Societal and economic options to support grassland-based dairy production in Europe

A. Van den Pol-van Dasselaar\textsuperscript{1}, T. Becker\textsuperscript{2}, A. Botana Fernández\textsuperscript{3} and G. Peratoner\textsuperscript{4}

\textsuperscript{1}Aeres University of Applied Sciences, De Drieslag 4, 8251 JZ Dronten, The Netherlands
\textsuperscript{2}University of Göttingen, Department of Crop Sciences, Grassland Science, von-Siebold Straße 8, Göttingen 37075, Germany
\textsuperscript{3}Axencia Galega de Calidade Alimentaria, Centro de Investigacións Agrarias de Mabegondo, Apdo. 10, 15080 A Coruña, Spain
\textsuperscript{4}Laimburg Research Centre, Laimburg 6, Pfatten, 39040 Auer, Italy

Abstract

Grassland-based dairy production provides multiple benefits to farmers and to the wider society, but the European grassland area has been significantly reduced during the last decades. This paper aims to explore societal and economic options to support grassland-based dairy production in Europe. In the recent past, several societal initiatives have emerged to stimulate grassland-based dairy production: treaties, premiums and market concepts. When developing stimulating initiatives, the mindset of the farmer should be taken into account. Farmers are key actors when it comes to maintaining and improving grassland-based dairy production systems since they decide on the day-to-day management of the farm. To maintain grassland-based dairy production and to preserve the associated ecosystem services, it is, therefore, necessary to clearly show the importance of this production system for society to the farmers (show the customer perspective) and to support this by valuing the products from these systems accordingly. “New” business models should financially reward farmers for their added value contributions in delivering ecosystem services.

Keywords

Dairy • economic • grassland based • mindset • societal

Introduction

The European Union (EU; 28 countries) currently has a permanent grassland area of about 60 million ha (Eurostat, 2017). Permanent and temporary grasslands, including both pastures and meadows (as defined according to Peeters et al. [2014]), represent 40% of the European total utilised agricultural area (Huyghe et al., 2014). A large acreage of these grasslands is exclusively used to feed ruminants. The production of ruminant feed is important since ruminants deliver food for humans as they convert the human inedible plant biomass into high-quality edible proteins (Bradford, 1999). Thus, these grasslands play an important role in human nutrition and food security. Additionally, grassland-based ruminant production systems deliver a number of other services to society, like carbon (C) sequestration (e.g. Soussana et al., 2010; Conant et al., 2017), biodiversity (e.g. Isselstein et al., 2005), protection of soils against erosion, preservation of the aesthetic value of cultural landscapes and the traditional cultural heritage, the attractiveness for tourists and thus, a contribution to maintaining the local population density (Van den Pol-van Dasselaar et al., 2014a).

However, grasslands are under threat. Under climatically and topographically favourable conditions, the European grassland area (in ha) has been significantly reduced during the last 30 yr (Huyghe et al., 2014). There are several causes for the decline in grassland area. According to the third report of the EU MAES initiative (Mapping and Assessment of Ecosystems and their Services), between 2006 and 2012 the main causes for this process were the conversion of grasslands into arable crops like maize (including the production of biofuels) and permanent crops (32% of the lost area), the sprawl of urban areas, economic sites and infrastructures (30%) and the withdrawal from farming (17%) (Erhard et al., 2016).

Farmland abandonment is still ongoing. Especially marginal grasslands tend to be abandoned in several European regions. It affects many parts of Europe, especially the mountain farms that are often grassland based (Battaglini et al., 2014) and the semi-arid areas in South Europe (Lasanta et al., 2017). In Galicia, for example, López Iglesias et al. (2013) pointed out an increasing rate of disappearance.
of farms between 1982 and 2009, with a reduction of two-thirds in the number of farms in that period. Of the total land released by farms which had disappeared, more than half was abandoned or was put into non-agricultural use (mainly rapid-growing Eucalyptus forests). Also in the mountain environment of the Alps, the number of farms decreased by 40% between 1980 and 2000 (Streifeneder et al., 2007). In the Italian Alps, this process was still apparent between 1990 and 2010, with a strong decrease in the number of cattle, sheep and goat farms (by 51.5%, 44.3% and 38.5%, respectively) (Battaglini et al., 2014). The existing grasslands have also undergone changes in the last decades. Dairy cow numbers decreased in the last 30 yr. Up to 2010, the grassland area was estimated to decrease along with the cow population (Peyraud & Peeters, 2016). The decrease in dairy cow numbers was mainly driven by the implementation of the milk quota regime in combination with an increasing milk yield of the individual cows. This improvement in individual animal milk production was achieved among others by improved genetics (Carta et al., 2009; Thornton, 2010; Oltenacu & Broom, 2010; Brade, 2016). In order to meet the increased animal energetic and nutritional requirements, the amount of concentrates and maize in the diet has increased (Knaus, 2013). This goes along with a declining percentage of milk being produced from grass (e.g. Isselstein et al., 2005). Moreover, high amounts of concentrates per kilogram of milk are detrimental to the net food production from grassland (Ertl et al., 2015; Berton et al., 2020). More and more European farmers have changed to all-year housing and do not provide access to grazing for their cows (Van den Pol-van Dasselaar et al., 2020). Some examples are as follows: only 42% of the German dairy cows have access to pasture (Gurrath, 2011), only 25% of Danish dairy cows have access to pasture (Van den Pol-van Dasselaar, 2016) and only 11% of Galician (North of Spain) dairy cows are in farms where grazing makes a significant contribution to the daily diet (Botana & Flores-Calvete, personal communication, 2017). Both management intensification and abandonment of grasslands have been found to be detrimental concerning biodiversity and aesthetic value (MacDonald et al., 2000; Köhler et al., 2005; Rey Benayas et al., 2007; Niedrist et al., 2009; Lindemann-Matthies et al., 2010).

This paper aims to explore the societal and economic options to support grassland-based dairy production in Europe. First, the importance of grassland-based dairy production to society is described. Second, societal initiatives to promote grassland-based dairy production systems are addressed. Since the farmer is a focal point of grassland-based dairy production, special attention is paid to the mindset of the farmer. Furthermore, a “new” and emerging business model to stimulate grassland-based dairy production is presented. Finally, the complications of all initiatives are summarised.

### Multiple benefits of grassland-based dairy production systems to society

Grassland-based dairy production systems provide a number of services to society (Plantureux et al., 2016). The Millennium Ecosystem Assessment report (Hassan et al., 2005) distinguished four groups of ecosystem services:

- Provisioning services (e.g. production of food)
- Regulating services (e.g. control of climate and disease)
- Cultural services (e.g. recreation and beauty of the landscape)
- Supporting services (e.g. nutrient cycles).

