit. This data is used to create a model that contains all inputs and outputs of the product and their amount.

The farm system was divided into three main phases: soil production (crop production), processing and animal farming. The system boundaries for this study were chosen to be in line with similar studies in this field. This is important to be able to compare the outcome of this study to other studies with similar functional units. All processes are produced within the system boundaries, hence the *sustainability model,* such as electricity and fuel. All the farm processes within the system boundaries are described in the diagrams below. When all data is gathered and put together, those diagrams will include input and output data.

**Processes – Þorvaldseyri farm**

The processes at the farm are described in the diagram below. The diagram is not complete and will evolve as the project progresses and while the farm's processes are studied in more detail.

As seen on the diagrams, there are two inputs from technosphere. That means products or services not produced within the farms system. Even though fertilizer use mainly comes from manure and other farm co-products, some additional industrial fertilizer is needed.

The household itself manages to be almost completely sustainable using the farms products and energy, according to the farm's residents. In addition, vegetables are grown in the garden for food.

The farm's energy input comes mainly from an on-farm power plant used exclusively for Þorvaldseyri. Boreholes for cold and hot water are also located on the farm's land, which provides heating for houses and facilities as well as cold water for consumption. Biodiesel is produced from rapeseed and used on the farm's machinery, as well as cooking oil for the household.

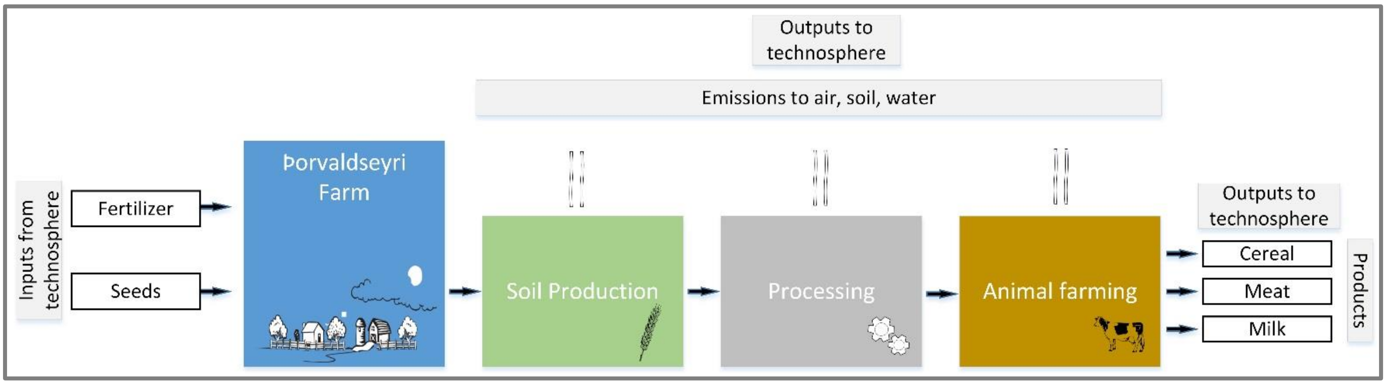



*Figure 2. Diagram of Þorvaldseyri, showing an overview of main processes within the studied system.*

**Soil Production**

Soil production is the overall name for processes on the farm that include crop or field growing. This is where the grass, cereal and rapeseed are grown. Water is derived from the local river and energy on the machinery from the rapeseed production, biodiesel.

Common grass/hay field growing. Livestock are fed hay and graze when walking free.

The cereal production at Þorvaldseyri is the farm's second most important production. It generates three products; whole cereal and meal as end products and feed input for cattle/milk production.

The rapeseed production generates four products; rapeseed is sold as an end product, rape meal is used as feed input, biodiesel and cooking oil is used on the farm's machinery and for household cooking.

