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Climate change adaptation processes seen through a resilience lens: Norwegian farmers' handling of the dry summer of 2018☆

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ABSTRACT

Climate change and more frequent extreme weather events are expected to significantly challenge food production and food security worldwide, underlining the need for adaptation within the agricultural sector. Although Norway, as other Nordic countries, potentially benefits from higher temperatures in terms of agricultural production, adaptation will be necessary. Employing resilience as a theoretical lens, this study investigates Norwegian farmers' handling of the dry summer of 2018, a summer that comprehensively challenged agricultural production throughout Europe. In-depth interviews revealed that farmers' main strategy was to improve their buffer capacity to be able to 'bounce back' (i.e., to get 'through' the summer to return to a 'normal' situation). Informal and formal networks, access to outfield resources and governmental support played key roles in enhancing the buffer capacity. Structural changes in the agricultural sector seem to challenge future access to the resources needed to improve the buffer capacity in times of crisis. Within the current environmental, social and political framework, farms are considered resilient, and strengthening buffer capacity is reasonable. However, a higher frequency of extreme weather events may require that other capacities, such as adaptive or transformative, be improved. Thus, resilience is not a given state and independent of values but strongly context dependent. To achieve long-term resilience, climate change adaptation needs to be politically encouraged and economically supported. Farmers need flexibility to use local resources. Worries about structural changes may draw farmers' attention away from making potentially important adaptations to climate change.

1. Introduction

Slow-onset climate change and an increasing probability of extreme events threaten food production and food security worldwide (FAO, 2018). The agricultural sector needs to become more adaptive to reduce the impact of climate change on food production (FAO, 2018). Climate change adaptation is a complex process comprising more than adjustments to biophysical change aided by technical solutions (Eriksen et al., 2015; Nightingale et al., 2020). Rather, climate change adaptation should be considered a complex socio-political process that simultaneously addresses both environmental and social changes (Eriksen et al., 2015; Wolf, 2011; O'Brien and Selboe, 2015; Gosnell et al., 2019).

The increasing focus on a contextual approach to climate change adaptation has generated growing attention in research and politics on community-based adaptation processes throughout the last decade (McNamara and Buggy, 2017). Addressing the community level draws attention to the fact that the impacts of climate change need to be handled in everyday life (McNamara and Buggy, 2017). The capacity of local communities in general and, specifically, farming communities to tackle climate variation as well as environmental and social change and crisis is important with regard to climate change adaptation from a long-term perspective (Eriksen and Selboe, 2012; Kelly and Agder, 2000).

An increasing body of literature deals with climate change and

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adaptation processes in farming communities in the Global North (Kvalvik et al., 2011; Eriksen and Selboe, 2012; Juhola et al., 2017; Wiréhn, 2018; Flemsæter et al., 2018; Neset et al., 2019a, 2019b; Crane et al., 2011; Griffiths and Evans, 2015; Niles et al., 2015). Although farming communities in these countries are expected to be less impacted by climate change than farming communities in the Global South (Bruinsma, 2003), and farming communities in Nordic countries may even gain from climate change, adaptation will still be necessary (Kvalvik et al., 2011; Uleberg et al., 2014; Wiréhn, 2018). While, for example, increased temperatures are expected to extend the growing season in the North, higher temperatures may lead to new weeds and diseases, and increased autumn temperatures may challenge the cold hardening of plants (Uleberg et al., 2014; Wiréhn, 2018; Neset et al., 2019b). Single events such as late frost may reduce yields despite higher average temperatures.

Regarding adaptation to climate change in Nordic farming communities, the literature reveals that farmers are knowledgeable about dealing with unpredictable growing conditions and that local ecological knowledge is transferred through informal networks (Kvalvik et al., 2011; Eriksen and Selboe, 2012; Juhola et al., 2017). Farmers have applied a number of adaptive actions (Wiréhn, 2018); however, as Juhola et al. (2017) point out, adaptive measures mainly comprise incremental changes while transformational activities are carried out to a lesser degree. Rationalisation within the agricultural sector reduces farmers' flexibility regarding farm operations, while the declining number of farms restricts knowledge transfer among farmers and challenges informal neighbour help (Eriksen and Selboe, 2012; Kvalvik et al., 2011; Flemsæter et al., 2018). These structural and economic changes are partly driven by a policy that requires farmers to adapt to changing rules and regulations. This requirement regards both Norway as a non-EU country and, for example, Sweden and Finland, where agriculture is regulated through the European Common Agricultural Policy (Kvalvik et al., 2011; Juhola et al., 2017). Adaptation to climate change may have some trade-offs, such as increased costs for farm enterprises and negative environmental consequences, for instance, increased nutrient leakage caused by improved drainage systems (Neset et al., 2019b).