Grassland-based dairy production contributes to all of the aforementioned groups of ecosystem services. These ecosystem services are more and more recognised by the society and are highly valued by all relevant stakeholders. A questionnaire among 1,959 stakeholders (farmers, government, research, advice, education, industry, non-governmental organisations [NGOs]) in several European countries that studied the importance of different functions of grasslands showed that some functions are especially appreciated by stakeholders. Respondents were asked to value more than 40 predefined functions of grasslands (related to the different groups of ecosystem services described earlier) for importance in their region on a range of 1 (not important) to 5 (important). The top five functions were (Van den Pol-van Dasselaar et al., 2014a):

- Grazing animals (4.2)
- High-quality forage (4.1)
- Dairy cow milk production (4.0)
- Low-cost animal feed (4.0)
- Beauty of the landscape (4.0).

Next to the production function, the stakeholders value especially what they see when they are in the countryside: the beauty of the landscape and perceived biodiversity, both in different plant species and in ruminants grazing and browsing these species. Similar examples are found in individual countries. In Germany, for example, it was shown that outdoor systems with grazing animals are perceived by consumers as more animal and environmentally friendly and more traditional than housed systems (Weinrich et al., 2014). Grazing is, however, not the only option with respect to grasslands that is valued by consumers. In this regard, it must be considered that topographical (i.e. steep terrain) and climatic constraints (i.e. short growing season at high altitudes), such as in the case of the Alps, may pose strong limitations in the utilisation of grassland. For instance, very steep terrains restrict the choices of the grazing animal species to small ruminants, while the shortness of the growing season requires a higher proportion of forage to be conserved and stored to feed the animals outside of the
Next to the positive image that grassland-based dairy production delivers to society, there are also a number of ecosystem services delivered that are less visible, but vital to the whole society, like the previously mentioned C sequestration (e.g. Soussana et al., 2010; Conant et al., 2017). Also, grazing may have a positive effect on animal welfare; for example, Burow et al. (2013) found that many daily grazing hours were more beneficial on dairy cow welfare than few daily grazing hours, and Armbrecht et al. (2018) found that pasture access had positive effects for claw diseases that are related to moist environments. Furthermore, exposure to certain types of agricultural landscapes, especially grasslands, could have an important role in human health and well-being. For example, when it comes to natural amenities, access to green spaces is thought to be especially beneficial to children as children in rural areas display long-term health benefits from playing outdoors (Makri & Stilianakis, 2008). There are also human health benefits to be derived from consuming products from animals raised on grass. In particular, milk from pasture-fed cows (grass or clover) has significantly higher concentrations of healthy fatty acids (Elgersma, 2015). These differences are reflected in the products produced from milk from pasture-fed cows. Pasture-derived butter, for example, has been shown to have lower atherogenicity scores and significantly higher concentrations of conjugated linoleic acid (CLA), a healthy fatty acid (O’Callaghan et al., 2016).

The multiple benefits of grassland-based dairy production systems to society would be lost once grasslands would be converted into other destinations. A further decrease in the European grassland area would then correspond to a decrease in the provision of these ecosystem services provided by grasslands. And as such, this would counteract some societal wishes. The societal wishes may, however, also offer new perspectives for grassland-based dairy production systems.

### New perspectives: societal initiatives to stimulate grassland-based dairy production

European citizens react more and more to changes in their rural area. Societal initiatives are developed in response to a rising awareness about these changes. To stimulate grassland-based dairy production, several societal initiatives have emerged (Table 1). The Netherlands provides a good example of the first two categories (treaties and premiums). In Dutch politics and society, there is a broad interest to promote access to pasture for cows. The visibility of ruminants, especially dairy cows, has however decreased in the last decades. In the year 2001, about 90% of the Dutch dairy cows grazed on pasture, while in 2016 this percentage had decreased to 65% (CBS, 2020). Grazing became a societal issue. The grazing dairy cow is seen as part of the cultural heritage of the Netherlands, and Dutch society has expressed its concern about less grazing. As a consequence, a “Treaty on Grazing” was initiated in 2012 by a number of organisations in the full dairy chain to reverse this trend. Currently, this Treaty, which aims to stabilise the percentage of farms that practise grazing, has been signed by >80 organisations, including farmer organisations, industry (e.g. feed and milk robot industry), education, NGOs, government and research. As part of the Treaty, many stimulating initiatives took place. The most prominent one was the introduction of a grazing premium that is provided by the dairy industry to farmers that practise grazing of dairy cows for at least 120 d/yr for at least 6 h/d. Grazing became an issue even in the Dutch parliament in 2017 when a number of political parties suggested the requirement to make grazing obligatory. Other parties were confident that the “Treaty on Grazing” would prevent a further decrease in grazing and, as such, the Treaty prevented the obligation. At the end of 2017, it was shown that the percentage of dairy farms with grazing was increasing again, which was seen as a success for the coming growing season. In these areas, management by mowing (meadows) also represents a traditional grassland use that is appreciated. Appreciation of the mountain landscapes generated by agriculture activities, including both summer pastures and meadows, was expressed, for instance, in a survey conducted in the Alpine area of Tyrol (Austria) and South Tyrol (Italy) (Pecher et al., 2018). In these areas, management by mowing (meadows) also represents a traditional grassland use that is appreciated. Appreciation of the mountain landscapes generated by agriculture activities, including both summer pastures and meadows, was expressed, for instance, in a survey conducted in the Alpine area of Tyrol (Austria) and South Tyrol (Italy) (Pecher et al., 2018).

### Table 1: Societal initiatives to stimulate grassland-based dairy production and some examples of these initiatives in Europe

| Initiative          | Explanation                   | Examples                                      |
|---------------------|-------------------------------|------------------------------------------------|
| Treaties            | Formal agreements             | Treaty on Grazing (The Netherlands)           |
|                     | between stakeholders          | Grazing Charter (Germany)                     |
| Premiums            | Prizes, bonuses or awards     | Grazing premiums (The Netherlands, Germany)   |
|                     | given as incentives           | Carbon Fund (Portugal)                        |
| Market concepts and | Constructs to promote         | Grass-fed branding of products (many European |
| differentiation of  | products                      | countries)                                    |

...
In recent years, the percentage of Dutch dairy cows that graze on pasture has further increased to 71% in 2018 (CBS, 2020). Runhaar et al. (2020) describe this as a successful example of a transition pathway to more sustainability. In the last decades, market-driven practices have led to less grazing in the Netherlands. This dominant logic, however, was increasingly challenged by institutional logics centring round cultural identity and sustainability values leading to specific actions, in particular the initiation of grazing premiums for farmers, the signing of the “Treaty on Grazing” and strengthening of advice and education. As such, the premiums and the Treaty contributed to a sustainability pathway rather than to market logics.

