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Roxy Bergsma, Lianne van Eerden, Eline de Kool, Eveline Massop,

Tara Roberts, Gijs Smits van Oyen & Kaylee Springer

Academic Consultancy Training, Team 2537

Rita Hoving (Wageningen Livestock Research) & Jack Windig (Wageningen University and Wageningen Livestock Research)

Science Shop WUR

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Abstract

Nowadays, the model of high input-high output is the basis of the food production in the Netherlands. Intensive farming characterises this type of model, and highly productive breeds such as the Holstein Friesian have been developed to cope with these systems. These developments resulted largely in the replacement of the original breeds that are less adapted to high-output farming. The six Dutch rare cattle breeds include the MRIJ, Dutch Belted, Dutch Friesian, Groningen White Headed, Deep Red, Red-and-White Friesian and one color variety (Witrik). The Dutch Rare Breed Society (SZH) looks for ways to more broadly apply the use of rare breeds in agriculture and is interested in the effect of these breeds on local ecology.

The main research question in this project is: *What can rare cattle breeds contribute to agroecological farming?* Through a variety of interviews with experts and farmers of rare cattle breeds, the project aimed to identify the impacts of Dutch rare cattle breeds on agricultural ecology and economics, and find ways in which these breeds can be used in agroecological farming systems. Following a quantitative and qualitative data analysis, the farmers showed quite some variation. However, the most important breed characteristics such as health, fertility, robustness, and low input requirements stood out. The combination of these characteristics make Dutch rare cattle breeds highly suited to agroecological farming systems. Knowledge gaps are identified and need to be investigated in the future, such as high input and low input cattle comparisons, a complete analysis of rare breed farms, and how market products from agroecological systems can be expanded.

Key words: Agroecology, Dutch rare cattle breeds, biodiversity, nature-inclusive, genetic diversity

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1. Introduction

In this chapter you can find information on the use of cattle in Dutch agriculture. A lot has changed over the past century as agriculture changed from extensive farming systems with local breeds, to intensive farming systems with high performance breeds. However, future farming systems that focus on agroecology and biodiversity might not be suitable for high performance breeds. In this chapter you can read about the six Dutch breeds and one colour variety that may be able to play a part in the transition to future farming systems. At the end of this introduction, you can find the research questions and the reading guide for this report.

1.1. Agriculture in the Netherlands

The Netherlands were known for their superior dairy cattle throughout the 19th century. Dutch dairy farmers were especially known for making excellent quality butter from the milk they produced. The best milking cows in the late 19th century already produced approximately 4000 litres of milk a year. Dairy farmers were considered wealthy and upstanding citizens (Strikwerda, 1979). However, war and economic recessions took their toll on Dutch dairy farming in the first half of the 20th century. The aftermath of WWII saw a severe decline of the Dutch cattle population. The Dutch government wanted to increase farm productivity and efficiency to prevent future food shortages. This resulted in an ongoing intensification and scale enlargement, combined with large scale mechanisation (Meerburg et al., 2009; Brouwer et al., 2016; Strikwerda, 1979).

Since the 1980's, the negative consequences of intensive farming practices have encouraged calls for a larger focus on environmental values in Dutch agriculture as the Dutch landscape changed dramatically (Feng, 1998; Bos, Smit and Schröder, 2013). Streams were turned into canals, trees, woods and hedges were removed, and groundwater levels decreased. This was followed by habitat loss and fragmentation, disruption and ultimately loss of species and decreasing biodiversity (Meerburg et al., 2009; Brouwer et al., 2016). The government started regulations to protect the environment and subsidize sustainable farming practices. However, on the other hand, regulations have increased the cost of production and required substantial investments for many farmers, resulting in a continuing trend towards larger farms (Centraal Bureau voor Statistiek, 2017). This trend has been strengthened by a long-term decline in real prices for products at the farm gate (ABN Amro, 2013). This has occurred at a world scale. The Netherlands is currently the second largest exporter of agricultural products in the world (WUR, 2019). Furthermore, cocoa, soy and palm oil are large import streams, causing additional pressure to the environment (HCSS, 2016).

Dutch agricultural production has also become increasingly intensified in order to meet the demands of shifting diets due to the rising incomes in developing countries (Tittonell et al., 2016). However, Western diets changed too, and the consumption of processed foods and dining out has increased. Medical experts have raised concerns about unhealthy Western eating habits, resulting in severe obesity (Hulshof et al., 2003). Additionally, unhealthy processed foods are often cheaper than healthy and unprocessed foods (Moubarac et al., 2017). Furthermore, the amount of food that is wasted in the Netherlands is high and should be diminished (Kramer et al., 1999). Thus, a revision of our consumption pattern is required (IPES, 2015). Another important

aspect is the current population growth, which is causing concern with how the world will be fed in the future, causing further pressure on the environment by technological advancement and increasing nature areas used for food production (Kramer et al., 1999). However, the search for solutions has become more apparent. Over the years, many examples of more sustainable, extensive or nature-inclusive farming have been established in the Netherlands, and there is potential to expand this further (Geographie, 2016; Runhaar, 2017; Centraal Bureau voor Statistiek, 2018).

1.1.1. Intensive versus extensive farming

In general, extensive farming stands out as having minor impact on the environment. Extensive farming generally has lower production levels and fewer animals, but more concern for biodiversity. Intensive farming is mostly about having high production levels and is usually accompanied by large numbers of animals. Land use differs between these two farming systems, with intensive farming often needing less land area than extensive farming (Benton et al., 2011). The general aim of extensive farming systems focuses on sustainability, through optimizing the use and management of internal production input as well as minimizing the use of external production inputs such as fertilizer, pesticides, concentrate feedstuffs and irrigation (Elbersen & Andersen, 2007; Nemecek et al., 2011). Furthermore, it aims to reduce the costs of production, avoid pollution and increase farmer profitability (Nemecek et al., 2011). Through extensive farming, the maintenance of biological diversity and productivity is managed (Biala et al., 2007).

Extensive farming systems can otherwise be categorized as low input farming systems and have characteristics that make them low input. Three different European low input farming populations were identified: organic, High Nature Value (HNV) and low input (Elbersen & Andersen, 2007). These farming systems follow closely to the systems described in Erisman & Verhoeven (2019). The general characteristics of these systems are that there are lower inputs per hectare as well as higher values in biodiversity, landscape, and environment. The question is how rare cattle breeds fit into low input farming systems and what characteristics they possess that will thrive in this type of system as opposed to high input breeds such as the Holstein Friesian.

Rare or local breeds are often owned by small-scale livestock farmers (Commission on Genetic Resources for Food and Agriculture, 2009). It has been suggested that rare local breeds thrive in a particular environment and may experience fewer health problems and have a higher production than breeds that are not adapted to these specific conditions. Local breeds possess unique characteristics such as drought tolerance and disease resistance, depending on the region they developed (Mathias & Mundy, 2010). These unique traits make them an important source of genetic diversity in an otherwise homogeneous agricultural landscape.

On a European scale, Holstein Friesian cattle are generally intensively selected for their beneficial production traits (Hiemstra et al., 2010). Many rare breeds do not undergo rigorous selection processes for production traits, like Holstein Friesians. Instead, these breeds have been developed and selected for their ability to deal with their local environment and circumstances, such as climate and weather conditions, and local food sources. This means that rare breeds are uniquely adapted to their area of development (Mathias & Mundy, 2010; Commission on Genetic Resources for Food and Agriculture, 2009). Even though Holstein Friesian cattle are favored in intensive farming systems that focus on high production, not all areas have made the conversion from extensive to intensive systems. As a result, many rare and native breeds have been able to

survive and thrive in local conditions where intensive farming systems have not been established (Hiemstra et al., 2010).

Genetic diversity is a fundamental part of livestock production, as it provides the ability for local breeds to adapt to constantly changing environmental and socio-economic demands (Van Breukelen et al., 2019). Before the 1970s, the Dutch landscape was filled with an array of different cattle breeds, the most prominent of which were the Dutch Friesian (76% of Dutch cattle), the MRIJ (22%) and the Groningen White Headed (2%). Others such as the Deep Red and Improved Red and White were developed from the main breeds in order to improve and conserve specific qualities (Van Breukelen et al., 2019). However, today, an estimated 90% of the entire population of cattle in the Netherlands consists of Holstein Friesian cattle, with the other 10% only partly Dutch varieties (Van Breukelen et al., 2019). Starting in the 1960s, most dairy breeds were crossed with the Holstein Friesian to increase milk production. This process, called 'Holsteinisation', has led to a dramatic decrease in the populations of rare breeds and a severe reduction in the genetic diversity within rare breeds (FHRS, 2020; Van Breukelen et al., 2019). With many of the rare Dutch cattle breeds having small population sizes, they are now more susceptible to inbreeding depression (Van Breukelen et al., 2019).

By being conscious of productivity and biological diversity, extensive farming tends to sync with the principles of agroecological farming systems. Agroecology is "the application of ecological concepts and principles to the design and management of sustainable agroecosystems" (Silici, 2014, p. 4). It is a holistic scientific discipline combining agroecosystems, human and environmental aspects, as well as a set of principles and practices that involve resilience, ecology, socio-economics and the cultural aspects of agriculture. Additionally, agroecology is a movement striving for a revision of modern agriculture. Some implications are that agroecological farming requires more management, different policies, and agroecology still evokes resistance from conventional agriculture (Silici, 2014). Agroecology is an approach to understand the ecology behind traditional agricultural practices. As a discipline, it stimulates the movement towards sustainable agroecosystems. When the theory of agroecology was first developed, it was at first mostly used by non-governmental organisations, directed at strengthening small-scale farmers and poor rural communities. However, in 2009 the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) recognized agroecology as an alternative discipline that can be applied to solve global issues such as hunger, poverty in rural areas, and sustainable development. Since then, agroecology has started to gain track in policy making, with the United Nations amongst others promoting agroecology as a way to improve food security and food sovereignty (Méndez, 2012). There are a number of research institutions throughout Europe that generate knowledge on agroecology, and that have programmes aimed at training the next generation of agroecologists. Courses on how to apply agroecology are also taught at farm schools (Wezel, 2018).

In the Netherlands, agroecology is mostly seen as a science and not as much as a practice, like it is in Belgium and Germany for example. Most of the agroecological practices for livestock focus on cattle, pigs and sheep (Gallardo-López et al., 2018). By understanding the ecology of organisms, some problems created by livestock production can be significantly changed for the better. Most notably the cattle industry's contribution to greenhouse gases can be reduced (Sommer et al., 2009). Currently, there is a lot of critique from the Dutch government and society about the contribution of agriculture to nitrogen emissions (NOS, 2019). Research is carried out to lower the emissions in barns, and statistics are accurately measured to keep track of emission

developments in the Dutch livestock sector (Centraal Bureau voor Statistiek, 2020; Sikkema A., 2019). According to farmers, having more outside time for livestock might be a solution to lower the emissions. They say this is because urine and faeces will then be naturally separated, so no ammonia is formed (AD, 2019). The Dutch government has made official plans to move towards the future by encouraging sustainable agriculture (Rijksoverheid, 2016).

1.2. The Dutch rare cattle breeds

The Netherlands are home to seven native breeds and one color variety. These seven breeds are the Dutch belted, Dutch Friesian, Friesian Red and White, Groningen White Headed, Deep Red, Meuse Rhine IJssel (MRIJ), and Improved Red Pied. The color variety is called Witrik. All of the aforementioned breeds and the color variety are considered rare and fall under the protection of the Dutch Rare Breed Society. The exception is the Improved Red Pied, which is a rare breed developed in the Netherlands, but one that is not protected by the Dutch Rare Breed Society and as such, is not considered for this report.

1.2.1. Dutch belted

The Dutch Belted, known in Dutch as the Lakenvelder, are known for their signature white belt around the midsection, hence their name. Their horns, feet and tongue also have to be pigmented to be considered an ideal Dutch Belted (FAO, 2020). The entire population is made up of 50% black and 50% red colour variation. Dutch Belted are native to the Netherlands, however they are distributed internationally. According to the SDG local risk status, the Dutch Belted cattle breed is considered at risk and endangered. They are mainly kept for hobby purposes, and were previously used as “park cattle” (FAO, 2020). Today, they are considered to be a dual-purpose breed, used both in milk and meat production. The Dutch Belted is considered to be a traditional sustainable dual-purpose breed, possessing a special mark (Lakenvelderrund, 2020). A herdbook was established in 1997 by Vereniging Lakenvelder Cattle (VLR). The population size consisted in 2019 of 1512 females (CGN, 2020).

1.2.2. Groningen White Headed

The Groningen White Headed, known as Groninger Blaarkop in Dutch, originated from a White Headed breed that was brought over from London in the 19th century for slaughter. After this, 90% of the Province of Groningen consisted of White Headed cattle in beginning of the 20th century and have been bred in the Province of Groningen, Zuid-Holland and along the Rhine in Utrecht ever since (Hiemstra et al., 2010). The population of Groningen White Headed is made up of 1927 female animals (CGN, 2020). According to the breed organisation Blaarkop Stichting, Groningen White Headed possesses valuable functional traits such as feed efficiency, fertility and health. In contrast however, Groningen White Headed have low milk production (Hiemstra et al., 2010).

1.2.3. Dutch Friesian & Friesian Red-and-White

The Dutch Friesian cattle breed, known in Dutch as Fries-Hollands vee, is native to the Netherlands, however they are distributed internationally, and they are considered to be at risk

and endangered (FAO, 2020). Up to 1975, the Dutch Friesian was considered to be the most important in the Netherlands. However, a considerable number of cattle had been exported to the United States around 1900, where they were bred to ultimately become Holstein Friesian (FAO, 2020). Since the 1970's, 'Holsteinisation' has been threatening the existence of the Dutch Friesian population (FHRS, 2020). Originally. Dutch Friesian cattle made up around 71% of the cattle population. Today, they only make up less than 1% in the Netherlands. The herdbook was established in 1879 by Fries Hollands Rundvee Stamboek (FHRS). As of June 2020, the population size consists of 2182 female animals (CGN, 2020). The main purpose of the breed is for milk production (FAO, 2020). According to the FAO (2020), the average milk yield per lactation is 6910kg, with a fat percentage of 4.52% and protein percentage of 3.56%.

The Red-and-White Friesian cattle, known in Dutch as Fries Roodbont, are native to the Netherlands and considered a local breed. They are mainly kept by hobbyists, with their main use in milk and meat production, making them dual purpose (FAO, 2020; Stichting Behoud Roodbont Friese Vee, 2020). According to the FAO (2020), the population status of the Red-and-White Friesian at the moment is being at risk and endangered. The population size estimated in 2019 is approximately between 700 and 1000 individuals. They have a conformation like the Dutch Friesian cattle. Their red colour is a single recessive gene, and homozygous individuals tend to have a darker red colour than the heterozygous individuals (FAO, 2020). Thus, a Red and White phenotype was registered in the Friesian Cattle studbook back in 1879 (Stichting Behoud Roodbont Friese Vee, 2020). However, the Black and White variety was increasingly popular, to the point where only 50 farmers joined the Association of Red and White Friesian in 1970, consisting of a total of 2500 cattle. Similar to the fate of the Dutch Friesian cattle, the Holsteinisation has meant a severe decline of the Red-and-White Friesian cattle population. By 1993, only as little as 21 Red-and-White Friesian cattle remained. Through conservation efforts with the help of the national gene bank, the population increased, reaching 269 individuals in 2004. According to the breed club, the population of Red-and-White Friesian cattle is at an all-time high since 1997, with 778 registered female animals as of August 2020. (Stichting Behoud Roodbont Friese Vee, 2020) However, the official population count of CGN lists a current population number of 594 females as of June 2020 (CGN, 2020).

1.2.4. MRIJ & Deep Red

The Meuse Rhine IJssel cattle (MRIJ) are a native Dutch breed originating along the Meuse and Rhine rivers, and have been recognised as a breed by CRV since 1905 (Hiemstra et al., 2010). Unfortunately, MRIJ have since been declining due to farmers switching to Holstein Friesian cattle (Eynard et al., 2018). The genetic value of the MRIJ is still increasing however, aided by breeding programmes run by the breed organisations MRIJ-East and MRIJ-South (Hiemstra et al., 2010). MRIJ cattle are the largest population of rare cattle breed in the Netherlands, with approximately 14,000 individuals registered. The official population number is listed at 9677 female animals as of June 2020 (CGN, 2020). According to the breed organisations, MRIJ possess robust characteristics such as milk yield, functional traits, conformation and muscularity (Hiemstra et al., 2010).

The Deep Red cattle, known in Dutch as Brandroond rund, originated from the MRIJ, due to the colour pattern of MRIJ changing to a white and light red after WWII, and then selection resulting in the genetic isolation of the 'deep red' cattle. The Deep Red had thus become an official breed in the Netherlands. According to the breed organisation Het Brandrode Rund, the Deep Red cattle

are very suitable as a free-roaming breed in nature reserves due to their sturdiness. Although the population size is small, hobbyists and volunteers maintain the genetic diversity of the breed (Hiemstra et al., 2010). The official population size of Deep Red cattle is 1121 females as of June 2020 (CGN, 2020).

1.2.5. Witrik

Witrik are native and local to the Netherlands and were found mostly in the West and North of the Netherlands. Today, they have spread throughout the country (De Witrik, 2020). Witrik are not considered to be a breed, but rather a colour variety. However, since 2002 a herdbook has been established for the Witrik by the 'De Witrik' foundation (FAO, 2020). The colour variety has made an appearance in several medieval paintings, indicating that it may have been an important part of the Dutch livestock for a very long time. When the Dutch Cattle Studbook was introduced in 1874, the Red and White MRIJ, Black and White MRIJ and Groningen White Headed were chosen for the studbook. However, farmers kept the Witrik colour variety in secret, to ensure it would not become extinct (De Witrik, 2020). The general description of an ideal Witrik is having "a white line over the back, white tail, white bottom and spotted head". Witrik cattle are generally used for vegetation management (FAO, 2020). There are estimated to be around 3000 individuals in the Witrik population (De Witrik, 2020).

1.3. The project

Dutch rare cattle breeds and agroecology come together in this project. An initial review of the subjects, along with existing knowledge from the disciplines of the researchers, shaped the research questions. A conversation with the commissioners yielded the aims for this project. These commissioners are researchers Jack Windig of Wageningen University and Wageningen Livestock Research, and Rita Hoving of Wageningen Livestock Research. The Dutch Rare Breed Society approached the Wageningen University & Research Science Shop (in short: the Science Shop) with a research request, which was put through to Windig and Hoving. In turn, Windig and Hoving approached MSc students participating in Academic Consultancy Training to conduct the research.

This study was performed by seven MSc students between Monday the 31st of August and Friday the 16th of October, which is seven weeks in total. The first three weeks were devoted to developing the proposal. The fourth and fifth week were spent conducting interviews and writing transcripts. The transcripts were finished at the start of the sixth week. Analysis of the transcripts happened in week five and six, as soon as the first transcripts were finished. Week six and seven were spent writing the report.

1.3.1. Aims and research questions

The aim of this project is to highlight the ways in which Dutch rare cattle breeds can contribute to agroecology. Disciplines including genetics, ecology and agricultural management will aid in this investigation. This project also aims to promote the use of these Dutch rare cattle breeds in sustainable agriculture. Therefore, the research question (RQ) of this project is:

- What can Dutch rare cattle breeds contribute to agroecological farming?

There are several essential components needed to answer the research question. Firstly, it is necessary to know the characteristics of the Dutch rare cattle breeds and the farming systems they are currently being kept in. Secondly, the ecological impact needs to be determined of the cattle characteristics and farm characteristics. Thirdly, the economic impact needs to be determined of the cattle and farm characteristics. After all, if the aim is to promote the use of these breeds, it is essential to know their economic viability. Lastly, it is necessary to know how these characteristics can be implemented into agroecological farming systems. Therefore, the following sub questions (SQ) need to be answered before the research question can be tackled:

SQ1: What are the characteristics of Dutch cattle breeds and their farming systems?

SQ2: What is the ecological impact of these characteristics?

SQ3: What is the economic impact of these characteristics?

SQ4: In which ways can these characteristics be implemented into agroecological farming systems?