Despite this growing knowledge about adaptation within Nordic farming communities, gaps still exist. A systematic review of the challenges, opportunities and adaptation strategies led Wiréhn (2018) to identify the following knowledge gaps: a large part of research regards biophysical impact assessment and does not focus on issues, such as adaptation capacities or barriers to adaptation. Furthermore, a systematic analysis of adaptation-induced trade-offs is lacking, and few studies address contextual vulnerability to climate change.

The study presented in this article addresses the latter gap within the context of the Norwegian farming community. Norwegian farmers operate – as indicated above – within a sector that is undergoing comprehensive structural changes while being strongly impacted politically. The extent of farming varies throughout the country; however, an international perspective considers Norwegian agriculture as primarily occurring on small farms (OECD, 2021). Climate and geography restrict the types of crops that can be grown and thus their yields (OECD, 2021). Since Norway is not self-sufficient in terms of agricultural products, domestic food security depends largely on imports, making Norway (although a resource-strong country) vulnerable to changes in the global food market (Bardalen, 2018). The Norwegian government aims to maintain the country's degree of self-sufficiency. Taking into consideration that the population is expected to increase by 20% from 2011 to 2030 this would mean an equivalent increase in food production (Meld. St. 9 (2011–2012)).

The complex political, economic and environmental contexts in which farmers operate, coupled with Norway's dependence on food imports and experience of extensive crop failure and economic losses due to extreme weather events during the last decade, indicate that the agricultural sector is not sufficiently prepared for potential climate change (Bardalen, 2018; Bjørkhaug and Rønningen, 2014). This situation makes adaptation within Norwegian farming communities interesting to study. This study examines an extreme weather event, the dry summer of 2018, that created comprehensive challenges for agriculture in large parts of Europe, including Norway (Skaland et al., 2019). In Norway, the degree of self-sufficiency declined from 50% (2017) to 45% (2018), remaining at the same level in 2019 (Rustad, 2020).

The study aims at contributing to knowledge about climate change adaptation processes at the farm level. Addressing the contextual framework in which farmers operate provides insight into what makes them vulnerable to climate change. The study considers the case of how farmers handled the dry summer of 2018 in Sør-Fron – a municipality in Eastern Norway strongly impacted by the drought – and investigates how such an event can inform the development of adaptation strategies. To analyse the processes of climate change adaptation at the farm level, this study uses social-ecological resilience as a theoretical lens. Resilience can be understood as the capacity of a system to adapt to contextual changes, unexpected shocks and lasting disturbances while retaining its essential functions (Folke et al., 2010). This study addresses the following questions: Which strategies did farmers choose to handle the dry summer of 2018? What implications do the chosen strategies for resilience to climate change have for future farming? What does it mean to be resilient at the farm level, both presently and in the future? The discussion of the latter question is based on our reflections on farmers' strategies to tackle the dry summer of 2018 and the implications the strategies may have for future farming.

2. Viewing adaptation at the farm level through a resilience lens

The concept of resilience originates from research on the capacity of ecosystems to return to a stable state after a disturbance (Folke et al., 2010). It was broadened to address alternative stability domains or stable states, to embrace the interlinkage of ecological and social systems and to consider that a system's nature will change over time (Folke et al., 2010; Walker et al., 2004). Adaptability, the ability to learn and adjust to changes, and transformability, the ability to convert to a new system configuration, have been introduced to acknowledge that both persistence and flexibility are needed to become resilient in an ever-changing world (Folke et al., 2010). Thus, resilience is not an intrinsic trait of a system, but a dynamic process. A system may have characteristics and capacities that make it more or less resilient within a given context (Darnhofer et al., 2016). Such an understanding implies a change in mindset towards farming systems, from aiming at optimising production within a rather stable context to embracing continuous change, tackling shocks and adapting (Darnhofer et al., 2016).

Farm resilience is an emerging feature of a farming system that is strengthened or weakened through interactions between the farms and the farmers and between the farmers and their context (Darnhofer et al., 2010). According to Darnhofer (2014), farm resilience comprises (1) buffer capability, the ability to temporarily reallocate resources to form resistance against minor disturbances, (2) adaptation capability, the ability to develop within the same system (Folke et al., 2010) and (3) transformative capability, the capacity to break path dependence (Walker et al., 2004). 'Capability' refers to the ability to see opportunities, implement measures, mobilise resources and learn in a constructive and reflective way; it does not refer to an automatic response to disturbances, (Darnhofer, 2014). The more commonly used term 'capacity' similarly implies the potential to see opportunities, implement measures and learn, but emphasises the ability to act in light of specific challenges. The latter we find especially relevant for our study and have decided to employ this term.