The example of the Dutch “Treaty on Grazing” with a large number of participants from different backgrounds has been followed in other countries. For example, since 2016 there is also a German “Grazing Charta” (Deutsche Weidecharta GmbH, 2017). Recently, German dairies started to promote pasture milk and a pasture-milk label was developed. Milk classified with this label comes from cows which graze on pasture for at least 120 d/yr for at least 6 h/d. Additionally, the farms must provide at least 0.2 ha grassland per cow; 0.1 ha of this grassland must be pasture for dairy cows. The farmers must provide an overview of their farm structure; the area which is supposed to be for dairy cows must not be used for heifers, calves or other animals. Compliance with these rules is monitored by the dairies and by independent control agencies. Farmers receive 1 cent more per kilogram of pasture milk, but this amount is expected to rise to 5 cents (Reuter & Frieler, 2017; Rohmann, 2017). Pasture milk was found to have a higher consumer price than milk without the label. The acceptance of the higher milk price by consumers is high (Mergenthaler & Schröter, 2019). The establishment of the German label was, however, difficult, because the dairy farmers, including the grazing farmers, were sceptical about the program. They feared that the program would lead to a strong market differentiation coming with a discrimination of all-year housing farms (Kühl et al., 2016). A similar scenario occurred in the Netherlands. Retailers were paying a premium for grazing milk. The premium was, however, not high enough to fully compensate the bonus-malus distribution of the price that the dairy industry implemented. This was, in part, due to the fact that a substantial proportion of the milk produced in the Netherlands is exported (Runhaar et al., 2020).

The Netherlands and Germany are not the only countries with societal concerns about the trends towards less grassland and fewer animals grazing on these grasslands. In several countries, such as Spain, France and Belgium, premiums are paid to farmers in certain regions that practise grazing or maintain grasslands. The institutions that pay for these premiums can be very different, from consumers to industry to government. Premiums are also paid to deliver certain ecosystem services provided by grasslands. In Portugal, for example, a Carbon Fund was established, paying farmers for delivering the ecosystem service C sequestration (Teixeira et al., 2015).

Another category of societal initiatives, next to treaties and premiums, are the initiatives that relate to the quality of the animal products produced and the associated market concepts. Grassland-based products, especially if they are grazing based or of regional origin, are currently positively perceived by consumers (Bernués et al., 2015) and qualitative aspects can be associated with them depending on the management practices applied (Coppa et al., 2017). A differentiation of such products is necessary to ensure recognisability and price acceptance by the consumers, as well as an acknowledgement and acceptance by public opinion in case public supporting measures are implemented in disadvantaged areas. Both authentication (the process verifying the characteristics of the product as complying with its description) and traceability (the ability to follow the movement of the product from the production site to the consumers) are relevant issues to this aim (Moloney et al., 2014). The increased interest in grass-fed branding implicates that grass-fed standards need to be set and claims need to be validated. Currently, first initiatives in this area arise; for example, the Irish industry has published a methodology to quantify grass in the diet (O’Brien et al., 2018). Standards will differ between regions.

In conclusion, in many European countries, ecosystem services associated with grasslands and grassland-based animal products are promoted by introducing premiums or marketing of differentiated products. Local products are promoted as authentic and marketed as such leading to premium prices for farmers.

The farmer as a focal point: the importance of the mindset of the farmer

When developing stimulating or supporting initiatives with respect to grasslands and grassland-based dairy production, it is important that the farmer should be taken into account, since it is the farmer who decides on the management of grasslands. Farmers are key actors when it comes to maintaining and improving the important functions of grassland-based dairy production. They are key actors, because they decide on the day-to-day management of their farm. In this way, in fact, a small percentage of the population is managing benefits for the whole society. It is known from on-farm participatory research and analysis of basic motivational drivers of European farmers that personal values, preferences, experiences and habits of farmers are very important in management decisions (e.g. Reijs et al., 2013; Baur et al., 2016). When farmers and their families are encouraged to change their system, the mindset of the farmers must therefore be considered.
An important aspect of the mindset of farmers is their attitude towards risk. Farming, and dairy farming in particular, takes place in a very unstable environment. Farmers experience risks from fluctuating weather conditions, plant and animal diseases, and also from changing prices and changing governmental regulations. As for managers in other businesses, there are different types of farm managers, who have different attitudes towards risk, show different risk management behaviours and choose different strategies (Schaper et al., 2010). According to a study by Granoszewski & Spiller (2013), farmers mostly show risk-avoiding behaviour. With age, the attitude towards risk changes, with farmers becoming more and more risk avoiding with increasing age (Schaper et al., 2010). The effect of the mindset of the farmer on decisions related to grasslands is illustrated by a few examples, which show that the attitude of the farmer is an important influencing factor for management decisions in grassland-based dairy production systems.

- A Swiss focus group analysing motivation and attitudes of farmers practising either intensive indoor feeding (IF) or full-time grazing (FG) showed distinctive mindset differences between the two groups concerning feeding strategies, economy and ecology (Baur et al., 2010). The IF group was found to react to the increasing market pressure by means of an increase in milk production, to seek a reduction in the dependency on seasonal variations and an increase in the planning capability and to perceive itself as a modern, market-oriented enterprise. The FG group put environmental sustainability, cost minimisation and considerations on common welfare in the foreground. Interestingly, it was shown that animal welfare was equally important for the two groups, although adequately fulfilling animal requirements through concentrates was the main concern of the IF group and the positive aspects of grazing on animal welfare were the main motivation of the FG group.

- Research from the Netherlands aimed to study the technical and social factors that affect the extent of grazing on commercial dairy farms (Van den Pol-van Dasselaar et al., 2016). Based on the “Theory of Planned Behavior” (Ajzen, 1991), it was hypothesised that the extent of grazing is influenced by the attitude of farmers towards grazing, subjective norms about grazing, perceived behavioural control of grazing and technical possibilities for grazing. An online questionnaire was sent to commercial dairy farmers and 212 valid responses were obtained. Results are analysed using factor analysis and multiple linear regression analysis. Combining technical and social factors in a multiple linear regression model accounted for 47% of the variation in the extent of grazing. These results from the Netherlands imply that future work on grazing should take the mindset of the farmer into account.

- For many farmers, an important obstacle to increasing grazing is their focus on a high milk yield per cow (Thomet et al., 2011), even though the relationship between profit and milk yield per cow is poor. Again, an effect of the mindset of the farmer can be found. A survey among Danish farmers showed that non-grazing farmers expected grazing to reduce their milk yield but the farmers from organic farms who offer their cows access to pasture did not associate grazing with reduced milk yield (Kristensen et al., 2010). A similar result was found in Germany, where the cows from north-west German grazing farms had less milk than the average in this region, but the respective farmers did not associate grazing with reduced milk yield (Becker et al., 2018). Also, Winsten et al. (2000) found that grazing farmers were twice as likely to increase their reliance on grazing as non-grazing farmers.

There are a number of things to address when looking at studies into the mindset of farmers. The first one is related to the methods used. Surveys, such as the ones used in these examples, are a common method of obtaining information on the mindset and the decision processes of farmers. But the information gathered with surveys needs a critical evaluation, especially with respect to the human tendency to avoid cognitive dissonance. When confronted with advice which implies another behaviour or management, farmers (like every human person) experience cognitive dissonance (Kristensen & Jakobsen, 2011). Cognitive dissonance centres around the idea that if a person knows various things that are not psychologically consistent with one another, he or she will, in a variety of ways, try to make them more consistent (Festinger, 1962). Cognitive dissonance can be reduced by a change of opinion, a change of behaviour or a change of perception or a combination of these. When a decision is made, people tend to perceive the positive aspects of their choice stronger than before, while they mainly see the negative aspects of the rejected alternative (Festinger, 1962).