1.3.2. Relevance

As discussed in 1.1 and 1.2 of this chapter, rare cattle breeds are disappearing, and this includes the rare Dutch breeds. Existing research suggests that rare breeds are uniquely adapted to the local environments in which they were developed. This would make rare breeds ideally suited for extensive farming systems with low inputs in their native home range. However, little research exists on this topic, and Dutch rare cattle breeds and their farms have been explored little when compared to the popular Holstein Friesian breed. Therefore it is important to start an exploration of these breeds and their farming systems, in order to make a proper assessment and see if they are indeed suitable for agroecological purposes. It is of utmost importance that these breeds have a purpose and that farmers find reasons to keep them. Not just as cultural heritage, but also as viable production animals that can thrive in future sustainable farming systems.

1.4. Reading guide

This first chapter is a thorough introduction of this report. It lists background information, explores the Dutch rare cattle breeds briefly, and names the Research Question and the derived sub questions. Chapter 2 goes into the methods for this research. It describes the methods that are used, goes over the protocols, and explains the validity and reliability. The results of this research are explained in chapter 3. The garnered data is presented in quantitative and qualitative sections and includes graphs and tables. The results are discussed in chapter 4. The qualitative and quantitative data are compared to each other and to existing literature. After this, the conclusions are drawn. The references can be found in chapter 5. The final part of this report consists of appendices that are referred to in the text.

2. Methods

This chapter describes the methods that were used in this research. In other words: how data was collected, by whom, when, and how it was analysed. Data was collected using literature review, and semi-structured interviews with farmers and experts. A total of ten farmers and five experts were interviewed. An elaborate interview protocol helped determine interview questions, helped with the analysis of the data, and helped protect the validity of this research.

2.1. Data collection

Data was collected through means of interviews and literature review, rendering this a cross-sectional study that is focused on the use of Dutch cattle breeds in agroecological farming systems. The interviews were used to collect data from keepers of six authentic Dutch cattle breeds (Dutch Belted, Groningen White-headed, MRIJ, Deep Red, Dutch Friesian, and Friesian Red and White), and from experts in fields related to farming systems and cattle breeds. A preliminary literature review helped determine the following fields of these experts: cattle breeding, cattle production systems, nature and agriculture policy, and cattle nutrition.

2.1.1. Interviews

Ten farmers and five experts were interviewed. Within the group of ten farmers, two farmers (Mr. Nijman and Mr. Aalvanger) were specifically asked about respectively the colour variety the Witrik and the multiple Dutch rare breeds they have on their farms. Therefore, these two farmers had a different interview. Throughout this report, the other farmers will not be referred to by their names due to privacy reasons. Instead, they are referred to by the codenames (Table 1).

Table 1. *The interviewed Dutch rare cattle breed farmers, production purpose of their cattle and farmer code names.*

Cattle breed	Main production	Codename farmer
MRIJ cattle	Dairy	MR1
MRIJ cattle	Dairy	MR2
MRIJ x Holstein Friesian crossbred cattle	Dairy	HM1
Dutch Friesian cattle	Dairy	FB1
Friesian Red and White cattle	Dairy and beef	FR1
Dutch Belted cattle	Beef	DB1
Groningen White Headed cattle	Dairy and beef	GW1

Deep Red cattle	Dairy and beef	DR1

The farmers were approached after contact with the following breed clubs:

- Vereniging Lakenvelder Runderen (breed club for Dutch Belted)
- Stichting De Witrik (foundation for Witrik cattle)
- MRIJ Vereniging (breed club for MRIJ cattle)
- Blaarkop Stichting (foundation for Groningen White Headed cattle)
- Stichting Roodbont Friesvee (foundation for Friesian Red and White cattle)
- De FH Vereniging (breed club for Dutch Friesians)
- Vereniging Het Brandrode Rund (breed club for Deep Red cattle)

The only requirements for the farmers were that they owned Dutch cattle breeds, and that they used these breeds to make a living. Hobby farmers were excluded. Some of the breed clubs provided farmers for the interviews. For various reasons, some breed clubs were unable to provide contact information of farmers. In these cases, the commissioners and the Dutch Rare Breed Society were able to provide contacts. Mr. Aalvanger was suggested by Mr. Nijman as Mr. Aalvanger has multiple Dutch rare breeds at his farm. All the farms, included in our project, are to some degree related to circular farming. All farms are divided following the classifications of farms of Erisman & Verhoeven (2019) (Table 2).

Table 2. *The interviewed farmer codenames and corresponding classification. Adapted from Erisman & Verhoeven (2019).*

Codename farmer	**Classification**
MR1	Average agricultural practices
MR2	Average agricultural practices
HM1	Highly efficient
FB1	Average agricultural practices
FR1	Max. utilisation own resources
DB1	Production and nature
GW1	Highly efficient
DR1	Production and nature

Farmer HM1 was initially approached under the assumption that they owned purebred MRIJ cattle. During the interview it became apparent that HM1 mainly kept crossbreds of Holstein Friesian with MRIJ, rendering the bloodlines of their herd approximately 50% Holstein Friesian. The decision was made to incorporate their data in this research all the same, because the data reflects the effects of crossing the popular Holstein Friesian breed with a rare Dutch breed. This may be of interest to farmers who are looking to make the transition from Holstein Friesian cattle to a rare Dutch breed.

All interviews with the farmers were preceded by a screening via telephone that was meant to ensure the farmers made a living from their Dutch cattle breed, and was also used to determine a date for the interview. The actual interviews with the farmers were conducted at their farms, with the exception of Mr. Aalvanger who was interviewed by phone due to practical limitations. Each interview was conducted by two people, with one person asking questions and the other making notes. The interviews were recorded after permission was granted by the farmer.

The experts were interviewed about their expertise in the fields of cattle breeding, cattle production systems, nature and agriculture policy, and cattle nutrition. The experts include:

- Henk Sulkers of CGN, the Centre of Genetic Resources in the Netherlands, who is interviewed about his expertise in genetics and practical knowledge of cattle breeding.
- Sipke Joost Hiemstra, the Director of CGN, who is interviewed about his knowledge of policy and animal production systems.
- Henk Lutke Willink of CRV, the international cattle breeding co-operative and the largest cattle registry in the Netherlands, who is interviewed about his expertise on genetics.
- Wouter Spek of the Animal Nutrition chair group at Wageningen University, who is interviewed about his expertise on cattle nutrition.
- Roelof Bos, Agricultural Manager of the Province of Friesland, who is interviewed about his expertise in policy and agroecology.

All interviews with the experts were done online via Microsoft Teams. The online interviews were conducted by two people, with one person asking questions and the other making notes. The interviews were recorded after permission was granted by the expert.

2.1.2. Interview questions

The interviews for both farmers and experts were semi-structured, following a list of pre-set questions but allowing the interviewees room for additional comments and discussions on what they thought was relevant. A list with questions was sent to the interviewees beforehand, so they had time to prepare. Each farmer was given the same list of questions. Due to the divergent nature of the experts' fields of expertise, they were all given separate lists of questions pertaining to their specific field.

The interview questions for the farmers were based on this study's research questions. Several "variables" were identified as being relevant to the research questions and these variables were

developed into “indicators”. The indicators were turned into questions in the interview protocol. This interview protocol can be found in Appendix A. The interview questions for the experts were derived from the preliminary literature review and adjusted according to each experts’ specific field of expertise. The list with interview questions can be found in Appendix B.

2.1.3. Literature review

A preliminary literature review was conducted for the proposal. This preliminary review helped determine which fields of expertise were relevant to our research, and which experts would be contacted for interviews. The preliminary review also helped determine the interview questions for the experts. An additional literature review was conducted for the discussion in this report. The preliminary and additional literature reviews include sources of the Dutch Rare Breed Society, sources provided by the commissioners and interviewees, independent searches on Google Scholar, and a rare breed book featuring old Friesian cattle breeds that was published in 1979. All used sources for the literature reviews are mentioned in either Chapter 1 Introduction, or Chapter 4 Discussion, and all used sources can be found in Chapter 5 References.

2.2. Data analysis

The interview protocol provided a clear handhold for the data sorting and analysis. As mentioned before, specific “variables” were extracted from each of the research questions. These variables are as follows:

- Herd characteristics
- Cattle breeds
- Farming systems
- Ecological impacts
- Economic impacts
- Implementation.

Every interview question for the farmers was sorted under these variables where they fit best. “Indicators” were then named for each of the research questions. It was determined which of the indicators would yield mainly qualitative or quantitative data, and which indicators would be important for answering the research questions or for background information. The indicators were thus colour coded as follows:

Green	**Important qualitative**
Orange	**Unsure qualitative**
Red	**Unimportant qualitative**

Blue	**Quantitative**

The complete list of sorted questions can be found in the interview protocol (Appendix A). An example of what this looks like:

Farmer		
Variables	*Indicators*	*Questions*
Herd characteristics		
	Breeding values	Can you give us any information on the breeding values of the bulls you use (in general or on average)?
	Strengths/weaknesses	What do you see as the strengths and weaknesses of your herd?
	Traits	Are there any particular traits that you are focussing on in your breeding? Which and why?

In the quantitative data analysis, the indicators were compared per farm. Data was extracted from the interview transcripts and documented in a spreadsheet for the different variables and indicators. From here, tables and graphs were formulated. For the qualitative data, a spreadsheet was created containing the different indicators. Then all the qualitative indicators were sorted for each variable. The main sections of the answers within the transcripts were allocated to the correct indicator, which was done for each farmer. The answers of the farmers were compared, and patterns were highlighted in their answers. Conclusions could be drawn once these patterns were visible. The data from the expert interviews was used to identify knowledge gaps regarding Dutch rare cattle breeds in sustainable agriculture. The data was compared to findings from the literature review and the farmer interviews. The expert data comparison is discussed in Chapter 4 Discussion.

2.3. Validity and reliability

In research, validity is about whether you are measuring what you intend to measure. In other words: how accurate are the methods. The validity of this research is supported by the interview protocol which can be found in Appendix A. In the interview protocol, our research questions are turned into variables, which in turn are turned into indicators. These indicators are then used to create the interview questions. This way of developing the interview questions ensures that you are measuring what you want to measure, which means the research validity is protected.

Reliability is about the consistency of the research. Because multiple people are doing interviews in this research, interrater reliability is important. This means that the different people doing the interviews will be consistent in asking the same questions, will be consistent in writing the transcripts, and be consistent in rating the same variable with minimal bias. In order to uphold interrater reliability, guidelines were constructed for conducting the interview (Appendix C), for the transcription (Appendix D), and qualitative and quantitative data sorting (Appendix E).

3. Results

Firstly, the results of the quantitative analysis of the interviews with the farmers are presented. Secondly, the results of the qualitative analysis of the interviews with the farmers are presented. Finally, the interviews with the experts are summarized in which important notes from those interviews are mentioned.

3.1 Farmers

This section is divided into quantitative results, qualitative results and a part for the summaries of the multiple breeds and Witrik breeder.

3.1.2 Quantitative results

All farmers interviewed kept cattle as their main source of income, which is represented in the size of their herd even though there are herd size differences between them (Figure 1). The MR1 farm has the largest herd with 298 animals, and the smallest herd is the DB1 farm with 92 animals. In between the largest and smallest herd in descending total number of animals, the MR2 farm has 238 animals, the DR1 farm has 200 animals, the GW1 farm has 170 animals, the HM1 farm has 151 animals, the FR1 farm has 123 animals and the FB1 farm has 105 animals. The FB1 and HM1 farms do not contain any breeding bulls or oxen, or the information was not provided by the farmers. Most farms have between 40 and 60 youngstock, except for the MR1 and MR2 farms which have 110 and 100 youngstock respectively. Regarding suckler cows, the DB1 farm consists of 30. The DB1 farm only has cows to produce meat. The rest of the farms contain milking cows, which primarily vary between 48 and 152. The MR1 farm has the most milking cows with 152, followed by the MR2 farmer with 117 milking cows. The HM1 farm follows closely behind with 109 milking cows, and the GW1 farm with 95 milking cows. The FR1, FB1 and DR1 farms consist of the smallest number of milking cows, with 72, 70 and 48 respectively.

For all the farms, the cows graze for an extended period of the year, as is illustrated in Figure 2. At the DR1 farm, the cows spend the most time outside, in total 271 days, followed by the FR1 farm where they spend 250 days outside, GW1 243 days, FB1 240 days, DB1 213 days, MRIJ average 200 days, and lastly HM1 where they spend 180 days outside. There is a maximum difference of 181 days between the farms. This difference is between the DR1 farm, where the cows are 271 days outside and the HF average, where the cows are 90 days outside. Cattle on both MR1 and MR2 farms spent approximately 200 days outside, making an average of 200 days with both combined. The farmers either gave an estimation of the number of months or days or hours that the cows were outside. A decision was made to present this data in days. This data was converted to days per year. The number of hours per day the cows are spending outside is not taken into account.

There is some variation between the average milk production per farm (Figure 3). There is a large difference between the highest and lowest milk yield of each farm. The cows on the HM1 farm have the highest yield of milk of 8800 liters per cow per year within the interviewed farms. The cows from the DR1 farm, however, have the lowest milk yield, with only 4500 liters per cow per year. Behind the highest yielding farm, the MR1 farm produces 7900 liters per cow per year. There is then a large difference of 1415 liters between the FB1 and MR1 farms, where FB1 cows produce 7000 liters per cow per year and the MR1 cows produce 5585 liters per cow per year. The GW1 farm produces 5130 liters per cow per year and the FR1 produces 5000 liters per cow

per year. The HF level gives the overall highest milk yield of 10522 liters. In comparison with the average milk production of the Holstein Friesian, there is a minimum difference of 1722 liters with the HM1 farm and a maximum difference 6022 liters with the DR1 farm. The DB1 farm is not included in this graph because it is aimed at beef production and not dairy production.

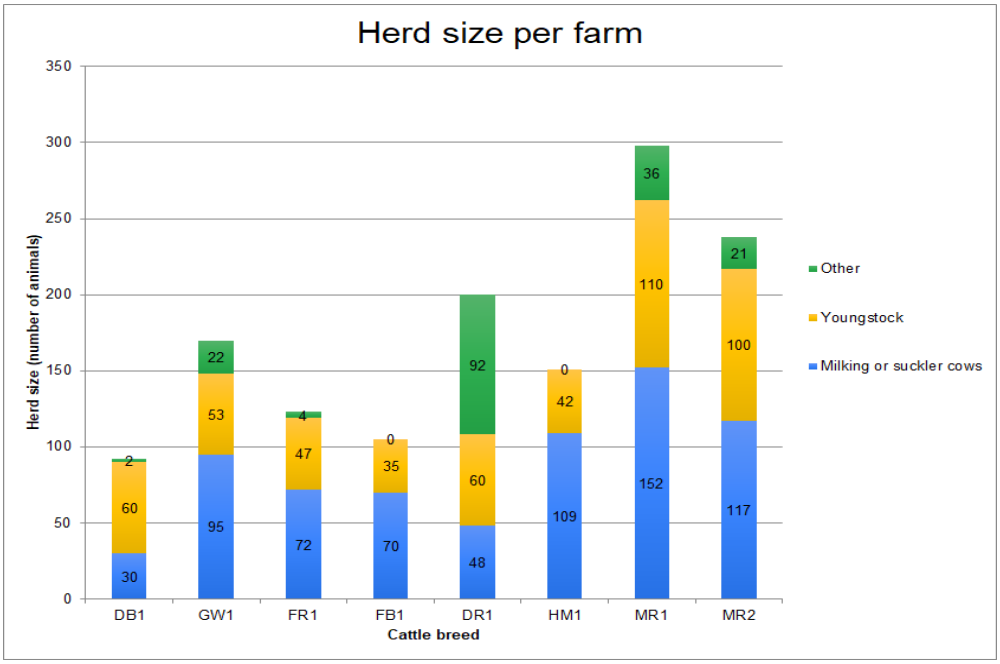


Figure 1. The size of the herd specified per cattle breed per farm. The number of milking (or suckler in case of DB1) cows are shown in blue, and youngstock (<2 years) that includes heifers and calves are shown in yellow. Bulls and oxen are included in the Other category, shown in green. DB1 = Dutch Belted, GW1 = Groningen White Headed, FR1 = Friesian Red and White, FB1 = Dutch Friesian, DR1 = Deep Red, HM1 = Holstein-MRIJ crossbreed, MR1 = MRIJ farm 1, and MR2 = MRIJ farm 2.

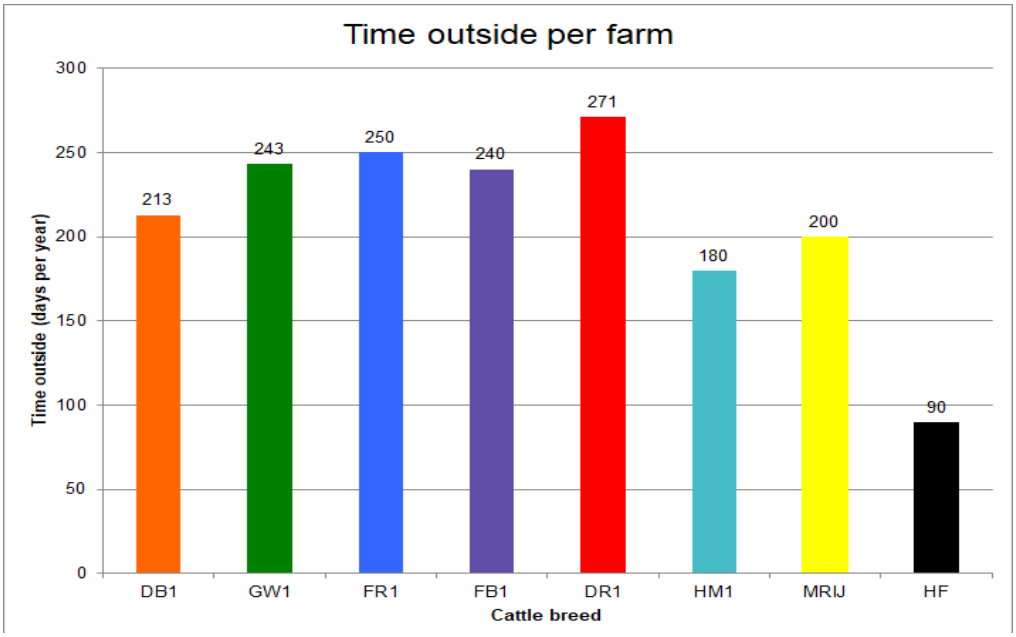


Figure 2. Time spent outside per cattle breed per farm. An average is calculated for the MRIJ farms. Time spent outside has been approximated from the number of months each farmer would have their cattle outside. DB1 = Dutch Belted, GW1 = Groningen White Headed, FR1 = Friesian Red and White, FB1 = Dutch Friesian, DR1 = Deep Red, HM1 = Holstein-MRIJ crossbreed, MRIJ = average of two MRIJ farms, and HF = Holstein-Friesian. Holstein Friesian data is obtained from CBS (CBS, 2018, 2020a).

There is some variation between the average milk production per farm (Figure 3). There is a large difference between the highest and lowest milk yield of each farm. The cows on the HM1 farm have the highest yield of milk of 8800 liters per cow per year within the interviewed farms. The cows from the DR1 farm, however, have the lowest milk yield, with only 4500 liters per cow per year. Behind the highest yielding farm, the MR1 farm produces 7900 liters per cow per year. There is then a large difference of 1415 liters between the FB1 and MR1 farms, where FB1 cows produce 7000 liters per cow per year and the MR1 cows produce 5585 liters per cow per year. The GW1 farm produces 5130 liters per cow per year and the FR1 produces 5000 liters per cow per year. The HF level gives the overall highest milk yield of 10522 liters. In comparison with the average milk production of the Holstein Friesian, there is a minimum difference of 1722 liters with the HM1 farm and a maximum difference 6022 liters with the DR1 farm. The DB1 farm is not included in this graph because it is aimed at beef production and not dairy production.