Resilience to climate change affects stakeholders on different spatial scales, and successful adaptation requires a multiple-scale approach (McNamara and Buggy, 2017; Schiere et al., 2012); however, it is at the farm level where climate change is directly experienced. Apart from laws, regulations and natural conditions that set the framework

providing farmers with room to manoeuvre, farmers decide what is done on their property (Darnhofer et al., 2010). Focusing on farmers and their decisions underlines that agency – the freedom to make choices in light of social-ecological changes – is important for enhancing resilience (Cinner and Barnes, 2019). How farmers perceive their farm's potential limitations and opportunities, in light of social, ecological or economic changes, determines how choices and decisions are made on individual farms (Scoones et al., 2007). Farmers, like everyone else, subjectively filter and interpret information and make decisions in accordance with their objectives and values, social context and traditions, and their perceived space of opportunity, which impacts their choice of pathway of actions (Darnhofer et al., 2010; Lade et al., 2020).

Farmers approach predictable (more or less) and slow-moving stressors with persistence (Darnhofer, 2014). More resources go into specialising operations, and disruptions are compensated for by the buffer capacity which enables farms to remain within a stability domain. If disturbances are perceived as more extensive, the strategy may be adaptation. Shocks can evoke strategies to either return to the pre-shock

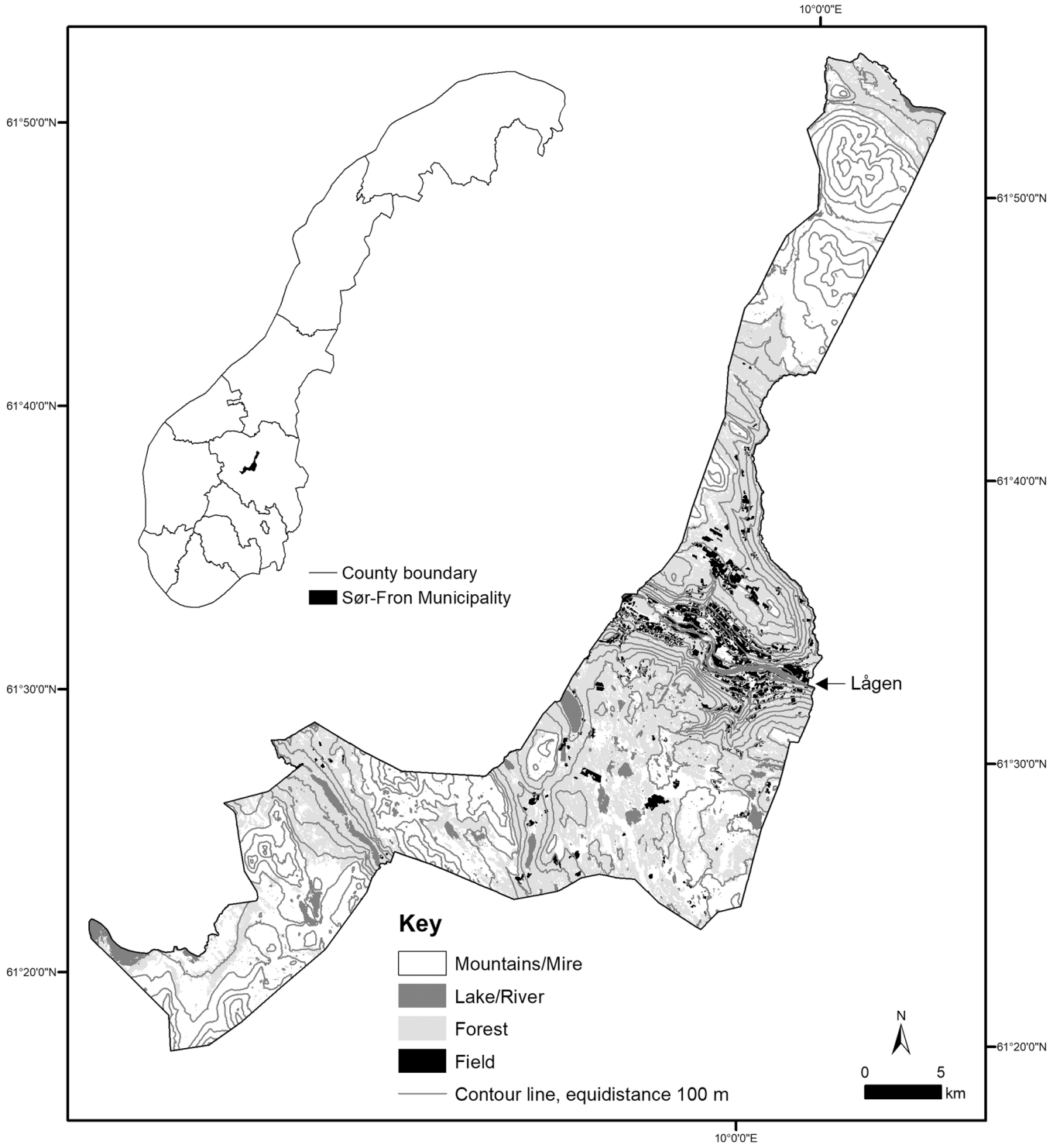

Fig. 1. Sør-Fron Municipality. The river Lågen flows at the bottom of the Gudbrandsdalen valley. Fields are located at the slope along the river. Fields at a further distance are arable land surrounding the seasonal farms. Mountain areas are used for outfield grazing.

stability domain (bounce back) or adapt and move towards a new stability domain (bounce forward) (Darnhofer, 2014).

3. Methods

3.1. Study area

Sør-Fron Municipality (Fig. 1) is located in the region with the most applications for compensation payments after the 2018 nationwide drought (Landbruksdirektoratet, 2018). Climate data show that precipitation in 2018 was low, especially in May and July, while temperatures were high (Fig. 2). A similar combination of little precipitation and high temperatures was recorded for 1947. In 1976, only precipitation was low, while the summer of 1996 was dry due to low winter precipitation (Tallaksen and Hisdal, 2018). Future prospects include a likely increase in showers, occurring at a higher frequency and with greater intensity, and a possible increase in summer droughts (Hisdal et al., 2021). Droughts may occur despite more summer precipitation due to increased evaporation caused by higher temperatures (Hisdal et al., 2021).