A further general flaw of studies about the mindset of farmers is the assumption that farmers strive to maximise profit. However, they might be motivated by many other aspects, for example, animal welfare or the recognition of other farmers (Kristensen & Jakobsen, 2011). Baur et al. (2016) found European farmers to be more conservative and less open to change than the general population but also identified a tendency of farmers to be less motivated by self-interest (self-enhancement) and more concerned with common welfare (self-transcendence). Though most farms are family businesses, data about technology choices on farms are routinely collected from only one person, usually a man. It remains unclear what role the decisions about farm technology play in an overall household strategy, since many studies on farms lack data on farm women. A study among American farmers found that farm households, where
technology choice is a joint decision of men and women, were more likely to adopt intensive rotational grazing, which was at that time and place a relatively new alternative to confinement milk production. This was also more prevalent among older couples. The role of the influence of children and parents on farm decisions needs further investigation (Zepeda & Castillo, 1997).

Finally, there is often a gap between the planned intentions of farmers and actual behaviour. In general, humans tend to be too optimistic in their intentions. An example of this is provided by Hennessy et al. (2016), who asked farmers about their future production levels and compared them with actual levels 3 yr later. A large majority of the farmers tended to be too optimistic, that is, they overestimated their future production levels.

### Grassland-based dairy farming as a low-cost strategy

If farmers are expected to further manage and maintain grasslands, it is an essential condition that they will have a reasonable income. Agricultural markets act mainly at a global scale and so individual farmers cannot influence, or only to a minor extent, the prices of products sold (unless they are in a situation where they sell directly from the farm). In economic theory, the law of supply and demand is considered one of the fundamental principles governing an economy. If supply increases, prices will tend to decline, other things being equal, and vice versa. In this business model, the income of the farmer is based on the price for animal products sold (often bulk production), minus the costs of producing these animal products. In Europe, subsidies may play a further role.

Nowadays, in many European countries, the application of the Common Agricultural Policy (CAP) results in subsidies promoting grassland-based systems (at the plot or farm level). These subsidies can be a major part of the farmers’ income. Where individual farmers cannot easily influence the price of animal products, a low-cost strategy (Porter, 1980) is a good choice. The assumption here is that farmers strive to reach maximum profit, which is not always the case as is shown in the previous section.

There are of course huge differences in income on farms with grassland-based dairy production. These differences are related to farm characteristics in combination with pedoclimatic conditions. In north-west Europe under an Atlantic climate, grassland-based dairy production is, however, mainly seen as an economic activity with low costs and high farm profitability (Dillon et al., 2005; Peyraud et al., 2010). An example of this is provided by Läpple et al. (2012), who showed that increased grazing and a reduction in concentrate feed usage improved profitability levels on Irish dairy farms. The findings indicated that lengthening the grazing season offers a cost-saving alternative on many Irish dairy farms, which could contribute to strengthening the competitiveness of the dairy sector. For example, lengthening the grazing season from the average of 233 d to 243 d would reduce the direct costs of production from 14.6 to 14.2 cents/L for the average farm. A key factor affecting the economic sustainability of grassland-based dairy production is the proportion of grass in the diet. A Dutch study showed that grazing is financially attractive if the cows eat sufficient amounts of pasture grass (Van den Pol-van Dasselaar et al., 2014b). If the intake of fresh grass is very low, grazing is less profitable than summer feeding. This is also illustrated in Figure 1 (Dillon et al., 2005),

![Figure 1. Relationship between proportion of grass in the diet of dairy cows and the total costs of production for different countries in the world (Dillon et al., 2005).](image-url)
where a high proportion of grass in the diet of dairy cows in different countries throughout the world corresponds to low total production costs. More recently, Hanrahan et al. (2018) analysed an extensive database of Irish commercial farms and showed that farm net profit per hectare was associated with pasture use per hectare. On average, over an 8-yr period, each additional tonne of pasture DM used on dairy farms increased gross profit by €278 and net profit by €173.

**Regional differences in profitability of grassland-based dairy farming**

Some regions of Europe do not have such satisfactory conditions to allow a low-cost forage production. The various farm-specific and pedoclimatic conditions that are present in Europe affect the potential for high-performing grasslands and hence influence profitability. In the Alps and other marginal areas, for example, topographically unfavourable features such as slope steepness result in limits to mechanisation (Sauter & Latsch, 2011), while climatic limitations such as low temperatures due to increasing altitude or latitude reduce the yield potential of grassland. Both constraints result in an increase in the production costs of forage (Peratoner et al., 2017).

Further examples from Italy, Galicia and Germany show that the economic effect of grassland-based dairy production may be restricted as the actual proportion of grass in the ration is relatively low. Comparing the energy requirements of the livestock and the energy available in grassland forage production of two valleys of South Tyrol – a mountainous region of the Alps in north-east Italy – an energy deficit of 46% and 47% was estimated (Tasser et al., 2012). A survey in the north of Spain – a humid temperate region with conditions for grazing where >60% of the Spanish milk is produced – showed that on average only 15% of DM of the total ration of lactating dairy cows came from grazed herbage (Flores-Calvete et al., 2017). And a first residual analysis of federal statistical data (Statistisches Bundesamt, 2014) from Lower Saxony – an important milk-region in Germany – showed that only 30% of the milk produced in this region is based on grass, grass silage and hay. The vast majority of the milk is produced with concentrates and maize (Ortgies, 2014). These results are in line with an analysis of 54 German dairy farms, where cows from all-year housing and exercise pasture farms got >70% of their energy from maize and concentrates and farms that provided at least 0.08 ha pasture per cow got only 50% of their energy from maize and concentrates (Becker et al., 2018). However, the cows in these systems are mostly high-yielding Holstein dairy cows, which can show energy deficiencies when their nutrition is not supplemented to a large part with concentrates (Hartwiger et al., 2018). Holsteins have a higher milk yield than Irish Holstein-Friesian, French Montbéliarde or French Normande, but this often goes along with a greater mobilisation of body reserves in early lactation and lower live-weight gain from mid- to end of lactation (Dillon et al., 2003). In low-input pasture-based systems, Holsteins showed a poor reproductive performance, and Fleckvieh cattle were better suited to this system (Piccand et al., 2013). New Zealand Holstein Friesians were found to be more efficient in a pasture-based milk production system than Swiss breeds (Thomet et al., 2010). A study with 60 farms in the north of Germany indicated that, where the nutrition is partly based on grazing, lower costs and lower revenues are found (Kohnen, 2019). An important role seems to be played by the amount of concentrates included in the diet, as increases in the price of concentrates result in an expected decline of the income per labour unit (Kiefer et al., 2013). However, in this regard, the profitability of grassland-based systems is also mediated by the milk-to-feed price ratio: in a study conducted on mountain farms in South Tyrol (NE Italy) at a milk-to-feed price ratio of about 1.8, high-input farms (roughage-derived milk: 20–25%) were found to generate higher incomes than low-input farms (roughage-derived milk: 45–49%) (Kühl et al., 2020).