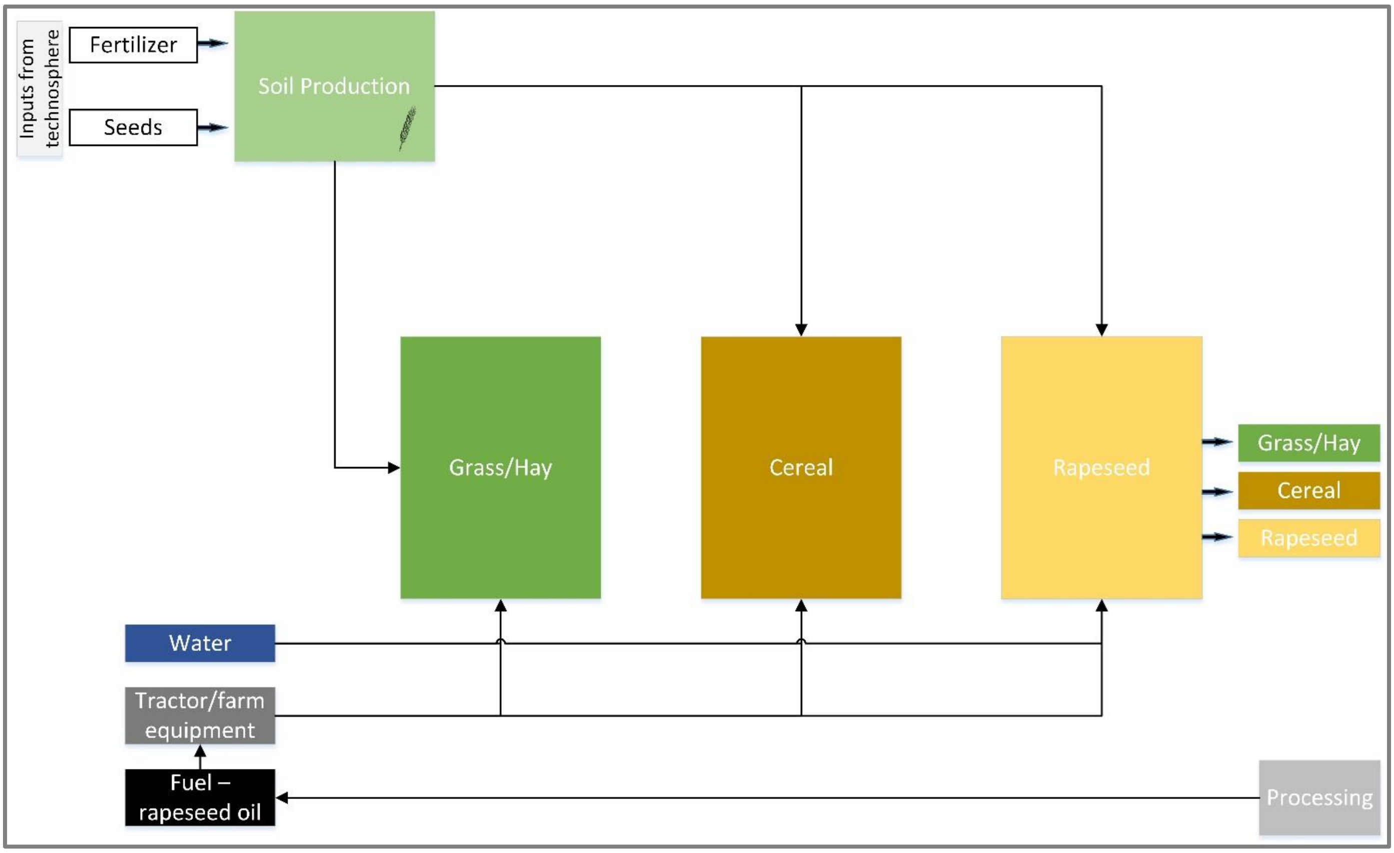