Trends within agriculture in Sør-Fron are similar to those in the whole country. The number of farms and active farmers has declined sharply, while the average farm and herd sizes have increased since the 1960s (Forbord et al., 2014).

Despite comprehensive structural changes, partly due to an agricultural policy that steers towards increased productivity and specialisation, the agricultural sector is politically protected and regulated (Kvalvik et al., 2011). Achieving the main objectives of agricultural policy – a significant degree of self-sufficiency, economic value creation and a viable and sustainable agricultural sector throughout the country – is mainly ensured through annual negotiations between the state and two farmers' unions (Bjørkhaug and Rønningen, 2014). Matters of negotiation include measures for achieving the policy objectives and the channelling of subsidies that aim to ensure the best suitable productions, given the geographical conditions (Bjørkhaug and Rønningen, 2014). Climatic conditions, large outfield areas and little arable land make roughage-based livestock production a cornerstone of Norwegian agriculture (Almås, 2018).

Despite declining number of farmers, farming and its related activities remain important for employment in Sør-Fron (Statistics Norway, 2021c). About 80% of the farmers are livestock farmers (cattle for meat or milk and sheep for meat), while the majority of the remaining farmers produce roughage (Statistics Norway, 2021b, 2021a). Farmland is mainly used for winter fodder production (roughage) and grazing. The meadows are commonly cut twice a year, and the grass is stored as silage. Due to the restricted availability of farmland in the valley, outfield areas in the mountains are used for summer grazing. Few farmers still engage in traditional seasonal farming in the mountains during the summer. However, many farmers cut the grass of the areas surrounding their seasonal farms for winter fodder. In Sør-Fron, as elsewhere in Norway, the livestock farming system partly relies on imported feed concentrates to meet expected production targets (Almås, 2018). Milk and meat are commonly delivered to and processed by agricultural cooperatives, such as Tine (milk) and Nortura (meat), which are large enterprises owned by several thousand farmers. In 2019, the farmers' organisations signed a letter of intent with the government to reduce emissions and increase carbon uptake. Although not juridically binding, the agreement makes emission reduction an important topic for agricultural extension services provided by cooperatives and the Norwegian Agricultural Extension Office.