**“New” business models to stimulate grassland-based farming**

So there is a tendency that, even though grassland-based systems are mainly seen as low-cost systems, dairy farmers choose to intensify their production systems, leading to more concentrates and maize in the rations of the cows, less grass in the ration and/or less grazing. This is a global phenomenon in response to farm internal and external driving forces (Oenema et al., 2014). Oenema et al. (2014) showed that the optimum level of intensification is a moving target, due to the changing biophysical, economic and societal environments. There are some regional differences. The assumed economic benefits of grassland-based systems are not achievable in practice in some European areas due to farm and pedoclimatic conditions or they are perceived as impossible by farmers. Farmers choose to be less grassland based and transform part of their grasslands into other systems. This trend then leads to a smaller grassland area. The business model with the underlying assumption that grassland-based dairy production is profitable and will therefore automatically be the preferred system in Europe no longer works to maintain grasslands in all European regions. Even though grasslands provide multiple benefits to the wider society, it is the individual farmer that needs to maintain these benefits by maintaining the grasslands. Farmers could be supported in this by financially rewarding the delivery of ecosystem services. In the past, additional services were not specifically rewarded by society,
which was used as the rationale for government interventions and associated taxes, subsidies and regulations. As pointed out by, for example, Bourne (2019), this government intervention often does not lead to the desired results. True incentives for the primary producer come as consumers are going to pay more for grassland-based products. Ultimately, higher prices for special products are an effective instrument. Next to that, it is interesting to see that in recent years, a number of societal initiatives have commenced to support the farmer in maintaining grasslands and grassland-based dairy production systems. These initiatives have been described in this paper and are region-specific and related to the desired ecosystem services for different types of grasslands in each region. This has led to a “new” and emerging business model where farmers are rewarded either for animal production or for societal demands/additional ecosystem services provided, or for both, via:

- Animal product prices (bulk production)
- Subsidies/direct payments
- Higher prices for special products
- Premiums.

**Governmental support**

The “new” business model described earlier leads to opportunities to realise the multiple benefits of grassland-based dairy production systems throughout Europe. In some areas, for example, countries with a good climate and highly productive grasslands like Ireland, grassland-based dairy production will remain an economically viable activity in itself and additional rewards for ecosystem services may further increase profitability. In other areas, societal initiatives to stimulate grassland-based dairy production will be necessary to maintain grasslands, for example, premiums for delivering ecosystem services and marketing of local products. Further work needs to focus on how to standardise and define the services delivered in the different European regions. The latest communication on the future of the CAP also stresses the importance of supporting the public goods produced by farmers. The CAP progressed in recent years from incentives for production to incentives for environmental sustainability. Future eco-schemes could be adapted to the different realities of countries. National and EU policies could further support grassland-based systems by introducing specific incentives, for example, to increase the grassland area near the farm or by promoting grassland-based products. Ecological, social and economic sustainable management schemes are required, even combining different management intensities at the farm level, to ensure, on the one hand, a further management of grasslands by the farmers and, on the other hand, the continued maintenance of ecological hotspots. These initiatives should be supported by innovative research and advice. Innovations in grassland management are continuously needed and are currently stimulated and promoted in regional, national and European projects. As such, they support sustainable development of grassland-based dairy production systems. The European project Inno4Grass is a clear example of such a project (www.inno4grass.eu). It aims to bridge the gap between practice and science communities to ensure the implementation of innovative systems on productive grasslands and to increase the profitability of European grassland farms and preserve environmental values (Krause et al., 2018).

**Concluding remarks**

Grassland-based dairy production provides multiple benefits to farmers and the whole of society. Supporting grassland-based dairy production is therefore relevant. A first prerequisite is the coherence between the site conditions, the socio-economic conditions and the production system (animal species, breed, grassland management). Furthermore, it requires “new” business models, where farmers are rewarded for added value. Farmers are key actors when it comes to maintaining and improving grassland-based dairy production systems since they decide on the day-to-day grassland management of the farm. The mindset of the farmer and a positive self-perception under the “new” business model, therefore, play a crucial role. Farmers are influenced by the human tendency to avoid cognitive dissonance, so behaviour usually changes when opinions or perceptions change. It is also clear that the often mentioned assumption that farmers strive to maximise profit is not so simple. Farmers are motivated by many other aspects, like animal welfare and social aspects such as the recognition of other farmers and society. To maintain grassland-based dairy production and to preserve the associated ecosystem services, it is necessary to clearly show the importance of this production system for society to the farmers (show the customer perspective) and to support this by financially valuing the products from these systems accordingly. We believe that it is the combination of these two (showing the importance and valuing this) that will shape the future and will lead to the sustainable development of grassland-based dairy production. Of course this should be accompanied by clear communication. Similarly, the acknowledgement of the farmer’s role by the society is the basis of targeted payment policies and the willingness of the consumers to pay a sound price for the products. This is related, in turn, to information campaigns towards the citizens and also to sound marketing strategies of grassland-based products,
including their authentication and traceability to prevent and avoid false claims.

Finally, the importance of the mindset of the farmer implies that farmer education is very important. Farmer education is an ongoing process promoted at several levels by multiple actors. Thematically broad education is delivered from professional schools for agriculture up to universities. As education grades are provided at specific points in time of the professional life of farmers, other ongoing training and knowledge transfer activities are needed about specific themes and can best be guaranteed by a network of extension services and innovation brokering systems interacting with the aforementioned educational and research institutions. Education provides farmers with knowledge, tools and skills that allow them to be more independent in their judgement, such as in the case of advertising and consultancy made by commercial companies. Special attention should be paid to the young farmers, since they represent the next generation of farming. Indeed, the students of today are the farmers and farm advisors of the future, and as such, they will determine the future of grassland-based dairy production.

References

Ajzen, I. 1991. The theory of planned behavior. Organizational Behavior and Human Decision Processes 50: 179–211.

Armbrecht, L., Lambertz, C., Albers, D. and Gauly, M. 2018. Does access to pasture affect claw condition and health in dairy cows? Veterinary Record 182: 79.

Battaglini, L., Bovolenta, S., Gusmeroli, F., Salvador, S. and Sturaro, E. 2014. Environmental sustainability of alpine livestock farms. Italian Journal of Animal Science 13: 3155.

Baur, I., Dobricki, M. and Lips, M. 2010. The basic motivational drivers of northern and central European farmers. Journal of Rural Studies 26 (Suppl C): 93–101.

Becker, T., Kayser, M., Tonn, B. and Isselstein, J. 2018. How German dairy farmers perceive advantages and disadvantages of grazing and how it relates to their milk production systems. Livestock Science 214: 112–119.

Bernués, A., Rodríguez-Ortega, T., Alfnes, F., Clemetsen, M. and Eik, L.O. 2015. Quantifying the multifunctionality of fjord and mountain agriculture by means of sociocultural and economic valuation of ecosystem services. Land Use Policy 48: 170–178.