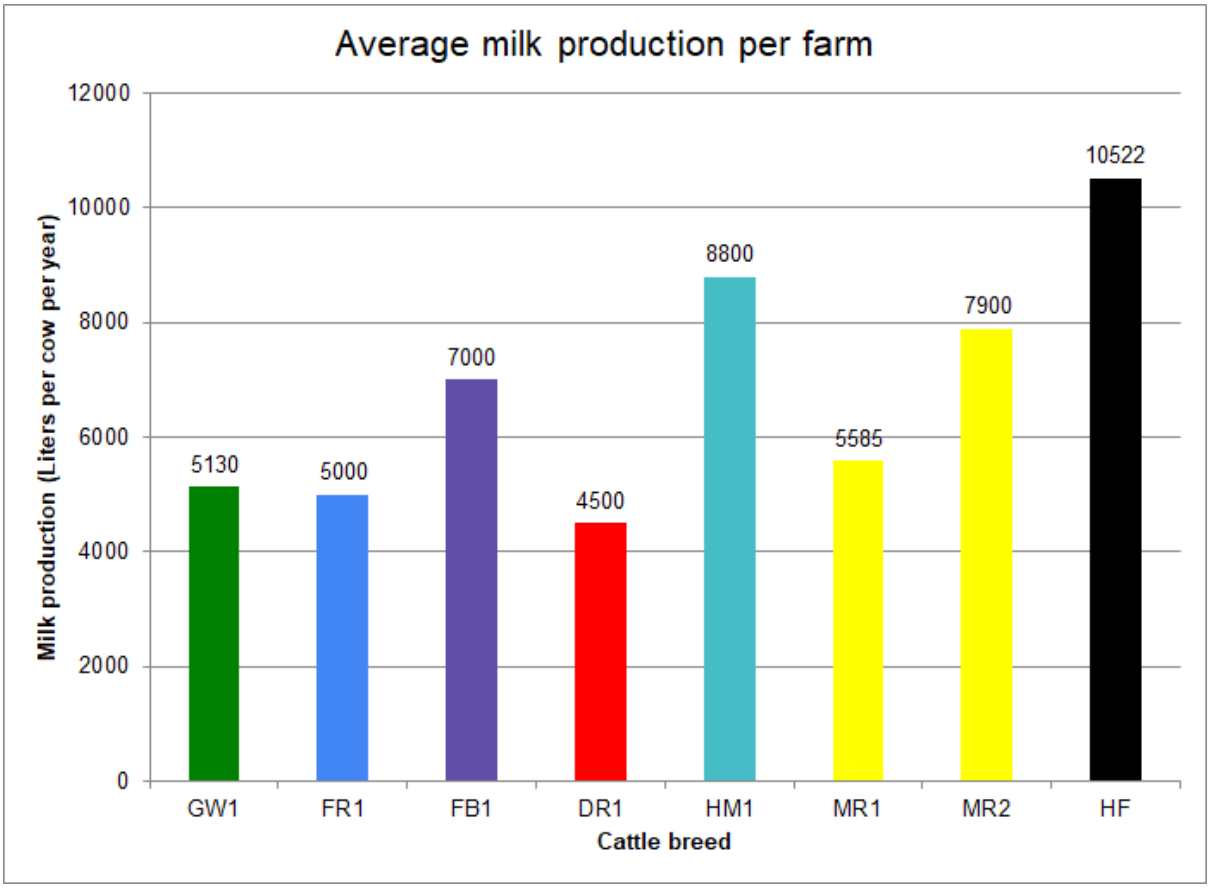


Figure 3. *The milk production per farm in liters per cow per year. GW1 = Groningen White Headed, FR1 = Friesian Red and White, FB1 = Dutch Friesian, DR1 = Deep Red, HM1 = Holstein-MRIJ crossbreed, MR1 = MRIJ farm 1, MR2 = MRIJ farm 2, and HF = Holstein-Friesian. Holstein-Friesian data is obtained from Coöperatie Rundvee Verbetering (2019).*

Similar to average milk production, there is some variation between milk protein and milk fat levels between the farms (Figure 4). The cows from the MR2 farm produce the highest amount of milk fat at 4.74% and the DR1 cows produce the lowest at 4.09%. The FR1 and HM1 produce high percentages of milk fat coming after the MR2 farm, with 4.67% and 4.63% milk fat respectively. Furthermore, the MR1 farm produces 4.52% milk fat, the FB1 produces 4.49% milk fat and the GW1 farm produces 4.41% milk fat. In terms of milk protein percentage per farm, the FR1, MR2 and HM1 have the highest percentage with 3.85%, 3.84% and 3.83% respectively. The FB1 farm

produces 0.04% less milk protein than the HM1 at 3.79%. Following from that, the GW1 farm produces 3.69%, the DR1 farm produces 3.69% milk protein and the MR1 farm produces the lowest milk protein percentage at 3.59%. In comparison with the other farms has the Holstein Friesian the second-last milk fat percentage and the lowest milk protein percentage, respectively 4.3% and 3,54%. Here, the DB1 farm is also not included as it is a beef cattle farm and not focused on dairy production.

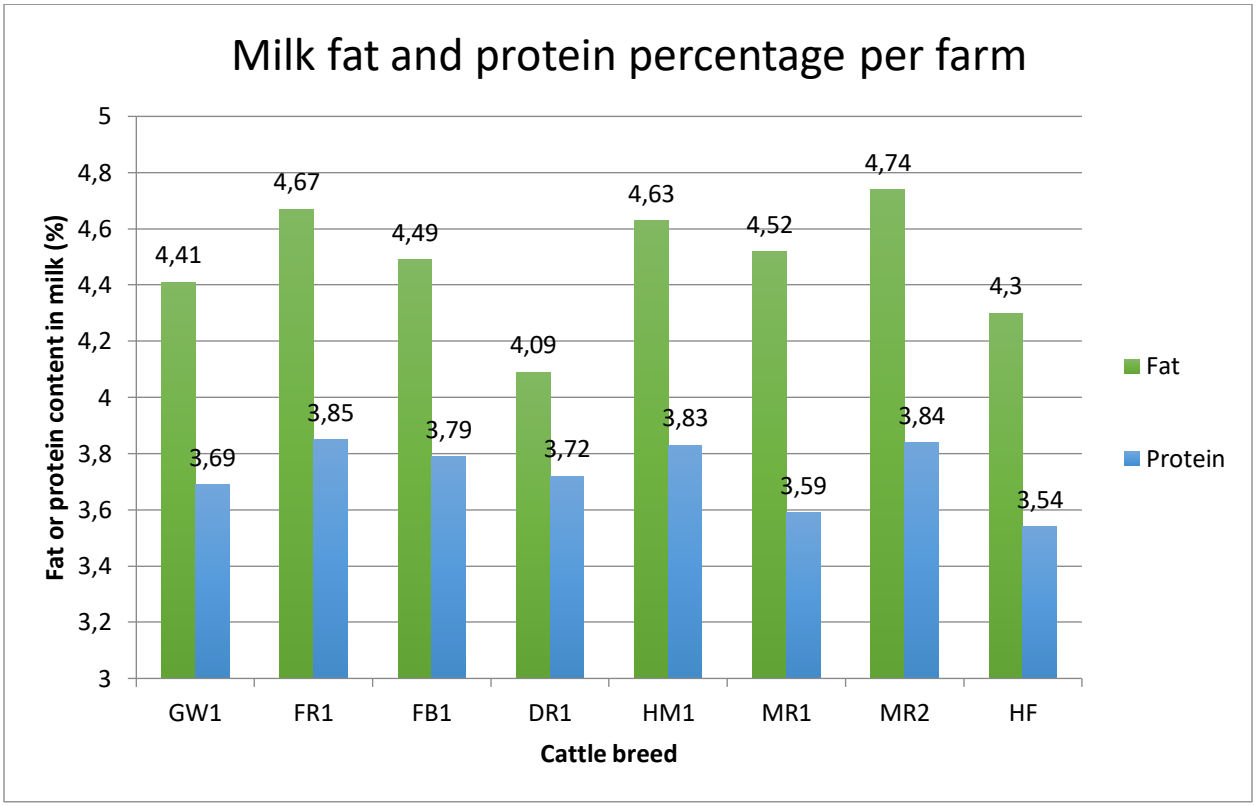


Figure 4. *Fat (blue) and protein (orange) percentages in milk specified per breed per farm. GW1 = Groningen White Headed, FR1 = Friesian Red and White, FB1 = Dutch Friesian, DR1 = Deep Red, HM1 = Holstein Friesian-MRIJ crossbreed, MR1 = MRIJ farm 1, MR2 = MRIJ farm 2, and HF = Holstein Friesian. Holstein Friesian data is obtained from Coöperatie Rundvee Verbetering (2019)*

The farms also have some income when the cows are sent to be slaughtered. This income is based on their slaughter weight, which varies somewhat between the farms (Figure 5). The MR1 farm has the highest slaughter weight at 395 kg and the FR1 has the lowest slaughter weight at 230 kg. The MR2 farm comes closely behind the MR1 farm with a slaughter weight of 375 kg. The average slaughter weight of Holstein Friesians is 322 kg. The DB1 farm has a slaughter weight of 320 kg, the GW1 farm has a slaughter weight of 310 kg and the FB1 and DR1 farms have an equal slaughter weight of 300 kg.

The different farms are located on different soil types (Figure 6). Sandy soil is the most prevalent type of soil found on the farms, at 41.25% of the total, followed by clay on peat at 37.50% of the total. River clay makes up 18.75% of the total soil type, and peat is the least prevalent at only 2.50% of the total soil types found on the farms. The amount of hectares present was summed up and distributed over the soil types as some had multiple soil types present at their farm.

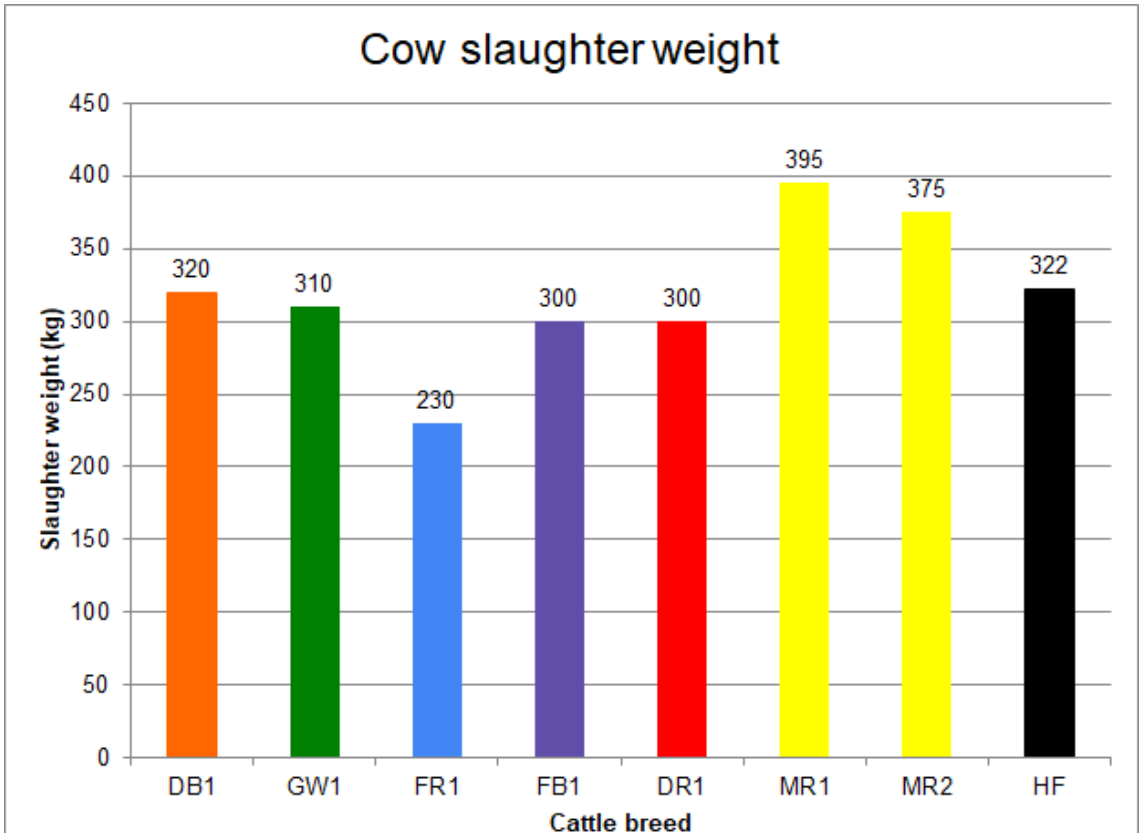


Figure 5. *The cow slaughter weight in kg per farm per breed. The Holstein Friesian-MRIJ farm did not know the average slaughter weight, which is why it is not included in this graph. DB1 = Dutch Belted, GW1 = Groningen White Headed, FR1 = Friesian Red and White, FB1 = Dutch Friesian, DR1 = Deep Red, MR1 = MRIJ farm 1, MR2 = MRIJ farm 2, and HF = HolsteinFriesian. The data is extracted from the interview and is an estimation of the farmer. Holstein Friesian data is obtained from Centraal Bureau voor Statistiek (2020b).*

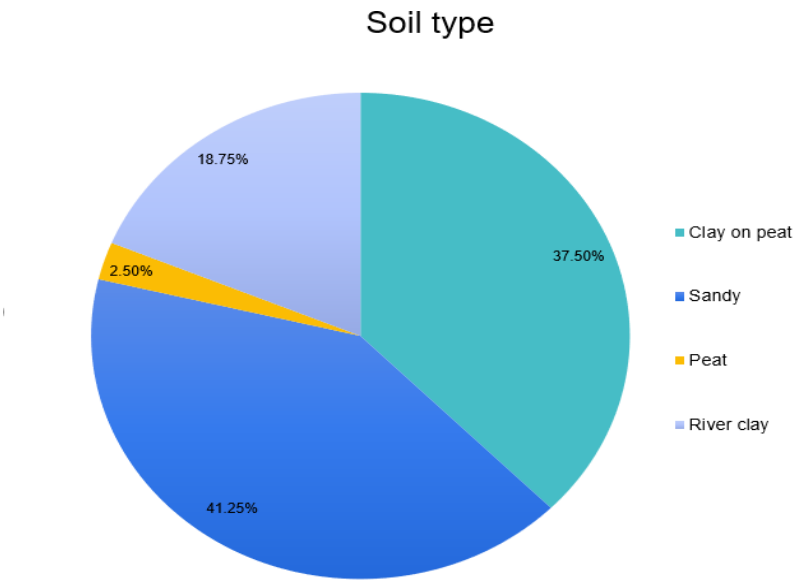


Figure 6. *The soil types found on the farms, presented as an average of the total soil used by all the farms combined. It represents the division of soil types among the total amount of hectares present on all the farms together.*

The farms differ in having a certification and the type of certification they had for their farm (Figure 7). Most of the interviewed farms have some type of certification scheme. Two of eight farmers (25%) had no certification, two of eight (25%) are organic certified, another two of eight farmers (25%) are VLOG certified. One out of eight farmers (12.5%) is biodynamic certified and the last farmer has a breed specific certification.

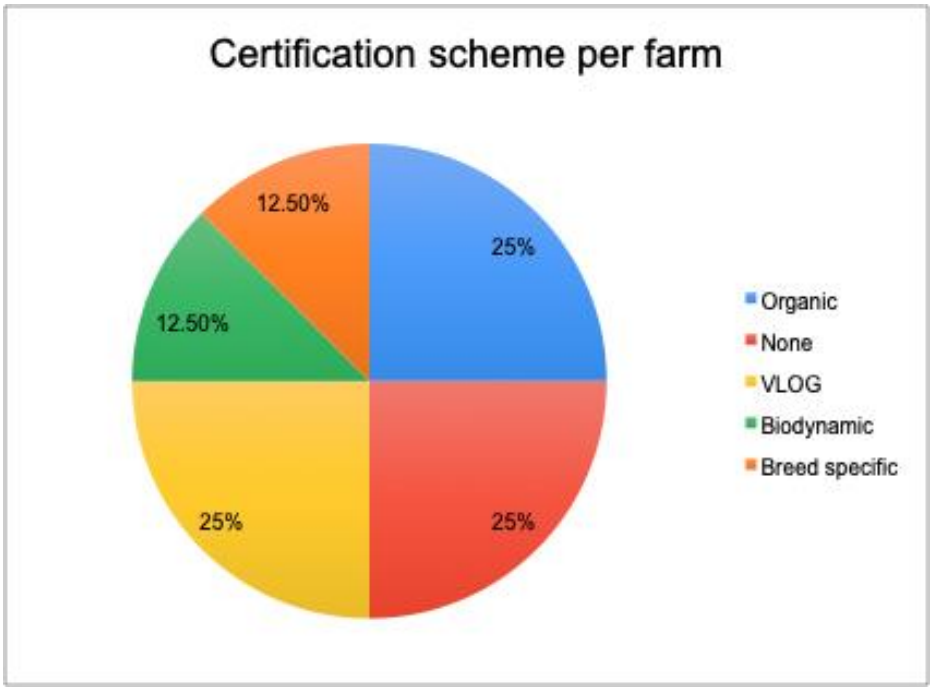


Figure 7. *The certification schemes present on farms, shown in percentages over all farms. One quarter of the farms interviewed had no certification scheme.*

Farmers were asked about factors that influence their breeding decisions. These factors include intuition ("gut feeling"), exterior (physical traits), production traits (milk production, milk contents, slaughter weight), EBVs (estimated breeding values of bulls), and external advice (like CRV, breeding tools, input from other farmers). The factors mentioned by the farmers during interviews were ranked in terms of importance, and the totals were converted to percentages. The method for ranking breeding decisions is further explained in Appendix XXX. The most influential factors that determine breeding decisions are intuition and exterior, both coming in at 26.67% (Figure 8). At 23.33%, production traits are also an important influencer of breeding decisions. EBVs and external advice are least important, coming in at 13.33% and 10%, respectively. For DR1, breeding decisions are influenced most by exterior. For GW1, the most important factor for breeding decisions is EBVs, and for FR1 it is production traits. For the FB1, breeding decisions are made mostly based on intuition of the farmer. For DB1, breeding decisions are mostly based on external advice. For MR1, breeding decisions are based on production traits. Breeding decisions for MR2 are mostly based on external advice and production traits, whereas for HM1 breeding decisions are only based on exterior. Note that the results shown above are not representative for these breeds as a whole, but only represent the findings of the interviewed farmers.

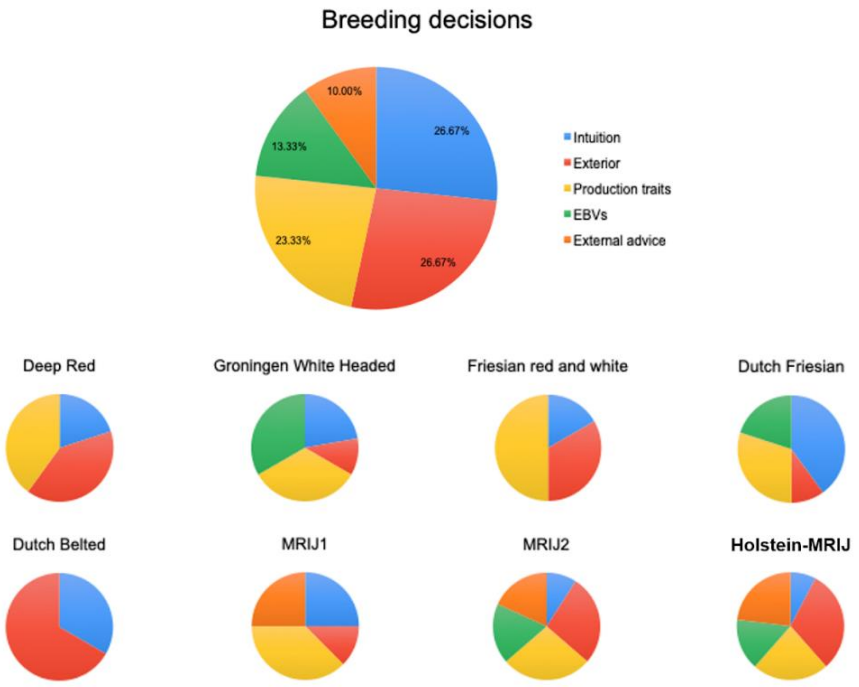


Figure 8. *Factors influencing the farmers' breeding decisions. The data all combined in a general graph. Underneath the general graph, also specified per farm. Decisions have been ranked in terms of importance based on the interviews with the farmers and transformed to percentages.*

There was also some variation in other farm characteristics such as farm size (Table 3). The DR1 and GW1 farms are the largest with 135 and 115 hectares of land respectively, whereas both the DB1 and MR2 farms are the smallest with only 40 hectares of land. Every farm consisted of grassland, however the FR1 and DR1 farms also have some nature reserves, and the FB1 and HM1 farms have cropland. Only the land on the DB1 farm is rented, whereas the land on the FB1 and HM1 farms are owned. For the rest, the land is both partly owned and partly rented. The DB1, GW1, FR1, DR1 and MR2 farms also have natural pastures, whereas FB1, HM1 and MR1 farms do not. In terms of breeding strategy, DB1 and DR1 farms only participate in natural breeding. In contrast, the HM1 and MR2 farms only use artificial insemination (AI). The GW1, FR1, FB1 and MR1 farms use both breeding strategies. 50% interviewed farmers only grow grass, while the other 50% also grow other crops. MR1 also has additional crops and crop rotation consisting of beetroots, carrots and potatoes. As for fertilizers, almost all the farms use manure and slurry as fertilizer. Almost all the farms also use multiple fertilizers, with a combination of manure and slurry or manure and artificial fertilizer. Only the FB1 and MR1 farms use artificial fertilizer.