3.2. Interviews

We chose a case-study approach to investigate farmers' handling of the dry summer of 2018, which allowed us to investigate complex social phenomena within their context (Yin, 1981). By investigating farmers' strategies for handling a climatic shock and the implications that the chosen strategies may have for future farming, we gained insight into the contextual framework that impacts resilience at the farm level. The project was approved by the Norwegian Centre for Research Data. Ten semi-structured interviews with 13 farmers (eight men, five women) representing ten farms (three interviews with couples) were carried out. Interviewees were selected to reflect the situation in different parts of the municipality and represented different ages and the split between part-time and full-time farmers. The latter criterion was difficult to fulfil, as only two of the interviewed farmers were part-time farmers with a full income outside their farm. The procedure to select the interviewees started with a list of farmers fulfilling the selection criteria that was provided by the local administration and complemented by snowballing. In addition, one interview was carried out with five representatives of the local administration and one with two representatives of the Norwegian Agricultural Extension Service.

The interviews were conducted in person in June 2019 (i.e. about one year after the farmers experienced the challenges of Summer 2018). The interviews with the farmers were carried out at the farmers' homes, and two other interviews were conducted in meeting rooms. The interviews lasted between one and two hours. Topics, such as the farmers' experience of the dry summer, important events and actors, and thoughts about adaptation and future development, were discussed during the interviews (see Supplementary Material for Interview guides). Except for two interviews, for which notes were made by hand, all interviews were tape-recorded and transcribed afterwards. NVivo 12 was used for both transcribing and coding the interview material. All interviewees were anonymised. The coding focused on identifying instances when farmers manifested the ability to see opportunities, implement measures, mobilise resources and learn in a constructive and

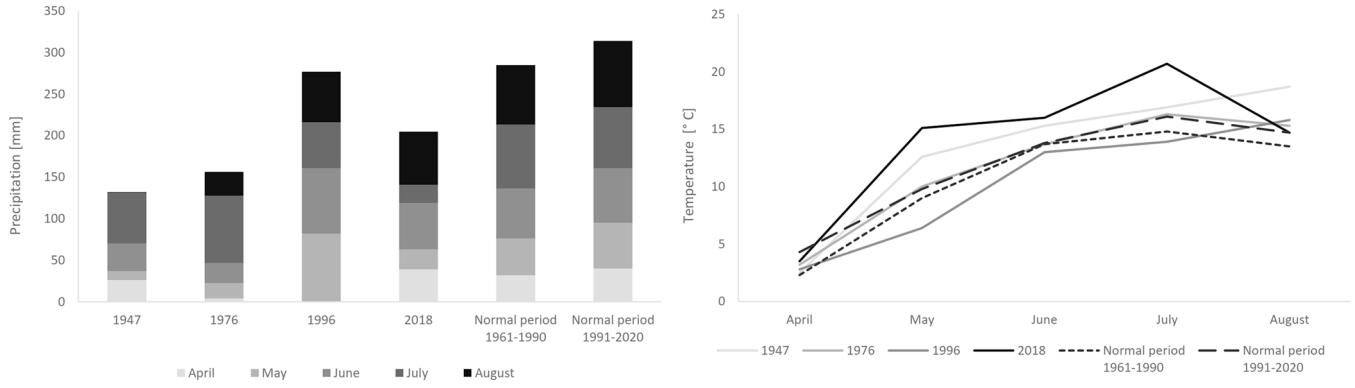

Fig. 2. Climate data for 2018, years with challenges for agricultural production and for normal periods. Precipitation data for April 1996 lacking; in August 1947 1 mm precipitation was measured. Data downloaded from the Norwegian Centre for Climate Services.

reflective way. Such an approach accounts for different resilience capacities, which do not represent automatic responses to shocks and disturbances. The coding was informed by literature on resilience attributes (Biggs et al., 2012; Cabell and Oelofse, 2012; Meuwissen et al., 2019), which describe the individual and collective competences that enhance resilience.

4. Results

4.1. The growing season of 2018 from the farmers' perspective

All farmers described the development of the growing season of 2018 in similar terms. After a very snowy winter that lasted throughout March, the weather changed rather suddenly. Temperatures rose, as one farmer expressed, 'We somehow never had spring last year [2018]; it got right to summer'. Most farmers experienced the start of the growing season as promising, with good growing conditions. However, those farmers who cultivated land on the alluvial plains on the river Lågen lost their first mowing to a big spring flood in early May. Towards the second half of May, the soil started to become dry. The grass growth declined, and the grass started to wither. The farmers cut the grass to save as much as possible from the first harvest. Apart from a thundershower in June, the weather was dry and warm until the first part of August.

Towards the end of June and beginning of July, the farmers started to worry about being able to harvest enough winter fodder for their livestock. Especially, those farmers who had little cultivated land available compared to the number of their livestock were concerned about the consequences of the dry weather for their harvest. The farmers became desperate, and several worried that they would have to reduce the number of their livestock, since they would be unable to feed their livestock during the winter.