Berton, M., Bittante, G., Zendri, F., Ramanzin, M., Schiavon, S. and Sturaro, E. 2020. Environmental impact and efficiency of use of resources of different mountain dairy farming systems. Agricultural Systems 181: 102806.

Botana, A. and Flores-Calvete, G. 2017. Personal communication.

Bourne, R. 2019. Market failure arguments are a poor guide to policy. Economic Affairs 39: 170–183.

Brade, W. 2016. Aktuelle Zuchtzielsetzung bei Deutschen Holstein-Rindern (Current breeding goals for German Holstein cattle). Berichte über Landwirtschaft 94: 1–18.

Bradford, G.E. 1999. Contributions of animal agriculture to meeting global human food demand. Livestock Production Science 59: 95–112.

Burow, E., Rousing, T., Thomsen, P., Otten, N. and Sørensen, J. 2013. Effect of grazing on the cow welfare of dairy herds evaluated by a multidimensional welfare index. Animal 7: 834–842.

Carta, A., Casu, S. and Salaris, S. 2009. Invited review: current state of genetic improvement in dairy sheep. Journal of Dairy Science 92: 5814–5833.

CBS 2020. Available online: http://statline.cbs.nl/Statweb/ [Accessed 26 June 2020].

Conant, R.T., Cerri, C.E.P., Osborne, B.B. and Paustian K. 2017. Grassland management impacts on soil carbon stocks: a new synthesis. Ecological Applications 27: 662–668.

Coppa, M., Cabiddu, A., Elsässer, M., Hulin, S., Lind, V., Martin, B., Mosquera-Losada, M.R., Peeters, A., Prache, S., van den Pol-van Dasselaar, A. and Peratoner, G. 2017. Grassland-based products: quality and authentication. Grassland Science in Europe 22: 39–60.

Deutsche Weidecharta GmbH. 2017. Pro Weideland-deutsche Weidecharta. Available online: http://www.proweideland.de/verbraucher/kriterien [Accessed 18 December 2017].

Dillon, P., Buckley, F., O’Connor, P., Hegarty, D. and Rath, M. 2003. A comparison of different dairy cow breeds on a seasonal grass-based system of milk production: 1. Milk production, live weight, body condition score and DM intake. Livestock Production Science 83: 21–33.

Dillon, P., Roche, J.R., Shalloo, L. and Horan, B. 2005. Optimising financial return from grazing in temperate pastures. In: "Utilisation of Grazed Grass in Temperate Animal Systems" (ed. J.J. Murphy), Wageningen Academic Publishers, Wageningen, the Netherlands, pages 131–147.

Duurzame Zuivelketen. 2017. Available online: https://www.duurzamezuivelketen.nl/nieuwsberichten/sterke-toename-weidegang/ [Accessed 16 November 2018].

Elgersma, A. 2015. Grazing increases the unsaturated fatty acid concentration of milk from grass-fed cows: a review of the contributing factors, challenges and future perspectives. European Journal of Lipid Science and Technology 117: 1345–1369.

Erhard, M., Teller, A., Maes, J., Meiner, A., Berry, P., Smith, A., Eales, R., Papadopoulou, L., Bastrup-Birk, A., Ivits, A., Ryo Gelabert, E., Dige, G., Petersen, J.-E., Reker, J., Cugny-Seguin, M., Kristensen, P., Uhel, R., Estreguil, C., Fritz, M., Murphy, P., Banfield, N., Ostermann, O., Abdul Malak, D., Marín, A., Schröder, C., Conde, S., Garcia-Feced, C., Evans, D., Delbaere, D., Naumann, S., Davis, M., Gerdes, H., Graf, A., Boon, A., Stoker, B., Mizgajski, A., Santos Martin, F., Jol, A., Lükeville, A., Werner, B., Romao, C., Desaulty, D., Larsen, F.W., Louwagie, G., Zal, N., Gawronska, S. and Christiansen, T. 2016. "Mapping and Assessment of Ecosystems and Their Services. 3rd Report – Final, Technical
Report – 2016 – 095. European Union, European Environment Agency, 183 pages.

Ertl, P., Klocker, H., Hörtenhuber, S., Knaus, W. and Zollitsch, W. 2015. The net contribution of dairy production to human food supply: the case of Austrian dairy farms. *Agricultural Systems* 137: 119–125.

Eurostat. 2017. Available online: http://ec.europa.eu/eurostat [Accessed 16 November 2018].

Festinger, L. 1962. *Cognitive dissonance*. *Scientific American* 207: 93–107.

Flores-Calvete, G., Fernández-Lorenzo, B. and Botana, A. 2017. Encuesta sobre estructura y sistemas de alimentación de las explotaciones lecheras de Galicia, Comisa Cantábrica y Navarra. Acción 1 del proyecto de investigación INIA-RTA2012-00065-C05 (CIAM-Galicia, SERIDA-Asturias, CIFA-Cantabria, NEIKER-Pais Vasco y INTIA-Navarra). Coord. autonómicos: Flores-Calvete, G., Martínez-Fernández, A., Doltra, J., García-Rodríguez, A. and Eguinoa-Ancho, P. INTIA, 52 pages.

Granoszewski, K. and Spiller, A. 2013. Vertragliche Zusammenarbeit bei der energetischen Biomasselerienung: Einstellungen und Bindungsbereitschaften von deutschen Landwirten (Contractual cooperation in the energy supply of biomass: attitudes and commitment of German farmers). *Proceedings of the 53th Jahrestagung der Gesellschaft für Wirtschafts- und Sozialwissenschaften des Landbaus eV*, pages 1–13.

Gurrath, P. 2011. “Landwirtschaft auf einen Blick”. Statistisches Bundesamt ed., Wiesbaden, Germany.

Hanrahan, L., McHugh, N., Hennessy, T., Moran, B., Kearney, R., Wallace, M. and Shallow, L. 2018. Factors associated with profitability in pasture-based systems of milk production. *Journal of Dairy Science* 101: 5474–5485.

Hartwiger, J., Schaeren, M., Potthoff, S., Hüther, L., Kersten, S., Von Soostten, D., Beineke, A., Meyer, U., Breves, G. and Dänicke, S. 2018. Effects of a change from an indoor-based total mixed ration to a rotational pasture system combined with a moderate concentrate feed supply on rumen fermentation of dairy cows. *Animals* 8: 205.

Hassan, R., Scholes, R. and Ash, N. (eds.). 2005. *Ecosystems and Human Well-being: Current State and Trends*. The Millennium Ecosystem Assessment series, Volume 1. Island Press, Washington, Covelo, London, 901 pages.

Hennessy, T., Kinsella, A. and Thorne, F. 2016. Planned intentions versus actual behaviour: assessing the reliability of intention surveys in predicting farmers’ production levels post decoupling. *International Journal of Agricultural Management* 5: 70–77.

Huyghe, C., De Vliegher, A., van Gils, B. and Peeters, A. 2014. “Grasslands and Herbivore Production in Europe and Effects of Common Policies”. Quae Éditions, Paris, France, pages 287.