There were not many differences between the farmers in terms of diet composition (Table 4). Only the FR1 and MR2 farms have no concentrates in their feed, whereas the rest of the farms do have some form of concentrates included in their diet. Additionally, information on whether clover and herbs are added into the feed is also specified. The DB1, FR, FB1, DR1 and MR1 farms do add clover and herbs to their feed, whereas the rest do not.

Table 3. *Table consisting of information regarding the characteristics of the different farms, including farm size (ha), farm type, whether the land is owned or rented, whether there are natural pastures, breeding strategies such as AI, natural or both, crops on the farm and types of fertilizers used.*

Farm characteristic	Rare cattle breed							
	Dutch Belted	**Groningen White Headed**	**Friesian Red and White**	**Dutch Friesian**	**Deep Red**	**Holstein-MRIJ**	**MRIJ1**	**MRIJ2**
Farm size (ha)	40	115	78	32	135	60	90	40
Land use*	Grassland	Grassland	Grass-land & nature reserve	Grassland & cropland	Grassland & nature reserve	Grassland & cropland	Grass-land	Grassland
Owned or rented	Rented	Both	Both	Owned	Both	Owned	Both	Both
Nature management	Yes	Yes	Yes	No	Yes	No	No	Yes
AI or natural breeding	Naturally	Both	Both	Both	Naturally	AI	Both	AI
Crops	Grass	Grass	Grass	Grass and maize	Grass and maize	Grass	Grass, maize and other	Grass and maize
Fertilizers	Manure and slurry	Manure and slurry	Manure and slurry	Manure, slurry and artificial	Straw manure and slurry	Slurry	Manure and artificial	Straw manure

Table 4. *Table consisting of information regarding the diet composition of the cattle on each farm. Concentrates and clover and herbs are included here.*

Diet composition	Cattle breed							
	Dutch Belted	**Groningen White Headed**	**Friesian Red and White**	**Dutch Friesian**	**Deep Red**	**Holstein-MRIJ**	**MRIJ1**	**MRIJ2**
Concentrates in feed	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
Clover & herbs in feed	Yes	No	Yes	Yes	Yes	No	Yes	No

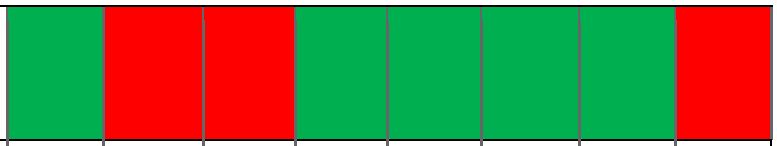
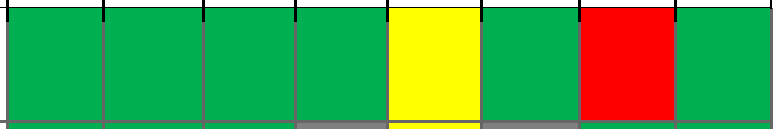
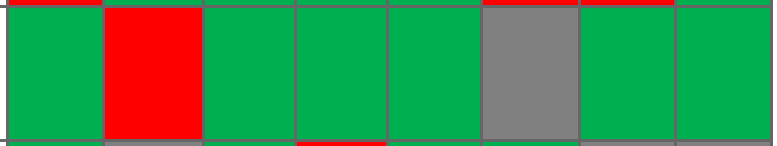
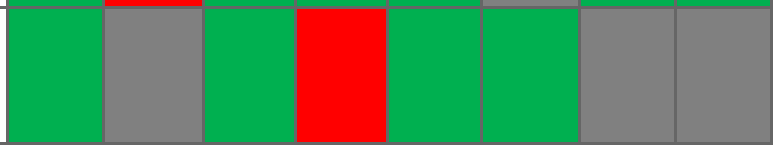
3.1.2 Qualitative Results

Qualitative results were divided into indicators, which were related to interview questions. The researchers looked for tendencies between the farmer's answers and then they were color coded. The green boxes indicate that a farmer gave an answer conforming to the tendency, red boxes indicate their answer did not conform to the tendency and yellow boxes indicate the answer was neither in agreement or disagreement with the tendency. The color coding easily visualizes the strength of the tendences (Table 5). The tendencies are described in a few words in the table as well. A tendency is considered strong when six or more of the farmers agree with the tendency, a tendency is moderate when there are five farmers in agreement, and a tendency is light when four farmers are in agreement, and the remaining farmers are either in disagreement or neither in agreement or disagreement. However, some tendencies may deviate a little from this classification.

Table 5. Visualisation of tendencies between interviewed farmers.

Indicator	Tendency	DB1	GW1	FR1	FB1	DR1	HM1	MR1	MR2
Herd characteristics									
Herd Strengths	Strong tendency: strengths connected to extensive farming								
Fertility problems	Strong tendency: few fertility problems								
*Insemination rate**	No tendency: A lower insemination rate than Dutch average								
Calving problems	No tendency: Few problems with calving								
Mortality rate	Moderate tendency: low calf mortality								
General health	Strong tendency: fewer health problems than in normal herds								
Veterinary costs	Strong tendency: lower veterinary costs and visits								
Cattle breeds									

Genetic diversity	**Strong tendency: worry about the genetic diversity for the breed**								
Purebred/crossbred	**Strong tendency: have or move towards purebred herd**								
Farming systems									
Breeding	**Moderate tendency for use both AI and natural breeding**								
Feed ration	**Light tendency for lower quality ration than normal**								
Barn type	**Strong tendency for use of cubicle barns**								
Ecology									
Nature management	**No tendency to participate in nature management**								
Economics									
Consumers	**Light tendency to selling to milk factories**								
Cost comparison*	**Moderate tendency lower costs than average farm**								
Breed impact economics	**Strong tendency towards positive impact on economics**								
Side activities	**Moderate tendency to having side activities**								
Impact of nitrogen regulations*	**Moderate tendency: nitrogen regulations have no impact**								

Impact of PO5-regulations	Light tendency: PO5-regulations have no impact	
Implementation		
Reason for breed	Strong tendency to conscious choice	
*Change of breed future**	Moderate tendency to keep breed	
*Trait implementation**	Strong tendency to use traits for business	
Future opportunities for breed	Moderate tendency for breeds in future extensive farming	
*Threats & challenges – Breed**	Strong tendency that genetic diversity is a threat	
*Threats & challenges - Farm**	Light tendency toward regulations can be problematic.	

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3.1.2.1 Herd characteristics

Strengths

There is a strong tendency that the strengths of the rare breeds can be connected to qualities that are useful for extensive farming. Farmers FR1, MR1, MR2, GW1, DB1, DR1 and FB1 all mention characteristics which are generally associated with more extensive farming as the strengths of their herd: do well on lower quality feed, are more robust and healthy, produce high quality milk and meat and have good fertility. Farmer HM1 also mentions robustness and milk protein and fat contents but puts more emphasis on the exterior of the cows and the milk production, which has increased significantly in recent years.

Fertility problems

There is a strong tendency that rare breeds have less fertility problems than high producing breeds. Farmers FR1, MR1, MR2, GW1, DB1 and DR1 note that they have very few fertility problems. FB1 also notes few problems but says that he does not have enough time to spend on fertility and insemination, so cows would get pregnant quicker if he had more time. HM1 also notes that his MRIJs have few fertility problems, but specifically says that this is not due to the breed, but to lower milk production.

Insemination rate

There is no tendency for insemination rate because three farmers did not give much information on this topic. FR1, MR1 and GW1 show a pattern with a lower rate than the Dutch average of 2.3 (all below 1.5). HM1 is a bit higher at 1.87 and MR2 is higher still at 2. This is still lower than the average. Also, some farmers use bulls if the cows do not get pregnant quickly, which may distort these results.

Calving problems

There is no clear tendency for less calving problems than high producing breeds. FR1, GW1, DR1 and FB1 all note that they rarely have problems with calving in normal situations. In abnormal situations, such as twins, the farmer or the vet sometimes has to assist. MR1, MR2, HM1 and DB1 all note that, although there were significantly fewer calving problems than on an average farm, they do occur. MR1 said that calves are quite heavy, and that the farmer was always present at a birth. MR2 noted that the farmer or the vet did have to assist with a jack at regular intervals. HM1 noted that calves could be a bit heavy, which could cause problems. DB1 said that the heifers often required assistance, from the 2nd calf on that was rare.

Calf mortality rate

There is a moderate tendency for farmers to have a lower calf mortality rate than high producing breeds. Almost all farmers note that calf mortality is very low. This ranges from a couple of calves per year (FR1 and DB1) to 5% (GW1). MR2 notes that calves are sometimes stillborn, but otherwise almost always survive. MR1 has a calf mortality rate of 8% and notes that sometimes calves die during birth, because they can be too heavy when he useds Belgian Blue bulls. Calf mortality at HM1 (10%) and FB1 (11%) is more in line with the national average.

General health

There is a strong tendency for less health problems. All farmers seem to experience fewer health problems than in normal herds, although they (almost) all do have some specific problems. Interestingly, these problems differ between farms, e.g. HM1 never has a displaced abomasum, while FB1 notes that it does sometimes occur. MR1, GW1 and DR1 specifically note that they have very few claw problems, while FR1 points out that that is the one problem that did occur last year in his herd. FR1, GW1, DB1 and MR2 point out that they have no or very few cases of milk fever, while it does occur in FB1's herd. MR1 and GW1 specifically mention udder health and mastitis, while it also occurs on a number of the other farms (including HM1 and MR2). No farmers have stated that mastitis does not occur on their farm.

Veterinary costs

There is a strong tendency for lower veterinary costs and less veterinary visits. All farmers mention that the vet comes less often than on an average farm. HM2, DB1, DR1 and MR2 say that the vet mainly comes for regular, periodical things such as vaccinating or pregnancy scanning. MR2 notes that his veterinary costs are comparable to the Dutch average, but a large part of that is due to his bulls, and for the dairy cows it is lower than the Dutch average. HM1 knows that his vet costs are 0,49 euro/l of milk, compared to a Dutch average of 1,10 euro/l.

3.1.2.2 Cattle breeds

Genetic diversity

There is a strong tendency that farmers do worry about the genetic diversity in their breed, although they do not think it is an issue at the moment on their farm. They can still use enough breeding material to prevent inbreeding. They also think that a high level of genetic diversity can still be maintained in the breed, although measures need to be taken about it. The exception is GW1, who does not think genetic diversity is a problem as a lot of outcrosses were made after an inbreeding crisis in the 1960's, and now the level of kinship is at 7%.

Purebred/crossbred

There is a strong tendency that farmers either have (almost) only purebreds, or that they would like to go into that direction but have not reached that point yet. This is mainly because they like the breed and want to preserve the breed by keeping it pure. It is also important to guarantee you have the positive traits of the breed. There are two exceptions: MR2 regularly crosses with Holstein Friesian (currently 7% Holstein Friesian blood in the herd) if a specific cow would be improved by that. HM1 mostly breeds a cross between Holstein Friesian and MRIJ, to get a robust cow with a high production.

3.1.2.3 Farming systems

Breeding

There is a moderate tendency for farmers to use both AI and natural breeding. Most farmers use both AI and a bull, the latter mostly after one or more inseminations have failed. HM1 only uses AI, and DB1 and DR1 only use bulls.

Feed

There is a light tendency that rare breeds perform optimally at a lower quality ration than normally. For FR1 this means only grass with a bit of lucerne pellets to ease the milking process. For GW1, DB1 and DR1 that means mainly grass, but some concentrates are necessary to increase production and keep the animals in a good condition. For MR1, MR2 and FB1 that means grass, maize and some lower-quality, cheaper concentrates, so that production is at an acceptable (higher) level. HM1 says that he has to buy feed anyway and that more expensive feed pays itself back via a higher production.

Barn type

There is a very strong tendency for the use of cubicle barns. All of the farmers use cubicle barns, although some combine that with a straw-bedded barn. However, FR1, GW1, DB1 and DR1 indicated that they would prefer to use (more) straw-bedded barns, because of perceived higher animal welfare, less disturbance in the herd, lower costs or higher quality manure. However, they are currently not able to convert to just straw-bedded barns, due to the other barn already being in place, more work to bed and muck out the straw-bedded barns, difficulty to convert the current barn or that a straw bedded barn would need too much space.

3.1.2.4 Ecology

Nature management

There is no clear tendency among farmers to participate in nature management. FR1, DB1 and DR1 fully participate, with natural grassland, grazing in nature reserves and other schemes such as delayed mowing or extensive grazing. Two farmers are less involved in nature management, with MR1 having natural field margins and some meadow bird conservation and MR2 renting 4 ha of natural grassland from the local Water Board. GW1 does not participate as he wants to manage his grass optimally for his cows and not for nature. HM1 and FB1 do not see the need for participating in nature management and say the existing schemes do not fit their farm.

3.1.2.5 Economics

Consumers

There is a light tendency for farmers to sell their milk product to milk factories. Four farmers only sell their milk to a regular milk factory. FR1, GW1 and DR1 also sell their milk to a milk factory but combine that with selling some meat of their animals directly to consumers. Only for DB1 is direct selling the majority of his business, as he sells all the meat of his beef animals directly to consumers or restaurants. The reasons that are given for selling to the milk factory are ease, the ability to sell large quantities and the fact that for organic or biodynamic milk the price is good, anyway.

Cost comparison

There is a moderate tendency for farms to have lower costs, however two data points are missing. Most farms mentioned that they have a lower cost of production than the average Dutch dairy farm. Reasons mentioned are lower input costs, lower veterinary costs and higher income from meat due to the dual-purpose animals. DB1 did not mention a cost of production and is difficult to compare to the others as it is a beef farm. FB1 also gave no cost of production. MR2 said his cost of production was about the average, but that was mainly due to the high input costs for the breeding bulls and the cost of production was lower than average for the dairy part of his farm.

Breed impact on economics

There is a strong tendency that these breeds have a positive impact on farm economics. No farmer assumes that the breed has a negative impact on their farm economics. FR1 says his cows perform well, but that might also have been the case with foreign breeds like Fleckvieh or Montbéliarde. MR1 says that the margin per cow for his MRIJs is at least as good as for HF cows. DB1 explains that his customers buy meat partly because of the story of the breed, and they stay because of the Dutch Belted superior meat quality. DR1 says that the breed's impact is positive but thinks that if his cows yielded 1000 litres per year more, that would increase income without increasing costs that much. MR2 said that lower costs and a higher milk price (due to good fat and protein contents) was the reason for good economic performance on his farm. FB1 was ambivalent about the economic balance between lower income and lower costs on his farm. HM1 could not say whether the MRIJs or the HF cows performed better on his farm, and he preferred the cross with HF to achieve higher milk production.

Side activities

There is a moderate tendency against doing side activities next to the cattle farm. HM1 was active in several organisations and also including some experimental fields for new grass varieties on his farm. Furthermore, he grew sugar beet and rented out land to other farmers. DR1 has a farm

shop which also sold products that were not from his farm, and also did agricultural journalist work. DB1 rented out some spaces to boats near his house and did some receptions and renting out of buildings. The other farmers had no side activities.

Impact of N regulations

There is a moderate tendency that nitrogen regulations have no impact. Five of the eight farmers expected no problems from nitrogen regulations for their own farm. The reasons for this were that they were far away from Natura2000 areas or that they expected not to be affected because they were already sustainable or had few emissions. HM1 said he did not know what the effect on his farm would be as the regulations are not decided yet, but he said it could have an impact in the future. FB1 said that he already had an impact from the current manure regulations because he has to pay for people to take his manure.

Impact of PO5- regulations

There is a light tendency that phosphate regulations have no impact. Most farmers said that phosphate regulations had no significant impact on their farm. This was mostly because of the particular circumstances on their farm: they had received permits to expand on time, they had enough land so their rights were not reduced or they did not want to expand in the future. The exceptions were HM1, who said that phosphate rights had made him reduce the number of young stock, but that had actually made his farm more efficient, and DB1 who said that he ignores the phosphate rights and trust he is not inspected. FR1 and GW1 were significantly impacted by phosphate regulations because they had to buy phosphate rights as they expanded. MR2 had to cull animals and says it influenced the decisions on which cows to keep and which to replace.

3.1.2.6 Implementation

Breed choice

There is a strong tendency that farmers made a conscious choice for their breeds. The main reasons given were that the farmers liked lower inputs, robustness and dual-purpose cows. DB1 also said the story behind the breed and the meat quality was important for his choice. MR1 said there were already MRIJs when he started, and he has not crossed with Holstein Friesian because he does not see the need. DR1 says he came across the breed by accident.

Changing breed in the future

There is a moderate tendency for farmers to not change breeds in the future. Five farmers said they would not consider changing their breed in the future, because they did not see a need, they preferred their current breed or they had already invested in it too much. DR1 is crossing some cows with Dutch Friesian to improve milk yield. Two data points are missing here.

Trait implementation

There is a strong tendency that the breed traits are used for business purposes. All farmers that gave information on how they implemented the positive traits of their breed on their farm said they could use these traits positively. They mentioned lower costs and higher milk prices and meat prices. Two data points are missing here.

Future opportunities for the breed

There is a moderate tendency for farmers to think Dutch rare breeds have a future in extensive farming. Five farmers mentioned that they thought dairy farming in the Netherlands would become more extensive in the future, under pressure from the government or society or otherwise. They said this would present opportunities for their breed and rare breeds in general, because they perform better on the lower inputs associated with extensive farming. MR2 specifically mentioned a farmer that had recently converted to organic and wanted to buy MRIJ bulls, because his HF cows had severe health problems on the lower-quality organic diet. GW1 said that he thought that land suitable for human food production would not be used for animal feed production, and that rare breeds do better on just roughage. FB1 also mentioned the more frequent health issues on most HF farms, and that public perception would favour rare breeds because of that reason. Three farmers mentioned other opportunities: MR1 said better marketing of rare breeds produce to achieve a higher price, HM1 mentioned the milk market in general and DB1 a specific marketing route for Dutch Belted meat.

Threats and challenges for the breed

There is a strong tendency that genetic diversity is a threat. Six farmers mentioned the low genetic diversity when asked what threats and challenges for their breed were. GW1 did not, but instead noted the risk that consumers are not willing to pay the extra price for sustainable and rare breed farming products and would instead choose for the cheapest products. He thought that the largest reduction in Groningen White Headed farmers has passed, and that numbers will stabilise now.

Threats and challenges for the farm

There is a light tendency that regulations can become a problem. HM1, DB1 and DR1 said regulations as what could be a threat or challenge to their farm in the future. They did not mention particular regulations, but rather regulations in general or uncertain new regulations in the future. FR1 said he thought he was ahead of regulations but mentioned specifically the risk of a ban on slatted floors. GW1 again mentioned the risk of consumers not being willing to pay a premium price for sustainable farming.

3.1.3 Farmer Summaries

In this section, the interviews of the two remaining farmers are discussed. These interviews are summarised here because the interviews differed from the other farmers' interviews and could therefore not be analysed along with the other farmers' interviews.

Multiple breed farmer

Mr. Aalvanger first described his farm. He sees himself as a 'Witrik-breeder' and has 18 Witrik cows. Furthermore, Mr. Aalvanger has 14 Groningen White Headed animals, 2 Dutch Belted, 3 'blue-pied' and 37 black or red pied (a combination of MRIJ and Dutch Friesian). In his breeding choices, he focuses on keeping Witrikken, and for the rest focusses on exterior qualities and high milk fat and protein contents. The diversity of breeds on his farm means that he is not worried about genetic diversity for himself but does see it as a problem for other rare breed farmers. As an example, he mentions that many of the new bulls used in the Friesian Red and White breed are from the gene bank and have therefore been used before in the bloodline of many animals.