In response to this difficult situation, the whole farming community mobilised. Farmers bought, for example, fodder from farmers in other parts of Norway who were hit less severely by the drought. The Norwegian Agricultural Extension Service and agricultural cooperatives arranged meetings and gave advice to farmers. In August, the weather situation changed, and it started to rain. The autumn weather turned out to be mild and moist and thus provided satisfactory conditions for grazing and harvesting.

As a consequence of the difficult growing conditions, the interviewed farmers lost between 30% and 70% of their harvest. Thus, farmers – especially those who had to buy a lot of fodder – experienced economic difficulties. A large share of the costs were transport costs caused by the long-distance transport of fodder. Production costs for the self-produced fodder were higher than in other years due to the small amount of fodder the farmers reaped from the harvest. Farmers had to invest additional work to secure enough winter fodder and experienced mental stress. Longer-term consequences include delayed investments and reimbursement of debts. Moreover, fewer lambs were born in 2019. However, none of the interviewed farmers had to significantly reduce their livestock numbers.

4.2. How did the farmers tackle the dry summer of 2018?

4.2.1. Encouragement to sustain livestock numbers and formal networks

The main aim of the farmers during the dry summer of 2018 was to sustain the number of livestock, most likely for at least two reasons. On the one hand, it is more costly to build up stock than to buy additional fodder for one winter. On the other hand, organisations, such as the Norwegian Agricultural Extension Service and agricultural cooperatives (Tine, Nortura and Felleskjøpet), strongly encouraged farmers to maintain their number of livestock and supported them in different ways to reach this aim. All interviewed farmers referred to a meeting arranged by these organisations. Not all farmers were present at the meeting themselves; however, all had contact with advisers from the organisations. The inviting organisations gave presentations about how to produce as much fodder as possible, buy additional fodder and use other fodder resources.

Felleskjøpet played a key role in providing alternative fodder, having purchased the necessary raw material to produce the feed concentrates that became an important fodder resource, especially for cattle farmers. Moreover, Felleskjøpet sold bales that the organisation procured from Iceland. The advisers from the different organisations were important supportive persons during the drought. Most of the interviewed farmers had personal relationships with the advisers, and it seemed that the farmers felt it was easy to contact them. Moreover, the organisations themselves were active. One of the organisations called all members to check on the farmers' status.

Thus, formal networks played a central role in farmers' ability to reach their goal of keeping their livestock. One farmer expressed, 'Nortura was, of course, worried that all should start to slaughter [their livestock]. Not only due to the consequences for their capacity, but because then it's all over. It is expensive for a farmer to build up a stock. Thus, Tine and Nortura were active, and we were very happy for that. And Felleskjøpet, as well; they took action and fixed other fodder resources. The latter [fodder] was not available. They had the solutions'.

4.2.2. Cooperation, purchase of fodder and informal networks

All farmers, with one exception, bought more fodder and more well-travelled fodder than normal to secure enough winter fodder. Some farmers bought additional fodder during the winter from local farmers who had purchased too much. The farmers underlined the importance of local and national cooperation as vital to tackling the difficult fodder situation. Even if it was a good year for selling roughage, the farmers felt that it was possible to buy fodder at an acceptable price and that fodder producers did not prey on their situation.

Most of the sale and purchase of fodder during the summer of 2018 was organised through informal networks (e.g. family and acquaintances). Individual people within such networks played a central role in finding solutions and buying fodder. Several farmers said that they bought more fodder than they needed and resold it to friends and family. All farmers got fodder through informal networks; however, some farmers also used more formal networks such as Facebook groups. The advisers from the Norwegian Agricultural Extension Service and the farmers underlined that those farmers who experienced the most difficulties were those with a restricted informal network and those who were not used to buying fodder.

Several farmers talked about feeling an increased sense of being part of a farming community during the summer. The situation was the same for everybody; all experienced similar problems. Mental support from other farmers was valuable in such a situation. One farmer said, 'It was not that here it was only us who work 24 h, and everybody is ok. The whole local farming community was working to solve the situation'. Another farmer expressed the feeling that all the farmers were very close. Unexpected cooperation evolved among people who normally did not work together. However, there were also a few farmers who had different experiences. They felt that everybody was mostly concerned about finding solutions for themselves during the most difficult times of the summer. They demanded that the local administration or one of the farmers' organisations coordinate and administer the purchase of fodder.