Isselstein, J., Jeangros, B. and Pavlú, V. 2005. Agronomic aspects of biodiversity targeted management of temperate grasslands in Europe – a review. *Agronomy Research* 3: 139–151.

Kiefer, L., Bahrs, E. and Over, R. 2013. Vorzüglichkeit der ökologischen Weidemilchproduktion im Kontext steigender Kraftfutterpreise. In: “Ideal und Wirklichkeit – Perspektiven Ökologischer Landbewirtschaftung” (eds. D. Neuhoff, C. Stumm, S. Ziegler, G. Rahmann, U. Hamm and U. Köpke), Beiträge zur 12. Wissenschaftstagung Ökologischer Landbau, Bonn, 5.–8. März 2013, Verlag Dr. Köster, Bonn, pages 500–503.

Knaus, W. 2013. Re-thinking dairy cow feeding in light of food security. *AgroLife Scientific Journal 2*: 36–40.

Köhler, B., Gigon, A., Edwards, P.J., Krüsi, B., Langenauer, R., Löscher, A. and Ryser, P. 2005. Changes in the species composition and conservation value of limestone grasslands in Northern Switzerland after 22 years of contrasting managements. *Perspectives in Plant Ecology, Evolution and Systematics* 7: 51–67.

Kohnen, M. 2019. Wie unterscheiden sich die Vollkosten für die Milcherzeugung von Weide- und Stallbetrieben? In: “Systemanalyse Milch – Hintergründe für die Praxis”. Grünlandzentrum Niedersachsen Bremen, Ovelgönne, Germany, pages 79–86.

Krause, A., Becker, T., Feindt, P.H., Huyghe, C., O’Donovan, M., Peeters, A. and Van den Poel-van Dasselaar, A. 2018. Towards sustainable European grassland farming with Inno4Grass: an infrastructure for innovation and knowledge sharing. *Grassland Science in Europe 23*: 925–936.

Kristensen, E. and Jakobsen, E.B. 2011. Challenging the myth of the irrational dairy farmer; understanding decision-making related to herd health. *New Zealand Veterinary Journal* 59: 1–7.

Kristensen, T., Madsen, M.L. and Noe, E. 2010. The use of grazing in intensive dairy production and assessment of farmers’ attitude towards grazing. *Grassland Science in Europe 23*: 964–966.

Kühl, S., Sijbesma, G. and Spiller, A. 2016. Einstellungen deutscher MilcherzeugerInnen zu Weidemilchprogrammen und Einflussfaktoren auf die Teilnahmebereitschaft. In: “ Jahrbuch der Österreichischen Gesellschaft für Agrarökonomie. Österreichischen Gesellschaft für Agrarökonomie. Band 25” (eds. K. Heinschink, T. Oedl-Wieser, F. Sinabell, T. Stern and C. Trible), Facultas Verlags- und Buchhandels AG, Vienna, Austria, pages 35–44.

Kühl, S., Flach, L. and Gauly, M. 2020. Economic assessment of small-scale mountain dairy farms in South Tyrol depending on feed intake and breed. *Italian Journal of Animal Science* 19: 41–50.

Läpple, D., Hennessy, T. and O’Donovan, M. 2012. Extended grazing: a detailed analysis of Irish dairy farms. *Journal of Dairy Science* 95: 188–195.

Lasanta, T., Arnáez, J., Pascual, N., Ruiz-Flaño, P., Errea, M.P. and Lana-Renault, N. 2017. Space–time process and drivers of land abandonment in Europe. *Catena* 149: 810–823.

Lindemann-Matthies, P., Briegel, R., Schüpbach, B. and Junge, X. 2010. Aesthetic preference for a Swiss alpine landscape: the impact of different agricultural land-use with different biodiversity. *Landscape and Urban Planning* 98: 99–109.
López Iglesias, E., Sineiro-Garcia, F. and Lorenzana-Fernández, R. 2013. Processes of farmland abandonment: land use change and structural adjustment in Galicia (Spain). *Research in Rural Sociology and Development* **19**: 91–120.

MacDonald, D., Crabtree, J.R., Wiesinger, G., Dax, T., Stamou, N., Fleury, P., Gutierrez Lazpita, J. and Gibson, A. 2000. Agricultural abandonment in mountain areas of Europe: environmental consequences and policy response. *Journal of Environmental Management* **59**: 47–69.

Makri, A. and Stilianakis, N.I. 2008. Vulnerability to air pollution health effects. *International Journal of Hygiene and Environmental Health* **211**: 326–333.

Mergenthaler, M. and Schröter, I. 2019. Hedonische Analyse von Milchpreisen auf Einzelhandelsebene: Qualitäts-, Siegel- und Markeneffekte. In: „Innovatives Denken für eine nachhaltige Land- und Ernährungswirtschaft. Contributions to the 15th Scientific Conference on Organic Farming, Kassel, 5–8 March 2019“ (eds. D. Mührath, J. Albrecht, M.R. Finckh, U. Hamm, J. Heß, U. Knierim and D. Möller), Verlag Dr. Köster, Berlin.

Moloney, A.P., Monahan, F.J. and Schmidt, O. 2014. Quality and authenticity of grassland products. *Grassland Science in Europe* **19**: 509–520.

Niedrist, G., Tasser, E., Lüth, C., Dalla Via, J. and Tappeiner, U. 2009. Plant diversity declines with recent land use changes in European Alps. *Plant Ecology* **202**: 195–210.

O’Brien, D., Moran, B. and Shalloo, L. 2018. A national methodology to quantify the diet of grazing dairy cows. *Journal of Dairy Science* **101** (9): 8595–8604.

O’Callaghan, T.F., Hennessy, D., McAuliffe, S., Kilkawley, K.N., Moloney, A., Dillon, P., Ross, R.P. and Stanton, C. 2016. Effect of pasture versus indoor feeding systems on raw milk composition with Emphasis on the Dutch Situation”. *LEI Wageningen UR, Wageningen*, 124 pages.

Oenema, O., de Klein, C. and Alfaro, M. 2014. Intensification of grassland and forage use: driving forces and constraints. *Crop & Pasture Science* **65**: 524–537.

Oltenacu, P.A. and Broom, D.M. 2010. The impact of genetic selection for increased milk yield on the welfare of dairy cows. *Animal Welfare* **19**: 39–49.

Ortgies, F. 2014. Eine Analyse der Bedeutung des Grünlandes in der Milcherzeugung auf Basis der Agrarstatistik in Niedersachsen. Bachelor thesis. University of Göttingen, Göttingen, Germany.

Pecher, C., Bacher, M., Tasser, E. and Tappeiner, U. 2018. Agricultural landscapes between intensification and abandonment: the expectations of the public in a Central-Alpine cross-border region. *Landscape Research* **43**: 428–442.

Peeters, A., Beaufoy, G., Canals, R.M., Vliegher, A. de, Huyghe, C., Isselstein, J., Jones, G., Kessler, W., Kirilov, A., Mosquera-Losada, M.R., Nilsdotter-Linde, N., Parente, G., Peyraud, J.-L., Pickert, J., Plantureux, S., Porqueddu, C., Rataj, D., Stypinski, P., Tonn, B., van der Pol-van Dasselaar, A., Vinu, V. and Wilkins, R.J. 2014. Grassland term definitions and classifications adapted to the diversity of European grassland-based systems. *Grassland Science in Europe* **19**: 743–749.