Problems with fertility or health are rare on his farm, and he does not notice any health differences between the breeds. In general, there are differences between the breeds though. For example, he also notices Groningen White Headed have a particular 'wild' streak to their character: they notice potential threats very well and are less easily handled. They also perform much better on a very low quality diet than the MRIJ. Nevertheless, Mr. Aalvanger is not preoccupied a lot with feeding and feeds more or less the same diet to all cows. He thinks the Dutch Friesians produce the most milk, followed by the MRIJ and then the Groningen White Headed. However, the latter do yield higher fat and protein contents.

Mr. Aalvanger sells his milk to a normal milk processor, and is not certified for anything except 'pasture milk'. Throughout the interview, he mentions that there are few issues with his system of farming. On the other hand, regulations are a problem, especially concerning his tied-stall barn. For the rare breeds side though, regulations do not matter much. One example he gives is that due to the lower production of his animals, he can keep a couple cows more on his phosphate rights than he would if he had Holstein Friesians. However, while he appreciates the 150 euros subsidy, he does not think it will be a significant incentive for farmers to transition to Dutch rare cattle breeds.

Witrik farmer

Mr. Nijman starts off by explaining the Witrik, this is a color variety that occurs in multi-colored breeds. This variety has been present since around 1344. This Witrik coloration inherits intermediate, so if you crossbreed two Witrik cows there is a 50% chance for a witrik color, 25% for a normal spotted color and 25% for white colored offspring. Hereby, the white offspring are the actual "purebred" Witrik. These animals however are not all liked and have some fertility problems. Overall, traits of Witrikken that are mentioned by their keepers are health, good legs, long productive life span and fertility.

There is a distinction between dual purpose Witrikken and Holstein Friesian-Witrikken, dual purpose Witrikken are found more on small-scale farms (up to 70 cows mostly), like most of the other rare breeds. In the opinion of Mr. Nijman the people that are interested and working with the rare breeds already look at a more extensive form of agriculture, starting with lower milk production and then joined by lower feed costs and lower veterinary costs. He thinks that people should look at the revenue (margin) per cow to know if they can achieve a decent revenue per cow regardless of the lower milk production and the more extensive farming methods.

The rare breeds are built to digest a lot of roughage and produce. In Mr. Nijman's opinion sustainable farming is that you breed an animal who can achieve your goals (milk or beef production), who lasts long and who can achieve those set goals on a feed ration that is produced on your own land. Therefore, a production of 10K liters per cow per year is simply not possible here in the Netherlands to feed from your own land. However, the consumers should be more willing to pay extra for the products to make it possible for the farmer to do extensive farming. There should be a way found to factor the environmental damage into the price of the product, he thinks. The responsibility therefore lays with politics, they should instigate this. Ideally, he would like to see the production chains to the consumer to be more transparent and clearer. There needs to be more understanding between farmers and consumers. Quality marks are in his opinion not the solution, the public is drowning at the moment in them and has no idea what they mean,

According to Mr. Nijman, sustainable farming means that there has to be no nonsense. With this, he means that the increasing world population needs to be educated about what is good food and where that food's origins lie. The chain between producer and consumer needs to become more transparent and maybe even shorter.

3.2 Experts

Summaries of the interviews with the experts can be read here. The most important information from the interviews is highlighted in these summaries.

3.2.1 Policy and animal productions systems

Mr. Sipke Joost Hiemstra started off by explaining the work of the Centre for Genetic Resources Netherlands (CGN) for the conservation of rare breeds. He explained that although CGN is supported financially by the EU and the Dutch Government, they experience obstacles in their work from the regulations. An example is the tight veterinary standards in the collection or use of semen for their genebank, which make it difficult to operate effectively. These regulatory problems have been somewhat alleviated in recent years when the Government has been more open to making exceptions for the purpose of conserving rare breeds. In general, regulations tend to negatively affect rare breeds indirectly, but not directly.

Mr. Hiemstra is afraid that as a consequence of the nitrogen issue, farming and nature will be more separated, and this will be detrimental to nature-inclusive systems including rare breeds. An example is that cattle will not be allowed to graze in protected natural areas anymore. However, there is a possibility that the opposite will happen when nature and agriculture are more integrated in agroecological systems. He fears that if nitrogen or greenhouse gas emissions are just looked at per unit of produce, the more efficient modern breeds will be at an advantage to rare breeds. However, he thinks other objectives, such as nature or inputs should also be taken into account, and that rare breeds perform better there.

Mr. Hiemstra mentions subsidies and gives the example of a government subsidy in the 1990s that supported rare breeds. However, the administration cost of that subsidy was much higher than the money paid to farmers, so it was discontinued. Afterwards, the government refused to reinstate a subsidy for rare breeds, until a few years ago. As Mr. Hiemstra explained, this new subsidy is part of EU policy like most policies concerning rare breeds, and then worked out by the national governments. The subsidy is intended to meet reduced income from rare breeds, and it set a 150 euros per Dutch rare breed milking cow in the Netherlands. However, while Mr. Hiemstra thinks this is welcome for farmers, he does not think that it will entice many farmers to switch to Dutch rare breeds. In general, he sees subsidies for rare breeds as a useful tool in supporting them, he does not think they can or should be the main way of conserving them. This is both from a practical perspective, that it would be too expensive, and from a theoretical perspective, that the breeds should have a function on a farm more than just to get subsidies.

Mr. Hiemstra thinks the best way to preserve rare breeds or expand their use is to make changes in the entire farming system. He mentions that rare breeds are often kept in multifunctional farming systems, where primary production is not the only goal. In these systems, rare breeds perform well because they are robust, cope with lower feed quality and other inputs and have a friendly character. He sees the future of rare breeds that these systems are used more and that then the animals are adapted to the system. This idea fits with the Government's expressed objective to move towards circular agriculture and more nature and landscape-friendly agriculture. However, the use of rare breeds should be financially sustainable for farms. Mr. Hiemstra thinks that more extensive and nature-inclusive farms should be paid for the public services they provide, by either high prices or the government. If Dutch rare cattle breeds perform well in these systems and have a function in these farms, they will then be used more as more farmers switch to this type of agriculture. Mr. Hiemstra says that the reason that rare breeds got out of common usage is that they did not fit in the intensive systems which were then popular. However, he says that although he cannot prove it, his gut feeling is that rare breeds will perform much better than modern breeds in systems where production is not the only or main goal. He cannot say whether Dutch breeds are better adapted to the Dutch climate and environment than foreign breeds. Mr. Hiemstra mentions that, whatever happens, an increasing diversity in farming systems means an increasing opportunity for different breeds or breeding goals.

3.2.2 Genetics - Interview 1

Mr. Henk Sulkers works at CGN and takes care of the daily business regarding the Gene bank. This daily business regards all Dutch farm animal and pet breeds. Up until '75 the whole cattle population consisted of original breeds, then the import of the Holstein Friesian started. Nowadays the 7 breeds cover only 1% of the Dutch registered cattle. The numbers are difficult to obtain since some breeds use more than one breeding organization for registration. However, the numbers are going up and down over the years, with once in a while a sudden increase due to the discovery of a farm with unregistered animals.

Mr. Henk Sulkers (CGN) identifies the large crossbred displacing as the biggest bottleneck, especially for the Groningen White Headed population. When breeders saw their neighbours reach enormous production with these crossbreeds, they followed. The gene bank plays an important role in the preservation of the breed and was the solution for the breed after the bottleneck. Nowadays you see bulls with a pedigree entirely made by the gene bank or it closely touches. The Friesian Red & White has been leaning on the gene bank since about '93 till a couple years ago, nowadays they barely need 40 straws a year. That is a tendency Mr. Sulkers sees, the breeds are becoming more self-sufficient over the years. Also breeds that do not get milked like the Dutch Belted experienced a bottleneck, in 1950 when the government announced a bull regulation. This meant that there were no bulls allowed from other breeds than Dutch Friesian, MRIJ and Groninger White Headed, and these needed to be black. With help of the import of American Dutch Belted bulls, the Dutch Belted type got preserved. Then, the Dutch Belted had their turn to help with restoring the Sheeted Somerset in England, which got displaced by modern milking breeds as well.

The genetic diversity in the breeds is a difficult topic according to Mr. Sulkers. For a healthy population a certain number of animals is needed and that is not achievable for these rare breeds. Especially for breeds that are kept more in biological ways this gets limited due to prohibitions of procedures like ET, Ovum Pick Up etc. This also means that, with exception of the MRIJ with their

larger population, there are no breeding values available. In terms of genetic diversity problems, he would say the Deep Red are most critical. This is because a lot of animals are not commercially kept, mostly as a hobby. Nevertheless, he says that the farmers are very conscious of genetic diversity and it's risks, which is maintained by the gene bank. For example, in the Dutch Friesian population they have a fundamental breeding program which is followed responsibly. In this program a certain amount of kinship/inbreeding is accepted. In the other breeds, this just happens due to insufficient unrelated males to avoid inbreeding effects. He experiences however that the commercial farmers are more open towards new ideas than hobby farmers, commercial farmers just want to make production where the hobby farmers are more focussed on keeping to the breed regulations.

Mr. Sulkers sees a lot of variation in the ways these breeds are kept, Dutch Friesian, Friesian Red & White and Groninger White Headed are mostly kept on commercial farms. This is a tendency that has been going on for ages, grandpa keeps Groninger White Headed, dad starts Holstein Friesian, but the son wants to go back to Groninger White Headed. There are some farms that milk Deep Red, but you can see the difference in production, but they think that acceptable. With the minimum on mechanisation, older buildings, they can get around fine with not so many cows. Since the rare breeds are known for their easy maintenance, they go with whatever they get. They don't need luxury and maybe lose a little bit on production but will rather look out for themselves than for the farmer.

According to Mr. Sulkers all breed communities have their own view on genetic diversity, the Groninger White Headed community wants to go to a double purpose cow and the Deep Red, like the Dutch Belted, rather focuses on the color and marking. Nonetheless, he sees the rare cattle breeds as very important to the total genetic diversity of Dutch cattle, especially due to their diversity and deviation from the other breeds. They can be seen as gene pools of our history and should therefore be valued. Even with the introduction of Holstein Friesian, the rare breeds did not remain too far behind. They stand out for their protein contents, and the amount of milk production increases over the years. Mr. Sulkers sees potential for the breeds in the future, since he thinks presently the value in the genetics of these breeds are not fully known but could be crucial to bring back in the future cattle populations. However, he thinks it is not necessary to keep these breeds purebred. The crossbreed of Holstein Friesian with Groninger White Headed he appreciates most, as it gives good productions and looks really good. Crossbreeding in between the rare cattle breeds is not an option, especially the Dutch Belted and the Deep Red are not at all open to such an idea, they are too stuck on their own type of cow. The Dutch Friesian and friesian Red & White do interchange once in a while.

Characteristics that stand out for these cattle breeds are health, fertility and lower input requirements. For the Groninger White Headed there has been a comparison done with Holstein Friesian and it concluded that lower production leads to a lower feed requirement, which lead to a lower emission of nitrogen and other gasses. And then the production is still reasonable, but the cows can last longer so the replacement percentage is lower. The time of insemination is also lower for the rare cattle breeds than in Holstein Friesian, a good fertility is an important characteristic of the rare breeds. Less favourable characteristics Mr. Sulkers find hard to come up with, there is not much known or told about inheritable genetic disorders. There are some disorders, like the smooth tongue in Dutch Friesian, that is still in the breeds and even in the bulls in the gene bank. That is something I'm warning about. He thinks it is interesting to also store the

genes of these animals with disorders, so you have material of negative parts too so you can research it more.

The future of the rare breeds Mr. Sulkers sees as moderately positive, especially the low numbers are a complicating factor. However, in the present the rare breeds could be more fitting to the new Dutch agriculture ideas than high producing breeds like Holstein Friesian. A possible threat is the tendency now to crossbreed Holstein Friesian with international breeds, the amount of Jersey nowadays is quickly increasing. This way the rare breeds are pushed to the background again, you need real breed fanatics to keep these breeds upstanding. Even in nature reserves international breeds like the Scottish Highlander get chosen over the rare cattle breeds, that is a real danger for the rare breeds. However, Mr. Sulkers still thinks that the breed needs to fit well with the farmer but also at the same time with the farming system.

3.2.3 Genetics - Interview 2

Mr. Henk Lutke Willink works at CRV where he is responsible for all breeds except the Holstein Friesians. CRV's mission is to be leading. They want to be customer-oriented in the field of livestock improvement. This is a key item for CRV. It does not mean to make a more beautiful cow, but to make a better cow for example in health, protein content, A2A2 etc. To use all the information that they have to make a better cow than the ancestors. If they can use all this information, it will be in service of the animal and farmer. CRV tries to supply the best genetics and information products that help farmers to maintain a healthy and efficient herd. Resulting in perhaps a higher income and possibly stimulating diversity if this is a wish of the customer.

CRV is seen as a Holstein Friesian orientated company. Mr. Lutke Willink thinks this is because Holstein Friesian is the biggest group they represent in the Netherlands. Nevertheless, they want to fulfil all the needs of the customers, even if this is not Holstein Friesian orientated. They do not make a distinction between breeds, but the amount of attention is related to the size of the breed. But if you compare the sales with the attention, then smaller breeds get a lot of attention. Also, he has the idea that you can never keep everybody happy. If you give one breed attention, the others are complaining. Nevertheless, he thinks that they are doing it right. They are always in contact with the farmers of small breeds as well. CRV really takes that seriously, there is an important interaction between them. CRV needs the information and the farmers need CRVs products. For CRV, demand and supply are very important. They want to meet the broad demand of their clients. To do this, they need to adapt quickly to developments which change the needs of their clients and look ahead for possible developments. In the past, they sometimes did not react adequately to certain developments. They saw the market change and decided to adapt their policy. They changed from only beef cattle, Holstein Friesian and MRIJ to having a lot of different breeds in their offer. In his perspective, it is important that CRV really is listening to what the farmer wants and trying to help him/her where possible. The knowledge is present in the company for the larger breeds as well for the smaller ones. Above all, they need to be able to think and participate in the discussion from the client perspective.

CRV is a cooperation with starting at the base with farmers, their clients. They are also involved in certain decision-making through meetings. Furthermore, they have two advisory boards within CRV which provide them with input for anticipating possible developments in the future and making policy. Also, external parties such as Friesland Campina for example are involved in information exchange. Furthermore, they have a committee of ethics to make decisions in what

is allowed in for example DNA manipulation. There are no restrictions in their policy imposed by the government or others.

He sees that the current livestock population is centered in provinces like Friesland, Groningen and Zeeland. Dairy cows are currently located on the grasslands in the Netherlands. Dairy farms are sold at the sand soils. So there is a change in number of animals per region. They don't see this as something negative. At the sandy soils, you see that animals are more kept inside. On the other side, there is more grazing outside at grasslands. And for example, in some areas not able to cultivate corn. This can lead to a certain division of type cow that is necessary on a certain soil with certain farming conditions. Going back to the past where the better cows were present on rich soils and the lesser cows on poor sandy soils.

The farmers that are farming with a rare breed are in his opinion an untypical farmer. He thinks you need to be quite stubborn if you are still farming with these breeds. They are doing something different than your neighbours and the rest of the world. They are following their own beliefs. Mr. Lutke Willink has a lot of respect for these farmers. Nevertheless, in his opinion some are too much focussed on breed variety instead of milk production or protein/fat content. In his perspective, they always should keep in mind to make profit. On the other hand, it also gives opportunities if people are doing it differently than others. In his opinion, these breeds will be useful if a farmer really wants to sell a story, are self-purifiers, and sell their products in a little shop at home. There are opportunities for these breeds in this niche market. Nevertheless, he thinks this will always be a small market. And you need to take risks to do something different than the rest. With the chance that it will not work out in the right way. For the biological market, the market is saturated. The dairy industry can produce more, but the demand from society is missing for more biological products. Also, the majority of clients of CRV are old-fashioned. These farmers just want to produce bulk and do not really care what is done with their product, it is just important if they earn good money for it. They are also not willing to think about changing the way of how they currently produce.

Mr. Lutke Willink thinks the rare breeds will be where they currently are and where they were in the past. He does not see a trend in the increase of these animals. Nevertheless, he thinks the breeds can contribute with their qualities to other breeds. To create a cow that fits and functions better in the business operations, for qualities as robustness and polled. These breeds are useful for genetic diversity in the whole cattle population. Nevertheless, within their own breeds genetic diversity is an issue. In these smaller breeds, registration of the animals is really important. Of course, also for other breeds but especially for the smaller breeds. Also, it is in the farmers own advantage as the government is currently paying subsidy for registered animals. Within the smaller breeds there is a lack of genetic diversity which leads to a consistent cow. Nevertheless, extremities are also missing in this sense if you only want to use purebreds. Another advantage of these rare breeds is that they are tested under Dutch circumstances. So, you know how they function within these circumstances and therefore you know how their offspring will do in the farming system. Dutch rare breeds are most used in grazing farming systems. So if there will be a change to more nature-inclusive farming, these breeds have an advantage. Maybe some farmers are forced by the government and society to change a little bit. But this is maybe more applicable on the Holstein Friesian than other breeds.

CRV is also currently working on making Holstein Friesian better suitable in the farming systems and will do this for other breeds also maybe afterwards. They are doing this by looking into feed efficiency to lower down their footprint for example. So, creating a cow that is better functioning on aspects as ecological and environmental impact. The focus is currently for foreign breeds and Dutch breeds the same. It is really easy to focus on the larger breeds and sell that story instead of the smaller breeds. Nevertheless, CRV thinks it is important to also have the smaller breeds in their assortment to offer a more diversity and be able to give smaller breeds opportunities. He thinks it is weird that clients get sperm from abroad if it is also available in the Netherlands. It is the task of CRV to set up good breed programs and be able to offer these products. CRV maybe needs to do more in the promotion of the Dutch breeds and certainly can do more. Nevertheless, CRV already offers a lot of data on their breeds, but clients are more choosing from intuition in his opinion. He thinks farmers should focus more on data and on making money instead of just doing something. It is important in his opinion to also visit farmers to also be able to see how it is in practice and hear what they experience and where CRV can help them.

In the future there will maybe be a shrinkage of the numbers of cows with regulations for phosphate for example. Nevertheless, it is what it is and Mr. Lutke Willink thinks the numbers will stay quite consistent. He thinks that in the future there will be a movement towards more grazing farming systems. There can be a side-track where there is more demand towards high quality and healthier products instead of more production. In this side-track, there can be a role for the rare breeds. In his perspective, there will maybe be more a division between two extremes. On one hand, the farming systems with a lot of grazing outdoors. On the other hand, farming systems where the cows are inside (most of the time), due to circumstances or principles. CRV is working to be able to offer cows for both systems, also within a breed. If the government imposes restrictions, farmers and CRV need to look for the optimal instead of the maximum. They need to adapt towards possibilities.

3.2.4 Animal Nutrition

Mr. Wouter Spek works for Wageningen Livestock Research at the chair group Animal Nutrition (ANU). They are currently working on feed evaluation systems for various livestock species like cattle, pigs, and chickens. They have a background in ruminants and have extensive knowledge on energy evaluation systems. One of those systems is the VEM system which was created in the 1970s. It is based on research with cattle from that time period, and this was the time that Holstein Friesians had not yet pushed out the Dutch breeds. The cows at that time were probably of Dutch Friesian type, which means that this specific research of Van Es used Dutch cattle to base the VEM system on. They have also performed research themselves on energy requirements for cattle and used Holstein Friesians. The results were that the modern cow has higher energy requirements than was predicted by Van Es' research with Dutch cattle. This might be because of the way the cow is built. For instance, if the Dutch cattle have less organ weight and more body fat, that means they have lower energy requirements for maintenance. Mr. Spek thinks this is a logical explanation for why modern breeds like the Holstein Friesian have much higher energy requirements. Dutch breeds like the Groningen White Headed or the Dutch Friesian, which are breeds that are not bred for high production levels, would fit the data of Van Es much more than the modern Holstein Friesian. They think that Dutch breeds have lower energy requirements for maintenance and have put in a proposal to research this matter.

Holstein Friesian cattle have very high production levels, which is interesting for farmers depending on their goals. But if their goals are not to produce as much as possible, but to preserve rare breeds, or to do nature conservation, or to make use of the soil most efficiently, then other breeds might be more interesting. Holstein Friesians can mobilize a lot of energy, but they need to get this energy back in some way or another, otherwise they lose a lot of energy. That's why Holstein Friesians need high quality diets that provide a lot of energy, and they do poorly on low quality diets that provide less energy.