4.2.3. Use of outfields

Besides formal networks that encouraged and helped farmers keep their livestock and informal networks that were central to the purchase of fodder and mental support, the availability of outfield resources was central to tackling the Summer 2018 drought. The grazing conditions in the mountains were, according to the farmers, surprisingly good during the summer, and the autumn rain provided fresh grass. All livestock that could be sent to the mountains was sent for outfield grazing, and several farmers kept them there some weeks longer than normal to save winter fodder. One farmer expressed, 'We saw last year [2018] how the

seasonal farm was worth its weight in gold. If we had not had it, we would have harvested barely one bale at home [the main farm], since we would have used it [the farmland] for cattle grazing'. Besides grazing, the areas close to the summer farms were used for mowing, and farmers related that the harvest in the mountains was nearly comparable to that of a normal year.

4.2.4. State support

Nearly all farmers applied for and received economic support from the government. In addition to the compensation payments, resulting from negotiations between farmers' unions and the government, all farmers in regions strongly impacted by the drought received a one-time increase in the subsidy for their livestock. Especially, those farmers who had recently invested in their farms and had large debts and those households without external income and thus less economic flexibility underlined the importance of state support. However, probably as important as economic support was the feeling of advocacy on behalf of the farmers. One farmer pointed out that they would not have received any compensation payments if the farm organisations and the farmers' unions had not embarked on negotiations with the government: 'It is very important that we have spokespeople upwards'. In addition, all farmers were very satisfied with the role of the local administration, which helped the farmers apply for compensation. The staff was increased to quickly handle all the applications and thereby swiftly pay the compensation.

4.3. The dry summer of 2018: possible lessons learned?

4.3.1. The summer as an eye-opener for one's vulnerability during an extreme weather event

The summer of 2018 was an eye-opener for the farmers. It has made farmers aware of the importance of having extra fodder in case of unexpected events since – as one farmer expresses – the annual budget of a farm does not consider the unexpected and costly purchase of fodder. Most farmers had fodder left in 2019 and had no intention of selling it before they knew how productive the first mowing would be. However, several farmers pointed out that it had become common for a farm to have more livestock than the fodder produced for it as a result of structural changes in the agricultural sector. One farmer described the development as follows: '[T]here are many who have expanded their businesses in this area, who have built larger and larger stables. But, the problem is that they do not have more acreage. Thus, many of them buy a relatively large share of the fodder. And then you get especially vulnerable in such situations as occurred in the last year [2018]'. Several farmers pointed out that a better balance between the land and livestock would be reasonable. Since it is difficult to access additional arable land, farmers see the cultivation of land in the mountains or the use of currently uncultivated land as possible solutions. In contrast to a young farmer who assumed that his generation would come to remember the summer, most farmers assumed that the learning effect of the summer would only last for about 2–3 years.

4.3.2. The feeling of having handled the situation

Although all farmers described the situation as desperate at the start of the summer, before the fodder sales agreements were settled and before it became clear how much feed concentrates they could use as substitutes for roughage, they gave the impression that a year after the crisis, they felt they had been able to handle the difficult situation: 'We had an incredible amount of work with it [to get hold of winter fodder]. It is not as easy as to just travel and press [the bales]. There are a lot of trucks that have to be loaded and unloaded; in addition, one has to disburse 300.000–400.000 kroner [c. 37.000–49.000 USD in 2018] for transport. That is somewhat difficult. But it is ok now; it went well'. However, some farmers also pointed out that they will experience long-term challenges as a consequence of the Summer 2018 drought for their farm such as a difficult economic situation.

Despite having felt able to tackle the situation and thus the confirmation that they had the necessary skills to deal with a difficult situation, the farmers expressed that they would not be able to tackle a similar situation soon. Moreover, farmers did not expect similar economic support from the government in a comparable future event.

4.3.3. Long-term effects

Most farmers talked about the dry summer as a special occasion that they did not expect to occur again very soon. As one farmer expressed, 'I think it is a long time between such summers. That means I choose to believe it'. Farmers could not endure the thought that they should be farmers in a situation in which difficult years become 'normal'. Thus, it seems that farmers are not planning for any comprehensive changes in their farm operations; however, adjustments are always being made since the weather is always somewhat unpredictable, and farmers have to handle this unpredictability. For example, farmers described the last few years as being wetter than normal, and they had maintained ditches to keep them in proper condition. Due to an increasing number of flood events, farmers with land close to the river made ridges to prevent the water from flooding their fields. In areas prone to landslides, investments have been made – also by the municipality – to secure the slopes and to control the water's course. Even if it was not necessary to irrigate during the previous decade, those few farmers owning irrigation equipment had maintained it. Moreover, one interviewee mentioned that some farmers started to grow more drought-resistant grass species after the dry summer.