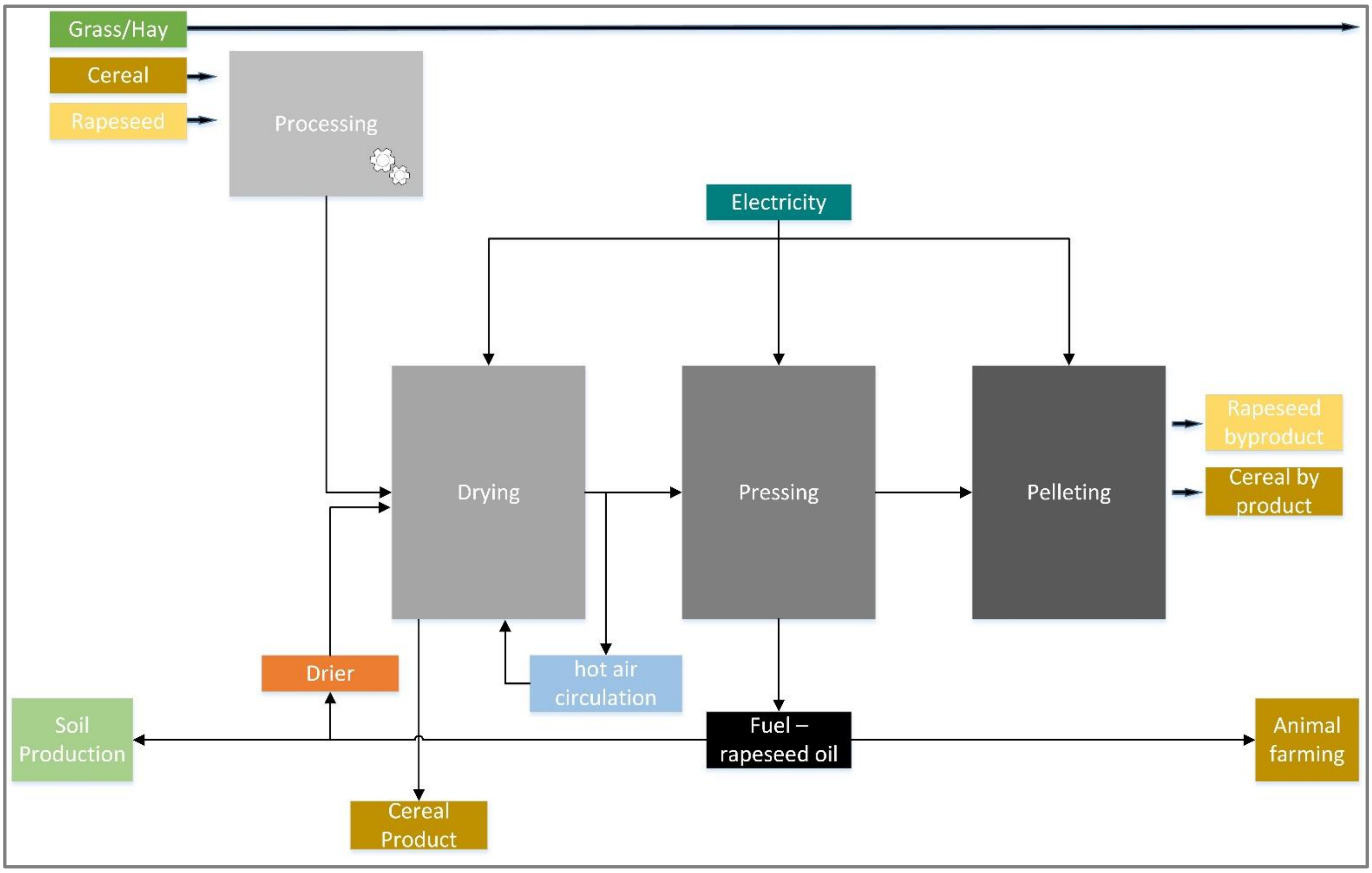