Feed requirements are affected by production levels, body condition, farming system, and disease pressure. Animals that produce a lot and have a low body condition score with little body fat, have higher energy requirements than animals that produce less and have a high body condition score with lots of body fat. Ambient temperature also has an effect, because animals need to use more energy when they are not in their thermal-neutral zones. So, it matters if an animal is outside a lot or not, or if the barn is well isolated or not. And disease pressure matters because if it is high, animals need to use energy to stay healthy. Holstein Friesian cattle are bred to produce, so they will produce even if disease pressure is high. On the other hand, Dutch breeds are not bred to produce, so if something is going on with them health-wise, they will stop producing and tend to themselves. So, it takes good managing skills from a farmer to manage a herd of Holstein Friesians.

Mr. Spek is not sure if there is a difference in feed efficiency between breeds but did read some reports on Jersey cattle that suggested this is the case. As for what would happen if Dutch rare breeds were fed a high quality diet instead of a low quality diet: They suspect that the Dutch breeds won't produce much more milk, but instead they are more likely to fatten up. This is likely because they are dual purpose breeds, bred not for milk production, but were always kept for both milk and beef.

When asked if there might be ways to have an agricultural system in which cattle aren't fed concentrates and maize, and no artificial fertilizers are used, so all the nutrients come from the farmer's own farm, Mr. Spek answered that this is like overexploitation of the soil. In the end they think this kind of system does not work, because you are taking more nutrients from the soil than you are adding back to it. One way to add nutrients back is by spreading cattle manure on the soil. But because you produce milk and beef, and those products leave the farm, you lose those nutrients and minerals and are not replenishing them on the farm. In that way you are mostly taking, and not giving enough back.

Last but not least, when asked about the future of agriculture in the Netherlands, Mr. Spek said that you have to look at the soil and use it for which it is best suited. For example, the peatlands in the west are not suited for agriculture in any way. Those soils are only really useful for nature grounds. And then you have the Flevopolder which is extremely fertile grounds, which should only be used by intensive livestock systems if you want to keep cattle there, otherwise it's a waste of the soil's potential. And then there are Natura 2000 areas, where the surrounding farms would do best if they are extensive due to nitrogen emissions. So, you really need to look at the soil type and its potential.

3.2.5 Policy & Nature management

Mr. Roelof Bos is working for the Province of Friesland as project manager to work together with other involved parties towards a further transition to sustainable agriculture. The policy of the

Province is based on multiple factors. Mainly on what society wants concerning nature-inclusive agriculture, sustainability and ground bound etc. If society wants it, politics wants it as well. Also, the Dutch government and farmers in the province want it. Friesland is a real agriculture province. The Province of Friesland felt that farmers in their province wanted to change as they say that more production and more intensive a death end was. There are more farmers that are interested in making the change towards a more sustainable, nature-inclusive farming system. Nevertheless, they need information from experts and compromise nothing economically. The province is telling the government that they should give the farmers certainty by having long term policies. The Province of Friesland decided in 2017 to submit a policy letter to achieve a sustainable, ground bounded agriculture in 2030 in the province. They are currently working on projects to be able to achieve this. In these projects different parties are involved, as society, government, farmers, nature organisations etc.

In the transition towards a more sustainable, ground bounded agriculture, economics is really important. It needs to be economically attractive for the farmer to switch towards an ecology friendly way of farming. The province has little possibilities to steer farmers towards a certain way of farming. The government and ministry are making policy. As a province you are not allowed to pursue policy or set standards yourself. So, the Province of Friesland supports and facilitates the farmers. The province does this by using three pillars: knowledge, subsidies and network. The province does not do this just with farmers, but also with the dairy industry and education institutions. They try to help all involved parties to achieve the goals. So, the province is very limited because they have no legislative power but try to support and facilitate other parties where possible. Nevertheless, on spatial planning the province can do something with policy. They are able to say where they want to have stables, buying up pig farms and relocating companies for example.

All aspects to include ecology more in agriculture are important for the province. Nevertheless, there are three main focus points. Firstly, Meadow bird policy is a main focus point of the province. You see that the numbers of meadow birds are declining in the province. This is also a subject where the province can make policy about. Secondly, an important focus point of the province is landscape management. It is important for the province to show their beautiful landscape to their citizens as well as to others. The intensification of farming is at the cost of the landscape. Lastly, water management is important for the province. This is for example focussed on biodiversity in surface waters. These aspects are also most important for the province as it is something which citizens will see and can participate in themselves. And in all the aspects where they can make a difference, they bring parties together or stimulate education. But again, with regulations or laws they are not able to do it, only with meadow birds' regulation a little bit.

For the characteristics that are connected to nature-inclusive agriculture, the most important one is extensification. Making sure that farmers have more land for less animals. Also, circularity is part of that. The province is trying to close regionally more cycles. So, less inputs from abroad. Another important aspect is to include nature in combination with landscape as much as possible. The last one is economics. These characteristics should all be applied in a way where there is a revenue model for the farmers. A lot of farmers are interested to change, but still need to be able to make money out of it. This can be done by the dairy industry paying a higher price for the products or that the products are sold from home. For the province saving the local heritage, the local breeds, is important from a cultural-historical point of view. In the past you say that farmers were breeding for a higher milk production. Nowadays, you see that more and more farmers are

also selecting towards sustainability, able to deal with lower quality of feed and robustness within their herd. But this is definitely a decision farmers make and the province has no influence on in his opinion.

A development that Mr. Bos sees in general is that farmers and nature management organisations have more interaction. They are working more together to help each other out. This is especially for beef cattle, as these nature areas are not really suitable for a good milk production. Nevertheless, this is also really limited in the province of Friesland as this is only possible near the Friese Wouden as there are some natura 2000 areas. This is more applicable in provinces like Brabant and Drenthe possibly.

The province is currently working on the implementation to be able to achieve the goal in 2030. They are doing this by supplying the network and helping the right parties to connect. This will be set up in a project where the farmer can come to the province for advice on being (more) nature inclusive. The province will supply a network with experts in different fields, like policy, nature, economics etc. Nevertheless, the province does not want to be the head of the project as they think it should be an independent organisation. There will become money available from LNV to be able to give this farmer advice for free. In this project three pillars are present. These are research, information and education.

4. Discussion & conclusion

In this Chapter, the results from Chapter 3 are discussed for each of the four sub-questions that the results correspond with. Then, limitations of this research are discussed and lastly, conclusions are drawn and recommendations for future research are given.

4.1 Characteristics of Dutch rare cattle breeds and farming systems

This section discusses results pertaining to the first sub-question. The first sub-question is: 'What are the characteristics of Dutch rare cattle breeds and their farming systems?'. This sub-question is split into a section about characteristics of the rare cattle breeds and a section about farming systems.

4.1.1 Breed characteristics

Like most Dutch cows, the cows of the interviewed farmers received grass as the basis of their diet. For all farms, this was fresh grass in pastures in the growing season, and silage in the winter or when grass growth was insufficient. The time that the cows spent outside varied between 180 to 270 days per year, higher than the average for Holstein Friesian cows at 90 days per year (figure 2). Farmer FR1 supplemented the grass ration just with lucerne nuts in the parlour to ease the milking process. Three farmers (DB1, DR1 and GW1) supplemented grass with some concentrates to maintain the cows' condition and increase productivity. Three more farmers (FB1, MR1 and MR2) fed grass as well as maize, and some low-quality concentrates. The last farmer (HM1) fed a more conventional ration of grass, maize, and high-quality concentrates. These results show that all farmers except HM1 fed a relatively low-quality diet compared to the average Dutch dairy farm. Some of the farmers mentioned that if they fed a higher-quality diet, that would not improve production, but rather only make the animals fat. Mr. Spek (ANU) agreed, saying that if the roughage was of high quality, many rare breed animals would probably not produce more from concentrates, depending on the animal and its production level. Since the milk production of rare breeds is usually lower, and protein is an important component of milk, the rare breeds may have a lower protein requirement. Consequently, the breed may need less energy for the digestion of protein. Furthermore, the more dual-purpose rare breeds have a higher percentage of their body weight in fat as opposed to organs, than modern more milk-typical breeds. According to Mr. Spek, the maintenance of fat requires less energy than that of organs, and therefore fatter dual-purpose breeds need less energy for maintenance per kg of bodyweight than modern dairy breeds. This was corroborated when Wageningen Livestock Research scientists updated feed analysis methods and they found that modern cows had a far higher maintenance energy requirement than when the analysis was first made 50 years ago.

A large proportion of the health issues on Dutch dairy farms is attributed to the negative energy balance that cows face after calving (Esposito et al., 2014). In the period after calving, milk production rapidly increases whilst feed intake lags behind. This difference means that cows use more energy for maintenance and milk production than they take in via feed, with a deteriorating condition as a result. The cows use up their reserves, and the negative energy balance starts to

affect their health, with problems such as milk fever as a result. This period of lactation also often leads to claw issues, as the minerals in the claws and bones are needed for the production of milk and the claws therefore weaken. Problems after calving, such as a remaining afterbirth or an infected uterus are also often the consequence of this negative energy balance. Furthermore, since the cow is lacking energy, it's reproductive cycle also struggles to start up properly. Often it takes longer for a cow to come into heat, the heat is less pronounced, or inseminations fail. These effects are responsible for most of the fertility problems in a dairy herd (Esposito et al., 2014).

Since the genetic capacity for milk production is lower for most rare breed cows, the negative energy balance is also smaller. This smaller negative energy balance then reduces the incidence of a number of health and fertility issues mentioned above, among others. This experience was widely shared among the interviewed farmers, who all mentioned that their animals were more 'robust' than other cows. The farmers all highlighted that there are fewer health problems and better fertility in their herds than high producing dairy breeds, which also adheres with the literature and what the interviewed experts said (Walsh et al., 2011). Mr. Sulkers (CGN) also mentioned that the Dutch rare breeds in general have good health and fertility and hardly came up with any negative traits. Farmer HM1, who sometimes crossbreeds MRIJ cows with Holstein Friesian cows, mentioned in his interview that his MRIJ cows do indeed have less fertility and health problems than his Holstein Friesian cows, and links this directly to lower milk production. For several health and fertility indicators he saw a direct relationship between production and issues with the cows. Mr. Aalvanger, who kept a number of different rare breeds, did not notice any differences between the rare Dutch breeds in terms of health and fertility. However, not all of the robustness of the rare breeds can be attributed directly to lower production, for example the low incidence of wrong growth in the claws. Therefore, it is as of yet uncertain which part of the rare breeds' robustness is due to lower production, and which part to other reasons. Given the relatively low number of farmers interviewed in this project, it is also uncertain to which extent the results regarding health and fertility are due to the breeds or to various management practices. Although care has been taken to include these practices in the research, some effects of management practices may have been excluded.

The lower milk production for rare breeds is partially offset by a higher fat and protein content in the milk. It is possible that these higher content levels are due to the fact that most Dutch rare cattle breeds were bred in a time when many farmers processed the milk into dairy themselves. Those farmers would therefore benefit directly from the high milk solids content. When Holstein Friesians were introduced, most of the milk was already processed by factories. This later introduction means that there was less of an incentive for farmers to breed for milk solids content, and that the Holstein Friesians' lower milk solids content was less of a problem from that perspective. Nowadays, a part of the milk price for farmers is determined by the fat and protein contents, so rare breed farmers usually get a premium on the milk price.

Another characteristic of the Dutch rare breeds is that they have a friendly character and are easy to use. Most farmers mentioned in their interviews that their respective breeds have a friendly disposition and are easy to handle. These characteristics are also mentioned by Mr. Hiemstra (CGN). In contrast, Mr. Aalvanger mentions that Groningen White Headed have a bit of a wild streak and are not as easily handled as other rare breeds. These are mostly experiences from the farmers, and little research on this topic could be found.

4.1.2 Farm characteristics

In the Netherlands, the average dairy farm has 94-97 milking cows (Centraal Bureau voor Statistiek, 2019). The farmers in this research differ a lot in the number of milking cows, some have less than the Dutch average (FR1, FB1 and DR1), while some are close to this average (GW1 and HM1) and others are above this average (MR1 and MR2). DB1 is an exception, as it is a beef farm and therefore it does not have milking cows. In 2019, the average Dutch farm with grazing animals, i.e. cattle had approximately 52.1 ha of land (Centraal Bureau voor Statistiek, 2017). Of the farmers interviewed, only one (DF1) is below this national average. Noteworthy are DR1 with 135 ha and GW1 with 115 ha. However, for both DR1 and GW1 nature reserves on which youngstock graze are included, explaining why it is such a high number. Regardless, most of the farmers interviewed used more land than the national average. Benton et al. (2011) suggest that more land use means a higher impact on the environment, which means a smaller land area needed for farming might be beneficial for nature conservation and ecosystem services. The reason for that is that if more farmers go to a more extensive manner of production, more land is needed to maintain current levels of food production. This means there might be less land available for nature conservation and ecosystem services. This is why extensive farming might not be the most sustainable option for future agriculture. Following this, Benton et al. (2011), suggest that local extensification can only happen in one area if another area intensifies. However, if the land used in extensive farming systems could be used for other purposes such as nature conservation, then that could be a solution if it does not hinder production levels. This would need to be researched.

Something important to notice is that few of the farmers we interviewed used estimated breeding values (EBVs) to make their breeding decisions. From the interviewed farmers, only GW1 uses EBVs to base his breeding decisions on. When asked about the compilation of EBVs of their respective breeds, most farmers replied that they would regard it as a positive development. It is a possibility that the farmers do not choose to use EBVs or are not aware of their availability. The problem, however, as was stated by some of them, was that the population size of the breed is not large enough to create reliable EBVs for the breeds. According to Mr. Sulkers (CGN), obtaining hard numbers can be difficult because some breeds are registered in multiple breeding organizations. However, there are EBV's known and available for the breeds with a larger population, namely the MRIJ, Groningen White Headed and Dutch Friesian (Ducro, 2019). The Dutch organization dedicated to the improvement of cattle, Cooperatie Rundvee Verbetering (CRV), does not make a distinction between cattle breeds that they work with, according to Mr. Lutke Willink (CRV). If there is sufficient demand for a breed, then CRV will supply them with semen.

Overall, Dutch rare cattle breeds appear to have less health and fertility issues, are more robust, do well on low quality feed, but do have lower milk production levels. Dutch rare breeds are dual purpose, so the breeds also have some income from beef production. To maintain or improve production levels of the breeds, farmers do not base their breeding decisions on EBVs. Also, the farms with the Dutch rare breeds are mostly kept for dairy purposes on large areas of land, which may influence the ecology, which is discussed in the following section.

Thus, Dutch rare cattle breeds appear to be less susceptible to health and fertility problems than higher producing breeds. Rare breeds are also shown to be more robust, with strong physical characteristics such as sturdy legs and the ability to graze outside for a longer period during the

year. They are also able to perform optimally on lower quality feed compared to higher producing breeds that rely on concentrates in their diet. However, some of the rare breeds do have a lower milk production, but this is compensated for the fact that they are also dual-purpose. A steady income for farmers is generally more likely due to their rare breeds being dual-purpose.

4.2 Ecological impact of Dutch rare cattle breed characteristics

In this section, results pertaining to the second sub-question are discussed. The second sub-question is: 'what is the ecological impact of Dutch rare cattle breed characteristics?'

The specific characteristics of Dutch rare cattle breeds and the farming systems in which they are kept mean that the breeds have a specific impact on the ecology of the farm and its environment, as well as further afield.

Arguably the greatest influence on ecology of a farm is the way in which the farm's land is managed. On Dutch cattle farms, most or all of the land is managed to produce feed for the stock (Van der Peet et al., 2018). Thus, the feed ration of the animals is an important factor for ecology. Session (2009) supposed that local breeds would be better adapted to rations of a lower nutritional value than modern, highly productive breeds. This is matched by the results for our indicator 'feed ration', which showed a tendency for a lower quality ration than is most common on Dutch dairy and beef farms. One farmer only fed grass and lucerne nuts, three farmers fed grass and some concentrates, three farmers fed grass, maize and some concentrations and the Holstein Friesian x MRIJ farmer fed a conventional ration.

Half of the farmers therefore did not grow maize, which is an exception for Dutch dairy farmers (Van der Peet et al., 2018). Replacing maize with grass is seen as beneficial for local biodiversity, because of the lower number and intensity of cultivations and the maintenance of cover and a food source over winter in grassland (Van der Peet et al., 2018). Especially permanent grassland (leys of more than 5 years) are associated with a positive impact on biodiversity, such as a relatively large species diversity, rich soil biology and providing a constant and recognisable place for animals such as meadow birds (Van der Peet et al., 2018).

A result of the lower feed quality requirement of rare breeds is not only that they are fed more grass, but also that (some of the) grass can be of lower quality. In conventional Dutch dairy farming grass is mowed around 5 times per year to ensure the harvest of young grass with a high crude protein percentage. Since the nutritional requirements for rare breeds are lower, (a part of) the grass can be harvested at a later stage. A delayed mowing date is beneficial for the conservation for many farmland species. For example, grass length and delayed mowing date are related to the survival rate of the chicks of several meadow bird species (Oosterveld et al., 2008). The different nutritional requirements of rare breeds also mean that five of the eight interviewed farmers were able to include clovers or herbs in their grass leys. This provides for a greater plant species richness in the grassland, which is beneficial to many wild insects, birds and mammals, including meadow birds (Oosterveld et al., 2008).

Furthermore, the use of lower-quality grass opens the possibility for the use of natural grassland on rare breed farms. This could also be seen among the farmers in our research, five of which were involved in the management of natural grassland or nature reserves in some way on their farm. This varied from converting a part of their farm to natural grassland or grazing in nature areas to managing field margins extensively. One of the farmers that did not participate said he managed his farm for his cows and not for nature and associated agricultural nature management with bad experiences from the past or that they had seen elsewhere. Since this was not a fundamental rejection, it could be classified as a lack of a positive attitude or trust that prevents these farmers from incorporating nature management on their farm. Since it has been shown that this problem can be solved through better management of the agricultural nature system, this offers potential for the further expansion of agricultural nature management among rare breed farmers (De Vries et al., 2019).

Additionally, the use of concentrates was lower among all but one of the interviewed farmers. Concentrates are often made from by-products of food processing, such as rapeseed meal, which is a by-product of rapeseed oil (Van der Peet et al., 2018). Other examples of concentrates are grain or maize meal that are grown specifically for animal feed. Most concentrates therefore originate in field crops, grown on land that could also be used for human food production. Furthermore, a large proportion of concentrates used in Dutch farming are imported from abroad (Meesters and Bos, 2013). Concentrates are imported because they are available cheaply in large quantities from other countries. Production in the countries where most concentrates are imported from, are associated with low environmental regulations and environmental degradation (Van der Peet, 2019). Therefore, the lower concentrate consumption of Dutch rare cattle breeds can benefit the conservation of the environment in other countries.

Another relevant issue in the context of ecological impact is the emission of greenhouse gasses (GHG). The extent of GHG emissions is usually mentioned per unit of produce and therefore, the level of production is one of the most factors in determining the emissions in a system. For this reason, it has been supposed that Holstein Friesian cows perform better on GHG emissions, due to their higher production (Vellinga & De Vries, 2018). However, the relevant production is not limited to milk, but also meat that is produced as a side-effect of dairy farming. Every kilogram of meat that is produced from a dairy farm is not required from a beef farm. In this context, research by Vellinga and De Vries (2018) showed that increasing efficiency in the dairy system was usually accompanied by a decreasing efficiency in the production of meat. The effect on GHG emissions of optimising milk production per cow was limited, with the resulting GHG mitigation depending on the level of emissions in the related beef system. If this theory is reversed, increasing the meat production in a dairy system may be a way of reducing GHG emissions. This offers potential for the dual-purpose Dutch rare cattle breeds, depending on the specific GHG emissions in the rare breed production systems.

Thus, Dutch rare cattle breeds are associated with a number of characteristics that are related to higher ecological quality on farms. More research will need to be done to determine the precise differences in the environment on farms where different breeds of cattle are kept. In the meantime, however, it can be assumed that the use of Dutch rare cattle breeds is beneficial for the local environment. This is corroborated by the experiences of Mr. Bos, a nature policy expert of the Province of Friesland. He mentioned that he saw higher biodiversity with breeds that are adapted to extensive farming because of different grassland management. Furthermore, he identified potential for using rare breeds on a larger scale in nature management in the future. However,

because rare breeds are currently a very low proportion of the Dutch cattle population, he saw the role of Dutch rare cattle breeds for improving ecology as marginal unless their use becomes more widespread.