Peratoner, G., De Ros, G., Senoner, J.L., Figl, U. and Florian, C. 2017. Effect of slope and altitude on the costs of forage production in mountain areas. *Grassland Science in Europe* **22**: 215–217.

Peyraud, J.L. and Peeters, A. 2016. The role of grassland based production system in the protein security. *Grassland Science in Europe* **21**: 29–43.

Peyraud, J.L., van den Pol-van Dasselaar, A., Dillon, P. and Delaby, L. 2010. Producing milk from grazing to reconcile economic and environmental performances. *Grassland Science in Europe* **15**: 865–879.

Pickand, V., Cutillic, E., Meier, S., Schori, F., Kunz, P.L., Roche, J.R. and Thomet, P. 2013. Production and reproduction of Fleckvieh, Brown Swiss, and 2 strains of Holstein-Friesian cows in a pasture-based, seasonal-calving dairy system. *Journal of Dairy Science* **96** (8): 5352–5363.

Plantureux, S., Bermués, A., Huguenin-Elie, O., Hovstad, K., Isselstein, J., McCracken, D., Therond, O. and Vackar, D. 2016. Ecosystem services indicators for grassland in relation to ecoclimatic regions and land use systems. *Grassland Science in Europe* **21**: 524–547.

Porter, M.E. 1980. “Competitive Strategy”. Free Press, New York. ISBN 0-684-84148-7.

Reijis, J.W., Daatselaar, C.H.G., Helming, J.F.M., Jager, J. and Beldman, A.C.G. 2013. “Grazing Dairy Cows in North-West Europe: Economic Farm Performance and Future Developments with Emphasis on the Dutch Situation”. LEI Wageningen UR, Wageningen, 124 pages.

Reuter, H. and Frieler, F. 2017. Neues Siegel für Weidemilch im Supermarkt. Hannoversche Allgemeine Zeitung. Available online: http://www.haz.de/Nachrichten/Wirtschaft/Niedersachsen/Pro-Weideland-Neues-Siegel-fuer-Weidemilch [Accessed 16 November 2018].

Rey Benayas, J.M., Martins, A., Nicolau, J.M. and Schulz, J.J. 2007. Abandonment of agricultural land: an overview of drivers and consequences. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* **2-057**: 1–14.

Rohmann, I. 2017 Weidemilch – neues Siegel sorgt für Klarheit. Westdeutscher Rundfunk. Available online: https://www1.wdr.de/verbraucher/ernaehrung/neues-siegel-fuer-weidemilch-100.html [Accessed 18 December 2017].

Runhaar, H., Fürschilling, L., Van den Pol-van Dasselaar, A., Moors, E.H.M., Temmink, R. and Hekker, M. 2020. Endogenous regime change: lessons from transition pathways in Dutch dairy farming. *Environmental Innovation and Societal Transitions* **36**: 137–150.

Sauter, J. and Latsch, R. 2011. Operating limits to mechanisation in mountain areas. *Grassland Science in Europe* **16**: 55–57.

Schaper, C., Spiller, A. and Theuvsen, L. 2010. Risikoneigung und Risikoverhalten von Milch-erzeugern: Eine Typologisierung
(Risk behaviour of dairy farmers: a typology). *Yearbook of Socioeconomics in Agriculture* **3**: 157–193.

Soussana, J.F., Tallec, T. and Blanfort, V. 2010. Mitigating the greenhouse gas balance of ruminant production systems through carbon sequestration in grasslands. *Animal* **4**: 334–350.

Statistisches Bundesamt. 2014. Land- und Forstwirtschaft, Fischerei. Available online: https://www.regionalstatistik.de [Accessed 16 November 2018].

Streifeneder, T., Tappeiner, U., Ruffini, F.V., Tappeiner, G. and Hoffmann, C. 2007. Selected aspects of agro-structural change within the Alps. A comparison of harmonised agro-structural indicators on a municipal level in the Alpine Convention area. *Journal of Alpine Research* **95**: 27–40.

Tasser, E., Mahlknecht, S., Meixner, W., Schermer, M., Teutsch, A. and Tappeiner, U. 2012. “Wir Landschaftsmacher – Vom Sein und Werden der Kulturlandschaft in Nord-, Ost- und Südtirol”. Athesia, Bozen, Italy.

Teixeira, R.F.M., Proença, V., Crespo, D., Valada, T. and Domingos, T. 2015. A conceptual framework for the analysis of engineered biodiverse pastures. *Ecological Engineering* **77**: 85–97.

Thomet, P., Piccand, V., Schori, F., Troxler, J., Wanner, M. and Kunz, P. 2010. Efficiency of Swiss and New Zealand dairy breeds under grazing conditions on Swiss dairy farms. *Grassland Science in Europe* **15**: 1018–1020.

Thomet, P., Cutullic, E., Bisig, W., Wuest, C., Elsässer, M., Steinberger, S. and Steinwidder, A. 2011. Merits of full grazing systems as a sustainable and efficient milk production strategy. *Grassland Science in Europe* **16**: 273–285.

Thornton, P.K. 2010. Livestock production: recent trends, future prospects. *Philosophical Transactions of the Royal Society* **365**: 2583–2867.

Van den Pol-van Dasselaar, A. 2016. “Kijken met een weide blik”. Publicatienummer 16-002PP. Aeres University of Applied Sciences, Dronten, 47 pages.

Van den Pol-van Dasselaar, A., Goliński, P., Hennessy, D., Huyghe, C., Parente, G. and Peyraud, J.-L. 2014a. Évaluation des fonctions des prairies par les acteurs européens. *Fourrages* **218**: 141–146.

Van den Pol-van Dasselaar, A., Philipsen, A.P. and de Haan, M.H.A. 2014b. Economics of grazing. *Grassland Science in Europe* **19**: 662–664.

Van den Pol-van Dasselaar, A., Philipsen, A.P. and de Haan, M.H.A. 2016. The effect of social factors on the extent of grazing. *Grassland Science in Europe* **21**: 62–64.

Van den Pol-van Dasselaar, A., Hennessy, D. and Isselstein, J. 2020. Grazing of dairy cows in Europe – an in-depth analysis based on the perception of grassland experts. *Sustainability* **12**: 1098.

Weinrich, R., Kühl, S., Zühlsdorf, A. and Spiller, A. 2014. Consumer attitudes in Germany towards different dairy housing systems and their implications for the marketing of pasture raised milk. *International Food and Agribusiness Management Review* **17**: 205–222.

Winsten, J.R., Parsons, L. and Hanson, G.D. 2000. Differentiated dairy grazing intensity in the Northeast. *Journal of Dairy Science* **83**: 836–842.

Zepeda, L. and Castillo, M. 1997. The role of husbands and wives in Farm technology choice. *American Journal of Agricultural economics* **79**: 583–588.