*Figure 3. Main processes within the soil production process.*

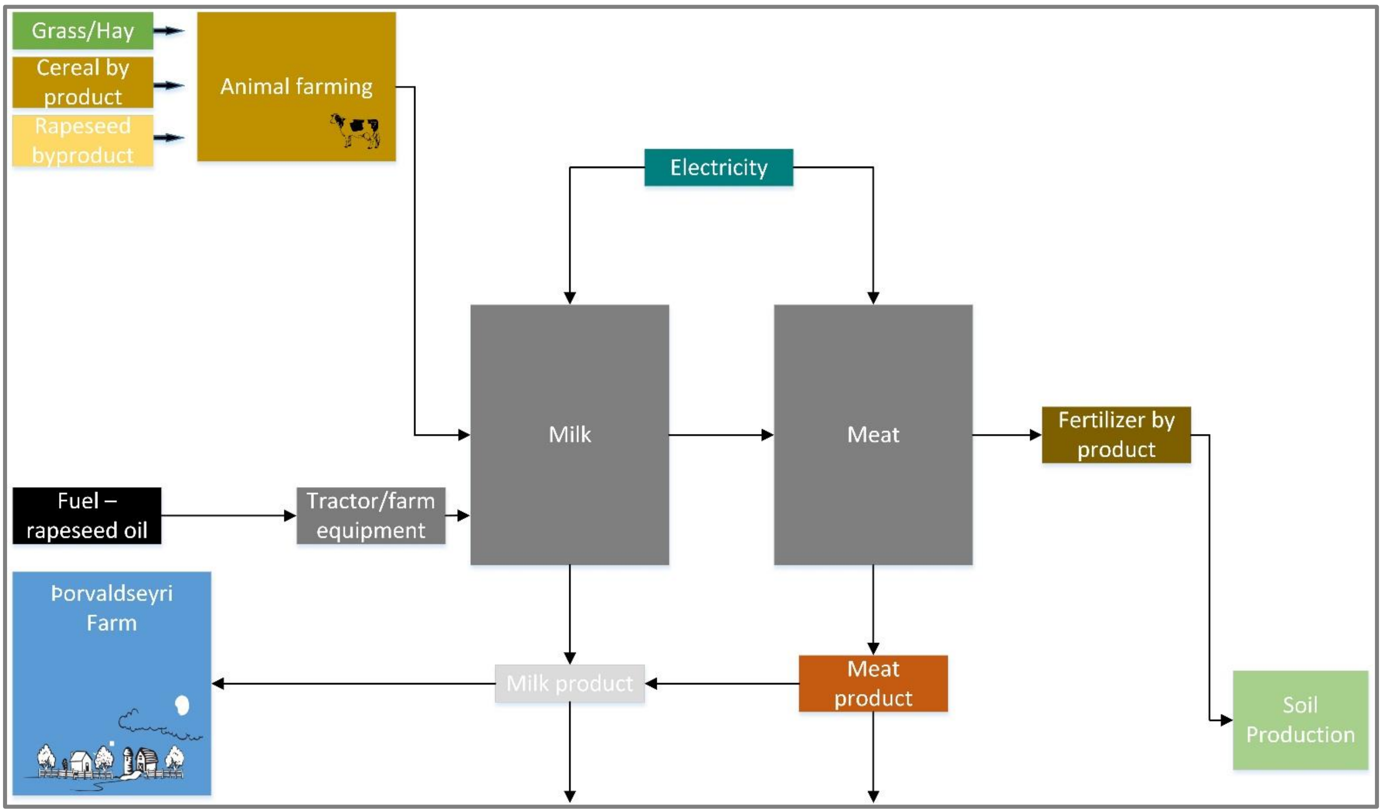
### Processing

The processing phase involves producing end products and co-products, feed material for animals, oil for cooking and machinery. Þorvaldseyri is equipped with a large corn and cereal drier. The facility derives its power from biodiesel and the on farm power plant for electricity. The biodiesel and cooking oil is made from pressed rapeseed. The pressing process derives its power from the farms power plant for electricity. Rapeseed meal is a co-product used for animal feed material. By-products and feed material is pelleted and made into animal feed. The equipment only uses electricity as power from the farms power plant.




**Animal farming**

Animal farming consists of producing milk and mear from cows. The feed material for the livestock is produced on the farm. Milk is the farms main production commodity but is also used for the household as well as meat. The production facility uses the on farm electricity generator and hot water for heating. Manure is used as fertilizer on fields and crops.



**Improved sustainability**

While Þorvaldseyri can be called a model farm on sustainability there are always improvements to be done. The farm itself can in theory be 100% self-sufficient for energy, raw materials, water and food, while still selling end products to support the farm financially. In this stage of this task, energy use, raw material use and general farm processes will be analysed to greater extent in the LCA model, with the goal of increasing sustainability at the farm. However, the Þorvaldseyri model can be used as a blueprint for other farms with similar conditions. When the LCA model is complete, it can provide a look into improved processes and guideline for farms willing to increase their overall sustainability.

# 3. References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