So, in terms of ecology, since rare breeds do not rely on concentrates, less cropland is required. Therefore, crops such as maize that is generally grown for concentrates can be replaced by grass, benefitting local biodiversity. Furthermore, grass can also be of lower quality, meaning less mowing is required, which also gives the opportunity for biodiversity to improve. Most of the rare breeds also feed on clovers and herbs, which are also being sown into the grass. This provides a higher plant species diversity, promoting a higher species richness for insects, birds and mammals. Overall, the way rare Dutch cattle breeds are kept in farming systems can serve to promote biodiversity.

4.3 Economical impact of Dutch rare cattle breed characteristics

In this section, results pertaining to the third sub-question. The third sub-question is: 'What is the economic impact of Dutch rare cattle breeds?'

The decline in Dutch rare cattle breed populations in the 1970s and 1980s was the result of so-called 'Holsteinisation', which led to the Holstein Friesian taking over 90% of the Dutch dairy herd. The main incentive for farmers at that time to cross with Holstein Friesians was that breed's higher productivity. This is matched by the results of our farmers, where milk production was between 1000 and 4000 kg lower than the Dutch average of 9155 kg/cow/year (CRV, 2019). The exception was HM1, who at 8800 kg/cow/year was close to the Dutch average. This clearly means a significant loss in income for the farmers.

Nevertheless, the farmers mention that part of this loss is compensated by a higher milk price. These economic consequences can be calculated for farmer MR2 as an example. If we attribute the difference between his milk yield and the Dutch average to the breed, he loses (9155 - 7900) x 0.33 (average milk price; Voorhorst, 2019) = 414.15 euros/cow/year. This is compensated by 2 cents more per kg: 7900 x 0.02 = 158 euros/cow/year. Therefore, even when taking the higher milk price into account, MR2 still loses 414.15 - 158 = 256.15 euros/cow/year in this scenario.

However, MR2's loss is due to his entire farming system, not just his choice of breed. The lower quality feed (which he has to buy in) means that his feed costs for the dairy cows are lower. The veterinary costs for the dairy cows are also lower. MR2 is confident that these differences more than make up for the loss in milk production.

For farmer FR1, the situation is different. In contrast to MR2, he has decided to move his entire farm into a very extensive, grass-based system. For milk production, this means he loses (9155 - 5130) x 0.33 = 1328.25 euros/cow/year. His milk price is around 0.60 euro/kg, compensating (0.60 - 0.33) x 5130 = 1385.1. Therefore, his choice means he earns 56.85, if we compare this system to an average farm. On top of that, he has lower feed and veterinary costs than the average farmer.

For HM1, the situation is again different. He has a system that is comparable to an average Dutch dairy farm. For milk production, he loses (9155-8800) x 0.33 = 117.15 euros/cow/year. If this is also compensated by 2 cents more per kg for high fat and protein, that makes 8800 x 0.02 = 176. So, this gives a positive effect of 176 - 117.15 = 58.85 euros/cow/year. HM1 mentions that the average feed and veterinary costs of his farm are comparable to the national average.

Important to notice is that these calculations leave out several factors that are relevant in farm economics and treat these numbers only as an indication of the economics of these farms in reality. Nevertheless, it becomes clear from these examples that, in a conventional system with rare breeds, the loss in milk production is not fully compensated by a higher milk price. When a lower cost of production makes up for that, the benefit is spread among several aspects of the farm and thus becomes less transparent to the farmer or other farmers comparing economic data. The lack of transparency in the economic benefits of rare breeds may contribute to the prevailing opinion among farmers that they cost money, even when rare breed farmers disagree.

The example of FR1 shows that when the farmer is able to incorporate the breed into a change in the entire farming system, he can even have a positive effect on the income side of his balance. However, this depends on whether there is a demand for the specialist, or niche, products, in this case by a specialist cheese factory. The same goes for some of the other interviewed farmers, such as DB1 who achieves a higher price by selling his meat directly to consumers and restaurants.

On the other hand, the example of HM1 shows that rare breeds can provide a benefit, even in a conventional Dutch dairy farming system, if used in the right way. For purebred rare breed animals, the production will most likely fall too far to have a positive effect on income. However, by using crosses to breed Holstein Friesians more in the direction of rare breeds, you can have highly productive animals with high fat and protein contents giving a good milk price.

In short, rare breeds have lower production levels, a higher selling price for their product, and lower costs. However, the most important factor, the balance between income and cost on a farm level, cannot be generalised between the different rare breed farmers. The effect on profitability depends on how the farmer uses the rare breed in his farming system to achieve the results that he wants.

The interviewed farmers mostly made use of the produce of his animals by selling their milk to conventional milk factories, which was the only form of sales for three farmers. Three farmers also sold meat of cull cows directly to consumers, but this constituted only a limited part of their business. Only farmer DB1 used direct selling as his main method of marketing. These facts mean that the farmers could survive on the normal conventional or organic milk prices, but it does not mean that that was the optimal economic situation for them. Furthermore, there was a tendency against having side activities, meaning that the income from the farm was sufficient for the farmers to live on.

A separate issue is the impact that regulations have on farm economics. Most farmers said that the phosphate rights system introduced in 2018 has not influenced their business in a significant way, mainly because of the specific situations on the farms. For example, they had already expanded before the system was introduced, their rights were not reduced because they had enough land, or they did not want to expand in the future. Interestingly, farmer HM1 said that because of phosphate rights he kept less youngstock, but that had actually made his farm more efficient and he made better use of old cows. Three farmers said that phosphate rights did

influence their farm negatively. The most relevant issue in Dutch agricultural regulations currently is nitrogen surplus. Most of the interviewed farmers expected that not to give problems for their own farm. The reasons for this are that they were too far from Natura2000 areas to be affected, or that they thought it would not apply to them because they were already sustainable, with few emissions. Of course, the impact of any nitrogen regulations in the future would depend on what form the regulations take.

So, in terms of economics, Dutch rare breeds have lower milk production because they were not intensively selected for high milk production traits. The milk price generally is better than average because Dutch rare breeds have better fat and protein percentages in their milk. Due to the rare breeds being healthier and requiring lower, cheaper quality feed, the farmers have a lower cost of production per liter milk. So, the lower income of milk production is balanced by a lower cost price and a better price for fat and protein content.

4.4 Implementation of Dutch rare cattle breed characteristics in agroecology

In this section, the results pertaining to the fourth sub-question are discussed. The fourth sub question is: 'In which ways can these characteristics be implemented into agroecological farming systems?'

Generally, the rare cattle breed farmers have made a conscious choice when choosing which breed to implement into their farming system. As previously mentioned, the main drivers for choosing their breed were that they are mostly dual-purpose, have lower inputs than high-production breeds such as the Holstein Friesian, and are robust. Moreover, most of the farmers would not change their choice of breed in the future, mainly because of the benefits they gain from these breeds. Highlighting the benefits of rare cattle breeds to farmers who are thinking of making the switch may be crucial, as these farmers are able to make a conscious decision to benefit their own farming system. Farmers have also described numerous ways that some traits of their cattle can be implemented into the farming system. For instance, the sturdiness of the Friesian Red-and-White's allows them to walk a kilometre from one area of the farm to another. Furthermore, a few of the farmers appreciate the attention they receive from the public for owning cattle breeds that they are not used to seeing. Production quality of most of the rare breeds is generally the main beneficial trait farmers will mention, and how well these fits into their system.

The qualities of the rare breeds such as robustness and coping with lower quality feed allow them to perform well in agroecological farming systems, where production is also not the main goal. Certain indications that rare cattle breeds are more robust than higher producing breeds such as the Holstein Friesian have been investigated. Most of the farmers of the rare cattle breeds have mentioned that the strengths of their cows include robustness, health, high quality milk and meat and good fertility. In terms of robustness, time that rare cattle breeds outside grazing per year is much higher than that of HF cattle, where the rare breeds spend between 180 to 271 days outside whereas HF only spend approximately 90 days outside (figure 2). This is a clear indication that HF do not bode well in outside conditions as well as most of the rare breeds do, which was also mentioned by some farmers. Furthermore, according to most of the farmers, the rare breeds are also said to perform optimally on lower quality ration than HF cattle do. To increase the milk yield of HF cows, a large amount of concentrate supplementation is included in their diet (Roche et al.,

2006). Conversely, it has been pointed out by the farmers that most of the cows' diet is made up of grass, and only some concentrates are necessary to increase production and keep the animals in a good condition. As stated previously, agroecological farming relies on low external inputs, including concentrates, so the rare breeds would be suitable for this type of system due to them being less reliant on concentrates. Thus, there are already multiple characteristics that rare cattle breeds possess which aid in implementing them into agroecological, low input farming systems.

As described above, most of the farmers interviewed made use of the characteristics of their breeds in their farming system. All could be described as having a farm that was more extensive than the Dutch average dairy farm, except HM1 who ran a conventional system. For the other interviewed farmers, a gradient can be identified, starting with HM1 as the most intensive, followed by both MRIJ farmers and the Dutch Friesian farmer, and then the other breeds with FR1 being the most extensive. The more intensive farmers on this gradient can be said to run a conventional system that is extensified to fit their breed. The more extensive farmers run a system that, in many aspects, is completely redesigned. These systems are very extensive and maximise the effect of the positive characteristics of the rare breeds, like robustness and lower nutritional requirements. By allowing the characteristics of rare breeds to come into their own in these unconventional farming systems, the farmers also maximise the profitability of their farm. As seen under section 4.3, farmer MR2 had to make up for a lower income by having lower costs as a result of his breed. However, farmer FR1 already benefited on the income side of his balance. Thus, the positive effects of the breed are larger and more transparent to other farmers, making it more likely that they would consider changing their breed and system.

However, the success of systems like that of farmer FR1 depends on a number of factors, primarily among which is the ability to sell his product at an appropriate price. There needs to be demand for these products at a sufficiently high quantity to guarantee an efficient and profitable way of selling for the farmer. This problem was also mentioned by farmer DB1, who found that sometimes it was difficult to find enough buyers for premium Dutch Belted meat. There are a number of examples, in this project and in the literature, that a higher price can be realised either on a small or on a larger scale (Barkema & Huson, 2020; Janmaat, 2020; Polman & Dijkshoorn, 2018). To offer perspective for farmers to switch to rare breeds, efforts should mainly be focussed on the retail sector, since the production of most farms is too large to market their produce via small-scale direct selling. Therefore, it needs to be investigated whether the market for high-quality, nature-inclusive rare breed milk and meat can be expanded to include a significant part of the Dutch and European retail. Results in other sectors have shown that it is possible to make agreements between farmers, retailers and others in the agro-food sector to stimulate markets into a desirable direction (Sumption, 2020). However, for this to happen the cooperation of retailers should be there, which ultimately depends on the demand from a large section of consumers. Thus, there is potential for a market for meat and dairy from agroecological systems to be developed. When and if this happens, it will take time, and success is not certain. Therefore, other methods of ensuring the conservation and expansion of rare breeds need to be looked at, that do not include a higher price paid by a large number of the consumers.

In terms of implementing rare cattle breeds in agro-ecological systems from an economic standpoint, financial subsidies may play a crucial role in convincing farmers to make the switch to implementing rare cattle breeds into their farming system. In the 1990s, there was a government subsidy that supported rare breeds, according to Mr. Hiemstra (CGN). However, the administration costs of that subsidy were much higher than the money paid to farmers, so it was

discontinued. Afterwards, the government refused to reinstate a subsidy for rare breeds, until a few years ago. Mr. Hiemstra explains the new subsidy that is part of EU policy, like most policies concerning rare breeds. This has been further worked out by the national government and is intended to meet the reduced income of rare breeds, with a 150-euro subsidy set per Dutch rare breed milking cow in the Netherlands. Although this strategy is welcomed by farmers, it may not be strong enough to act as the main way to conserve the rare breeds. According to Mr. Hiemstra and a number of interviewed farmers, the subsidy is not enough to entice many farmers to switch to Dutch rare breeds. Although subsidies for rare breeds can be a useful tool in supporting them, this does not mean that subsidies can or should be the main way of conserving rare breeds. Subsidies are expensive for governments and therefore uncertain on a long-term basis. Furthermore, there is also a case that breeds should be maintained because they have an inherent use to farming or other fields, not just on the basis of public money. A policy incentive for endangered sheep breeds in the EU saw a subsidy of 200 euro per individual animal paid to farmers in order to reduce biodiversity loss (Canali, 2006). However, the policy has been poorly designed due to incomplete definitions of rare breeds from regional and national authorities. Due to this, there has been a failed effort to conserve rare sheep breeds, as they have observed to be continuously declining (Canali, 2006). Farmers GW1 and FR1 also mentioned that they are open to receiving the subsidy, however not necessarily crucial for keeping their rare breeds. Convincing farmers to make the switch to rare cattle breeds may take more than just a subsidy and is not the only answer to conserving them. Mr. Hiemstra thinks that more extensive and nature-inclusive farms should be paid for the public services they provide, by either higher prices for their products or the government. If Dutch rare cattle breeds perform well in these systems and have an actual function in these farms, Mr. Hiemstra expects that they will be used more and become more preferable.

Rare cattle breeds still face a number of threats and challenges that may inhibit their ability to be implemented into agroecological farming systems. Uncertainty for the threats of the rare cattle breed farms in the future is evident. Some farmers have explained that future general regulations may have an impact on their farming practices. With current uncertainty around GHG and other environmental emissions, human health effects, land use and other issues, the impact of regulations is a relevant issue for all Dutch livestock farmers. However, as some farmers mentioned, most regulations are designed for conventional farming systems, so unconventional farmers may be impacted more from regulations which do not fit their practices. Furthermore, due to the increased price on rare cattle breed products, other farmers are also worried that consumers would not be willing to pay it.

Another major problem that the interviewed farmers did mention for the Dutch rare breeds is genetic diversity, but only for the breed in general and not in their own herd, as was mentioned in the Results section. Mr. Sulkers (CGN) confirmed that genetic diversity was indeed a problem for all Dutch rare cattle breeds. For example, Friesian Red and White have severe issues with genetic diversity, with an absolute inbreeding coefficient of 0.1% (de Haas et al., 2011). However, the farmers think that if measures are taken, sufficient genetic diversity can be maintained. Currently, the inbreeding increase per generation for the rare breeds in the Netherlands are 0.25-0.5% for Deep Red and Friesian Red and White, 0.5-1.0% for Dutch Friesian, Dutch Belted and MRIJ, and <0.25% for Groningen White Headed (Rassenlijst Nederlandse landbouwhuisdierrassen, 2020). Based on these increases, Deep Red and Friesian Red and White are considered vulnerable, Dutch Friesian, Dutch Belted and MRIJ are endangered, and Groningen White Headed is normal. Compared to the Dutch inbreeding increase per generation for Holstein Friesians in the

Netherlands, which is 0.5-1.0%, three of the breeds are doing as well as the Holstein Friesian and the other three rare breeds are doing even better.

A solution to the genetic diversity problem could be to crossbreed. From crossbreeding, there would be a heterosis effect, which means that the offspring performs better than either of its parents. However, most of the farmers were interested in keeping the breed pure to preserve the type and to guarantee the breed's positive traits in the next generation. Farmers were interested in breeding with animals of the same breed in foreign countries. And DR1 would also breed with animals in Germany, with similar characteristics as Deep Red cattle, but were not registered in the studbook. Currently in the Netherlands, crossbreeding of rare breeds with HF is not done on a large-scale, but they have provided some good results as was mentioned by Mr. Sulkers (CGN). Two of the farmers crossbreed MRIJ cows with HF, one of them only does it with individuals who could actually improve from it (MR2) and the other often breeds MRIJ with HF to achieve a more robust cow with a high milk production (HM1). HM1 is trying to combine the positive traits of the MRIJ, here the robustness, with the high production of HF, thereby looking for heterosis in the offspring. The MR2 farmer did mention that the heterosis effect does not last, so if the first generation of heterosis offspring are bred with each other, the benefits are lost. However, if these heterosis offspring are the solution to the question of having a high-producing cow with less inputs, then a healthy population of purebred cows would also need to be maintained in order to breed the heterosis offspring. This would give the rare breeds a purpose and a clear reason why they should be maintained. Mr. Nijman during his interview mentioned that Witrikken could be used to increase genetic diversity for the other rare breeds as well, because they are not closely related to any of the other breeds and thus has a larger genetic distance to any of the other breeds, even though it is only a colour variety. However, when asked about this, other farmers did not see this as a solution because it is only a colour variety and these Witrik cows are not selected for anything other than their markings.

Thus, Dutch rare cattle breeds are implemented in farms by using their strengths such as robustness, health, high quality meat and milk and good fertility. Also, the rare breeds require relatively low inputs such as grass and hardly any concentrates, making them much more adapted to agroecological farming practices, where low inputs are the norm. An issue which has so far inhibited the use of rare breeds by more farmers is the lack of a clear economic benefit, and although there are potential routes to alleviate this, the ways to achieve this are not straightforward. However, compensation for public services they provide, for example through subsidies, can help to control this problem in the short term. Also, rare breed populations are at risk due to low levels of genetic diversity, this can be managed through careful breeding practices.

4.5 Limitations

There are some limitations to this research, the main one being the number of interviews that were conducted. The research had to be conducted within eight weeks, which limited the number of farmers interviewed to only one farmer per Dutch rare breed. A decision was made to interview three farmers with MRIJ cattle, as that is the largest Dutch rare breed according to numbers from CGN. It would have been preferable if more farmers per breed had been interviewed, as it would have made the results more representative. Therefore, a consequence of this small sample size is that conclusions made in this research should be considered with care, because it is not representative of each Dutch rare breed population. Also, because of the small number of

interviews conducted, no statistical analysis was performed on the quantitative results. Conducting a survey was also not possible due to the time constraint, because there would not have been enough time for enough participants to respond.

There are multiple definitions of agroecology and a lot of terms are associated with the concept of agroecology, such as circular farming, nature-inclusive and sustainability for example. Therefore, it was difficult to set the boundaries of this research. The definition that is used in this study is “the application of ecological concepts and principles to the design and management of sustainable agroecosystems”. The different definitions of agroecology potentially could have led to different results and conclusions for this research, depending on the chosen definition. The definition chosen for this research is broad, which might mean that the conclusions may have been different if another definition had been used.

Another limitation of this research is that interviews were inconsistently conducted. In some interviews, the questions were followed completely and in other interviews some of the questions were not answered or overlooked. This means that not all farmers interviewed, answered all the questions, likely resulting in loss of information i.e. data. Some farmers were contacted again about the missing answers, for other farmers their answers could be inferred from answers to other questions. However, this results in a decrease in the reliability of the research. Furthermore, the way the information is gathered from interviews is a limitation. Information from interviews is likely to be biased. After all, it cannot be reasonably expected that an interviewee is particularly critical of their own practices, especially when they are comparing themselves to others. Farmers might have made assumptions about their farms, which might have caused bias in the results.

The definition of what is considered a purebred cow is subject to interpretation. Different parties have diverging ideas on what makes a purebred, even amongst farmers there is no consensus. Some parties consider breed purity only when bloodlines are 100% of a certain breed. Others consider a cow purebred when it has bloodlines over a certain percentage belonging to the respective breed. That certain percentage varies greatly as well. It may be as low as anything over 50%, or as high as over 98%. The interviewed farmers participated in a phone screening before the actual interviews were scheduled. This phone screening was intended to make sure the farmers met certain requirements, such as owning a certain Dutch rare cattle breed. However, because of the aforementioned differences in interpretation, the farmers ended up having various percentages of breed purity in their herds. Some farmers had bloodlines that belonged 100% to a specific breed, while other farmers only had herds with barely over 50% of a certain breed. For example, originally the MRIJ breed would be represented by three farmers. However, one of these farmers turned out to have a herd that was 50/50 Holstein Friesian-MRIJ. This meant that his herd was completely different from the other two MRIJ herds that consisted of 100% MRIJ and over 85% MRIJ, and it skewed the results for the MRIJ breed. This is why the decision was made to remove the third herd from the MRIJ category and give it a separate category of Holstein Friesian-MRIJ.

In the methods of the breeding decisions there are a number of limitations to be considered. First, only a relatively small number of farms are considered, since from every breed there is only one farm with the exception of MRIJ which originally had three farms assigned. Statistical analyses were therefore not possible; however, a valuing analysis was performed. Analysing data in this way comes with multiple limitations, such as only one person performing the data valuing. The valuation of the data is based solely on one person’s interpretation and may therefore be biased or misinterpreted. The farmers also did not get to validate the valuation afterwards. Moreover, the

person that did the valuation was not present at all the interviews, so it is based on interpretation of transcripts from interviews. In these transcripts the question about breeding decisions had been asked in a general way to the farmers with no options provided for them to choose from. This resulted in some farmers talking about certain components influencing their breeding decisions whereas others did not mention them. Thus, in the results the number of components in the pie charts are unequally distributed, with one pie chart having five components influencing the breeding decision and the other pie chart including only three components that influence the breeding decision. In other words, only the topics that were talked about in the interview were valued and the unmentioned topics were completely left out. It is unknown how much these unmentioned topics are of value to the farmers in their breeding decision and they have not been corrected for in the analysis.

4.6 Conclusion

To conclude, Dutch rare cattle breeds are implemented in farms by using their strengths such as robustness, health, high quality meat and milk and good fertility. Also, the rare breeds require low inputs only such as grass and hardly any concentrates, which makes them more adapted to agroecological farming practices. Since rare breeds do not require much concentrates, farmland management strategies can shift to more nature-inclusive, biodiversity friendly strategies. Although there is potential for designing profitable agro-ecological dairy and beef systems around Dutch rare cattle breeds, the success of these systems is not guaranteed. Therefore, the lack of clear positive effect of rare breeds on a farm's profitability may provide an obstacle to farmers switching to rare breeds. However, if public services provided by farmers such as ecosystem services, are compensated by subsidies, this problem can be solved. Furthermore, rare breed populations are at risk due to low levels of genetic diversity, this can be managed through careful breeding programs. Although there are knowledge gaps about Dutch rare cattle breeds, the results of this research show that the Dutch rare cattle breeds can be utilised in extensive, nature-inclusive farming systems.

4.7 Recommendations for future research

Based on this research, a number of future research projects can be named. This research has shown that there are some knowledge gaps regarding Dutch rare cattle breeds. For example, there is very little information on feed efficiency of Dutch rare breeds. This would be useful to have more information on, especially on the efficiency of low quality roughage as that is the main component in a low input farming system. Even though, Dutch rare cattle breeds seem to fit well in extensive farming systems, they might also still be improved through selective breeding, to be even better adapted to low input farming systems. This could also be researched. Another knowledge gap identified by this research was that extensive farmland could become dual or even multipurpose land by integrating farmland and nature reserves, as long as that does not decrease production levels at all or only little. This solution could be a way to negate the negative idea that more farmland means less area for nature. Finally, this research would recommend that information on Dutch rare breeds, their importance and usefulness is promoted to farmers with high-producing breeds.

As mentioned, the sale of premium rare breed products from agroecological systems would greatly increase the economic case for rare breeds. The potential of this market should be researched to enable investment in its development. Therefore, market research should be done to investigate what the specific demands from consumers for these products are, and how the production and marketing systems can be adapted to meet these demands.

This research found that farmers with Dutch rare cattle breeds hardly use EBVs for their breeding decisions, because there are no or little EBVs for their breed. This knowledge gap could be further investigated by researching a method to calculate EBVs for small populations. Enabling farmers to make breeding decisions based on a wider range of decision-making tools will facilitate the conservation of specific breeds.

Our research has found that Dutch rare cattle breeds are suited to agroecological farming systems in the Netherlands. We have compared these breeds with the Holstein Friesian breed, and found that there are a number of aspects where rare breeds perform better in the agro-ecological systems that we investigated. However, this does not mean that it is not possible to develop agro-ecological systems where (some animals of) the Holstein Friesian breed have a place. It should be researched whether agro-ecological systems can make use of the high production or other qualities of the Holstein Friesian, to increase the adaptability and uptake of these systems.

Furthermore, this research has stated that Dutch rare cattle breeds have better health and lower veterinary costs. This statement, however, is mostly based on the opinions of the farmers and experts. An idea for future research could be to do a health and veterinary costs comparison of the Dutch rare breeds together with high producing breeds such as Holstein Friesians. Finally, a life cycle assessment (LCA) could be performed on farms with Dutch rare cattle breeds. This assessment could then be compared with farms with high producing cattle breeds, and conclusions can then clearly be drawn on the environmental impact of farms with rare cattle breeds as opposed to farms with high producing cattle breeds.

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Appendix A. Interview protocol

Below are the tables used to derive the interview questions for the farmers, as well as which indicators and variables they answer. In the two final columns, a cross indicates how the questions will likely be answered.

Research Questions	Variables	Answered by	
		Lit review	Interview
Which characteristics of rare cattle breeds can be identified that contribute to farming systems?	- Herd characteristics - Cattle breeds - Farming systems	X X	X X X
What is the ecological impact of these characteristics?	- Herd characteristics - Ecological impacts	X	X X
What is the economic impact of these characteristics?	- Herd characteristics - Economic impacts	X	X X
In which ways can these characteristics be implemented into agroecological farming systems?	- Herd characteristics - Implementation - Farming systems	X	X X X

Quantitative

Useful

Unsure

Not useful

Farmer		
Variables	*Indicators*	*Questions*
Herd characteristics		
	Breeding values	Can you give us any information on the breeding values of the bulls you use (in general or on average)?
	Strengths/weaknesses	What do you see as the strengths and weaknesses of your herd?
	Traits	Are there any particular traits that you are focussing on in your breeding? Which and why?
	Fertility	What kind of fertility problems do you have in the herd? How many inseminations do you need on average per pregnancy? Is there anything else about fertility that is different with your cows?
	Calving interval	What is your average calving interval?
	Calving problems	How often do you have problems with calving, or with the cows after calving?
	Health issues Veterinary costs	Are there any particular health problems that often occur in your herd? Are there any particular health problems that don't occur in your herd? What is your view of the strengths and weaknesses regarding health on your farm?
	Calf mortality rate	Can you give an indication of the calf mortality rate? How is calf health in general?
	Additional characteristics	Are there any other characteristics that are special for your herd or breed that we haven't talked about yet?
Cattle breeds		
	Herd size	How many cows, calves, youngstock, bulls do you have on your farm and of which breeds?
	Purebred/ crossbreed	Do you keep purebred cows or do you crossbreed with other breeds? If so, which breeds? What are your thoughts behind this?

	Genetic diversity	Are you concerned about the genetic diversity within your herd/your breed?
	Information	Can you get enough information (EBVs for instance) on the traits you want to breed for? Would you like to see anything changed on the "Stierenkaart"?
Farming systems		
	Farm size (ha)	How many hectares do you farm? How big are the different pastures/fields? How many do you have in total?
	Soil type	What is/are the soil type(s) on your farm?
	Certification schemes	Do you participate in any certification schemes (organic, VLOG, etc.)? What are your thoughts about these certification schemes, and why do you (not) participate?
	Time outside (days)	How long are the cows outside during the year?
	Barn type	Can you tell us something about your barn? (how many places, stalls or not, what surface, what bedding material, …)
	Calf rearing	What is the calf rearing system like?
	Owned/rented	Is it all owned, or is some rented?
	Land distance	Is all the land near the farm or is some farther away?
	Feed type	What do you feed your (dairy) cows? a. Homegrown or not b. Concentrates or not c. Grass or not: salad buffet (mix of herbs & clover)
	Grazing system	How is your grazing system? How long are they in an individual pasture? How long does it take before they return to a pasture?
	Influence breed on rations	What are your considerations in making the ration? Why is the ration like it is? What is the influence of the breed on the ration?
	Pastures	Do you include any natural pastures in your farm?
	Breeding (AI/naturally)	Are cows inseminated via AI or bred naturally?

	Breeding decisions	What do you base your breeding decisions on? Options: EBVs, exterior, external advice, intuition etc.?
	Production lifespan	Can you give an indication of your replacement rate or age on average?
Ecological impacts		
	Crops	What do you grow on your land? How much is grass, maize and other crops? If there are other crops, is there a set rotation and why?
	Cutting grass	How often do you cut the grass per year, on average?
	Nature schemes/ecosystem services	Do you participate in any nature or landscape schemes? For example: flower strips, supporting ground nesting birds, planting trees/hedges, natural grassland, later mowing, higher water level?
	Fertilizers	How do you fertilise your land? Do you use fertilisers, farmyard manure and/or slurry? And in which amounts?
	Pesticides	Do you use pesticides and which types of pesticides do you use most often?
	Other inputs	Do you use any other inputs to the fields?
Economical impacts		
	Veterinary costs	Can you say anything about the veterinary costs on your farm compared to the average?
	Milk production	How much milk do you produce on average per cow per year? What are the percentages fat and protein?
	Meat production	What is the average deadweight per animal and how many animals do you slaughter every year? What is the average slaughter age?
	Consumers	Who do you sell the milk and/or meat/animals to and in which way? What are the advantages and disadvantages of this way of selling? Can you say anything about the price? In relation to the standard? Are there any extra demands that the seller makes for your product? Is there more work in selling this way? How much demand is there for this way of selling?
	Cost comparison	Do you know your cost of production / litre of milk, or your critical milk price?

		How would you say your costs compare to the average farm? Why is that exactly?
	Monetary compensation	Do you feel like you get a fair financial reward for the ecosystem services you deliver, so nature, landscape, water management, etc.?
	Breed impact on economics	What is your view on how the breed affects the economics of the farm?
	Side activities	Any other side activities or other work that give revenue?
	Impact of nitrogen/phosphate laws	What is the impact of regulations on for example nitrogen and phosphate on the economics of your farm?
	Co-operations	Do you have any close co-operations with neighbouring farms (like land exchange, manure-for-straw deals, etc.)?
Implementation		
	Breed choice	Why did you choose this particular breed? Would you ever consider changing the breed? If so, to which breed and why? If not, why not?
	Trait implementation	How do you use the positive characteristics of this breed on your farm? What changes do you want to make in your farm to make better use of the characteristics of your breed?
	Future opportunities	What do you see as the future opportunities for your farm and the breed in general?
	Future threats	What do you see as the future threats and challenges for your farm and the breed in general?

Appendix B. Interview questions

Here, the list with interview questions that were used for each of the farmers, with the exception of farmer WR1 and MU1.

General

1. How many cows, calves, youngstock, bulls do you have on your farm and of which breeds?
2. How many hectares do you farm? Is it all owned, or is some rented? Is all the land near the farm or is some farther away? Do you have any close co-operations with neighbouring farms (like land exchange, manure-for-straw deals, etc.)?
3. What is/are the soil type(s) on your farm?
4. Do you participate in any certification schemes (organic, VLOG, etc.)? What are your thoughts about these certification schemes, and why do you (not) participate?
5. How long are the cows outside during the year?
6. Can you tell us something about your barn? (how many places, stalls or not, what surface, what bedding material, etc.)
7. Can you tell us something about your milking parlour? (how many places, what configuration, do they feed in the parlour, etc.)
8. What is the calf rearing system like?

Feed

9. What do you feed your (dairy) cows?
    a) Homegrown or not
    b) Concentrates or not
    c) Grass or not: salad buffet (mix of herbs & clover)
10. What are your considerations in making the ration? What is the influence of the breed on the ration?
11. Can you describe your grazing system?
    a) How big are the different pastures/fields? How many do you have in total?
    b) How long are they in an individual pasture? How long does it take before they return to a pasture?
    c) Do you bring the cows in and out of the pasture at a particular grass length (or biomass/ha)? If so, what are those lengths?
    d) Do you include any natural pastures in your farm?

Breeding

12. Are cows inseminated via AI or are they bred naturally?
13. Do you keep purebred cows or do you crossbreed with other breeds? If so, which breeds? What are your thoughts behind this?
14. Are there any particular traits that you are focusing on in your breeding? Which and why?
15. How important is breeding for you? How much time do you spend on it?
16. What do you base your breeding decisions on? Options: EBVs, exterior, external advice, etc.?

17. Can you get enough information (EBVs for instance) on the traits you want to breed for? Would you like to see anything changed on the “Stierenkaart”?
18. Can you give us any information on the breeding values of the bulls you use (in general or on average)?
19. What do you see as the strengths and weaknesses of your herd?
20. Are you concerned about the genetic diversity within your herd/your breed?

Fertility

21. Do you have fertility problems in the herd and if so what kind?
22. What is your average calving interval?
23. How many inseminations do you need on average per pregnancy?
24. How often do you have problems with calving, or with the cows after calving?
25. Is there anything else you would like to say about fertility in your herd?

Health

26. Are there any particular health problems that often occur in your herd?
27. Are there any notable health problems that don’t occur in your herd?
28. Can you give an indication of your replacement rate or age on average?
29. Can you give an indication of the calf mortality rate? How is calf health in general?
30. Can you say anything about the veterinary costs on your farm compared to the average farm?
31. What is your view of the strengths and weaknesses regarding health on your farm?

General question:

32. Are there any other characteristics that are special for your herd or breed that we haven’t talked about yet?

Ecology

33. What do you grow on your land? How much is grass, maize and other crops? If there are other crops, is there a set rotation and why?
34. How often do you cut the grass per year, on average?
35. Do you participate in any nature or landscape schemes? For example: flower strips, supporting ground nesting birds, planting trees/hedges, natural grassland, later mowing, higher water level?
36. How do you fertilise your land? Do you use fertilisers, farmyard manure and/or slurry? And in which amounts?
37. Do you use pesticides and which types of pesticides do you use most often?
38. Do you use any other inputs to the fields?

Economics

39. Can you say anything about the level of production?
    a) How much milk do you produce on average per cow per year? What are the percentages fat and protein?
    b) What is the average deadweight per animal and how many animals do you slaughter every year? What is the average slaughter age?
40. Who do you sell the milk and/or meat to and in which form?
41. What are the advantages and disadvantages of this way of selling?
    a) Can you say anything about the price? In relation to the standard?

b) Are there any extra demands that the seller makes for your product?
c) Is there more work in selling this way?
d) How much demand is there for this way of selling?

42. How would you say your costs compare to the average farm? Why is that exactly?
43. Do you feel like you get a financial reward for the ecosystem services you deliver, so nature, landscape, water management, etc.?
44. What is your view on how the breed affects the economics of the farm?
45. Any other side activities or other work that give revenue?
46. What is the impact of regulations on for example nitrogen and phosphate on the economics of your farm?

Implementation

47. Why did you choose this particular breed? (personal reasons or because that breed fits better in his/her farm system)
48. Would you ever consider changing the breed? If so, to which breed and why? If not, why not?
49. How do you use the positive characteristics of this breed on your farm?
50. What changes do you want to make in your farm to make better use of the characteristics of your breed?
51. What do you see as the future opportunities for your farm and the breed in general?
52. What do you see as the future threats and challenges for your farm and the breed in general?

Closing

53. Is there anything that you would like to tell us about your farm and breeds which was not covered by our questions?

Appendix C. Interview format

Below, the guidelines on how to conduct an interview are given. These were followed by all interviewers.

Interview with	*Name farmer*
Interview taken by	*Name group members*
Date	*Date of interview*
Time	*Time of interview*
Location	*Location of interview*

Opening:

- Courtesies (how are you today)
- Gratitude for interview
- Ask if interview may be recorded
- Interviewers and interviewee introduce themselves

Start of interview:

- Short intro research

We are conducting research on Dutch rare cattle breeds. We want to know in what way Dutch rare cattle breeds can contribute to agroecological farming systems. This is especially relevant considering our society's transition to more sustainable and circular agriculture.

-> Farmers

We contacted you because you keep XXX breed. We are hoping you can tell us about your animals and your way of farming. Let's get started.

-> Experts

We contacted you because you have in-depth knowledge into XXX. We are hoping you can give us more insight into this topic. Let's get started.

- Questions

End of interview:

- Thank for participation
- Ask if interviewee would like to receive the transcript for review
- Ask if interviewee would like to receive the final report

Appendix D. Transcript protocol

In the table below, instructions for transcribing the interviews are listed. These instructions were used in most interviews, as they were constructed after the first interview had already been conducted. The already transcribed interviews were checked to ensure all information was included, but not redone due to time constraints.

Free transcription	- Transcript the interview in sentences, without the "uh's" and "umm's". - Do not change words in your own interpretation, use the exact words that the interviewee uses. - You can rewrite sentences to some degree to make them readable but stick to the words the interviewee uses.
Start of transcription	Start transcript at introduction of interviewers and interviewees.
End of transcription	End transcript after interviewee answered these two questions: - "Would you like to receive the interview transcript for review?" - "Would you like to receive the final report?"
Sidetracks	Sidetracks, so parts of the interview that go off track and do not answer the question asked, do not require transcription. Instead, put a short and concrete summary between (parentheses) For example: Interviewer: "What can you say about Holstein Friesian fertility?" Interviewee: "Holstein Friesian fertility is awful, but not so awful as Dutch draft horse fertility." (Personal story on how Dutch draft horse fertility is very bad, and artificial insemination often requires dozens of straws) "Holstein Friesian cows generally get pregnant after insemination with on average 2,2 straws, so you need 3 straws per cow."

Appendix E. Data sorting

Variables with their corresponding indicators are determined to be either quantitative or qualitative, based on the answers given by the farmers. Also, for each quantitative indicator the method for visualisation in a graph is given. If an indicator makes use of categories, then the different categories have also been noted.

Quantitative:

Cattle breeds

- Herd size → numbers per farm (multicoloured bar chart; one bar is one farm)
    - Total number of cows
    - Milking cows
    - Youngstock
    - Other (i.e. bulls and oxen)

Farming system

- Farm
    - Size: amount of land (ha) → numerical data
    - Type: → categorical data
        - Grassland
        - Cropland
        - Nature land
        - Other
- Soil type → categorical data (pie chart) (farmers are not randomly selected!). Choose from:
    - Sandy
    - River clay
    - Clay on peat
    - Add rest of soil types present in NL
- Certification schemes → categories (pie chart). Choose from:
    - None
    - VLOG
    - Organic
    - Organic-dynamic
    - Other
- Time outside → number of days/hours (depends on what farmers gave)
- Land owned or rented or both → choose one (categorical data)
- Feed type
    - Concentrate or not → binary data
    - Include herbs or clover in grass → binary data
- Include natural pastures → binary data
- AI or natural or both → categorical data
- Breeding decisions → categorical data
    - Intuition
    - External advice
    - EBVs
    - Exterior

    - Other
- Production lifespan → age or rate

Selected during the analysis

Ecology

- Crops → categorical (pie chart?). Choose from:
    - Grass
    - Maize
    - None
    - Other
- Fertilizers → categorical. Choose from:
    - Artificial
    - Slurry
    - Straw Manure
    - None
    - Other
- Pesticides → binary data (can change to categories)

Economics

- Milk production → numbers
    - liters/kgs per year per cow
    - Fat percentage
    - Protein percentage
- Meat production → numbers
    - Slaughter weight per cow
    - Slaughter age
    - Number of animals per year

Qualitative:

Herd characteristics

- Strengths
- Weaknesses
- Fertility
    - Problems
    - Inseminations
    - Other
- Calving
    - Interval
    - Problems
    - Mortality rate
- Health
    - Issues
    - Veterinary costs/visits
- Additional

Cattle breeds

- Genetic diversity

- Purebred/crossbred

Farming system

- Breeding
    - Reasons for AI or natural
- Feed ration
    - Reasons for feeding concentrates

Ecology

- Nature schemes/Ecosystem services

Economics

- Consumers
- Cost comparison
- Breed impact on economics
- Side activities
- Impact of nitrogen regulations
- Impact on phosphate regulations

Implementation

- Breed choice
    - Reasons for breed
    - Changing breed future
- Trait implementation
- Future opportunities
    - Breed
    - Farm
- Future threats
    - Breed
    - Farm
- Challenges
    - Breed
    - Farm

Appendix F. Valuation of breeding decisions

The breeding values have been analyzed through a scoring method. During the interviews, the farmers were asked the questions “What do you base your breeding decisions on? Options: EBVs, exterior, external advice, etc.?” and “Are there any particular traits that you are focusing on in your breeding? Which and why?”. All the replies from the farmers on these questions were analysed in the transcripts by one person. There were 5 parameters identified important for breeding decisions from the farmers’ replies: Intuition, Exterior, Production traits, EBVs and External advice. According to the formulation and order the different parameters were mentioned in reply to the questions, the parameters got valued. If a parameter was not mentioned, it was valued zero. If a parameter got mentioned first and multiple times it got valued the highest. Based on the order and emphasis placed on the other parameters, they got valued accordingly. These valuations have been translated into pie charts for every farm and afterwards combined into a general breeding decisions pie chart to illustrate the importance of the parameters for all the farmers.