All farmers had clear ideas about what it meant to farm responsibly, including adjusting to climate change. A young farmer said, 'It is so popular to call things robust. We hope to become robust. We plan to have manure in storage, fodder in storage and money in the bank to pay if something happens and we [have to] manage a year without income'. Most of the farmers expressed that they had these aims.

Were the number of dry summers to increase, only a few farmers believed that it would be possible to carry on with the same kind of agriculture that is currently practiced. They assumed that many would abandon farming or that comprehensive transformations would be needed. A farmer pointed out, 'I think that if it became so bad in Gudbrandsdalen, then I think the whole world would soon have too little food. Then, I think it would become more popular to produce food. Thus, if such a situation was to occur, I think things would be completely different, since it would be much more appreciated to produce the food one has the possibility to produce, based on the available resources. Thus, maybe one cannot compare that situation with today's'.

Most farmers expressed that the current development in agricultural policy is much more precarious than climate change. This regards, for example, the development of the level of subsidies. The main worries concerned the structural changes and rationalisation of agricultural policy. Many farmers believed that if the current policies were to proceed, few farmers would be left within a decade. Farmers were worried that the small- and medium-sized farms in Gudbrandsdalen would not be able to compete with farms in other parts of Norway, which could respond to the request for large-scale farming.

5. Discussion

5.1. 'Bouncing back' and current farm-level resilience

The farmers' main strategy was geared towards 'getting through' the dry summer to return to a 'normal' situation. Thus, farmers decided to 'bounce back' as a response to a shock (Darnhofer, 2014). Other farming communities have shown similar reactions to extreme weather events and loss of harvest (Griffiths and Evans, 2015; Eriksen and Selboe, 2012). Making gradual adjustments – an approach taken by other farming communities (Juhola et al., 2017), such as accumulating a larger stock of fodder resources and trying to secure more arable land – may ensure that the stability domain remains unchanged.

To 'bounce back', buffer capacity is necessary (Darnhofer, 2014). When farmers realised that the summer of 2018 would become difficult, the buffer capacity required to absorb the shock was not present at the farm level. Formal networks, such as the Norwegian Agricultural Extension Service and the agricultural cooperatives, were powerful actors guiding farmers in their choice of pathway of actions (Lade et al., 2020). We assume that while the cooperatives especially tried to help their members as best as possible, they were also interested in avoiding a drop in deliveries and subsequent consequences for processing. Informal networks proved invaluable in acquiring fodder resources. As with other studies, this study illustrates the importance of informal networks for supporting key social processes, such as knowledge sharing and cooperation (Eriksen and Selboe, 2012; Juhola et al., 2017, Daugstad, 2019; Cinner and Barnes, 2019). Solidarity within the farming community was an important mental support for the farmers.

In addition to the knowledge and help provided by formal and informal local networks, cooperation on the regional and national scales and access to outfield resources strengthened the farmers' buffer capacity. The dry summer of 2018 increased awareness about the value of outfield resources for grazing and the flexibility provided by outfields in terms of fodder access. Outfield resources, a source for autonomously tackling the shock, were not only used to 'get through' the summer but also for farmers' self-conception and identity. The combination of access to outfield resources and good local ecological knowledge, with the latter contributing to individual self-worth and collective cultural identity (Eriksen and Selboe, 2012), allowed the farmers to consider themselves capable. While outfield resources increased the buffer capacity locally, economic support from the government was an external and important source for strengthening the buffer capacity.

Considering the current social, political and environmental context as being quite stable, with rather few extreme weather events so far, increasing the buffer capacity helps farmers become resilient in times of crisis. Moreover, increasing buffer capacity supports farmers' continued resilience during the current 'normal' situation. Thus, by aiming for long-term robustness (i.e. persistence), a typical strategy used to handle disruptions during rather stable periods (Darnhofer, 2014), farmers may choose a pathway of actions that allows them to tackle continual stress, such as structural changes in the agricultural sector. However, such a strategy may not be resilient in light of future climate change, such as a possible increase in summer droughts. Resources to strengthen buffer capacity may not be as available as in the summer of 2018: Declining farming communities, a consequence of farm abandonment, weaken informal networks and limit access to support and knowledge (Kvalvik et al., 2011; Eriksen and Selboe, 2012). Large-scale production and intensification encouraged by agricultural policy (see Introduction) do not necessarily facilitate the use of outfield resources. For example, even if the state subsidises outfield grazing (Landbruksdirektoratet, 2021), livestock, especially milk cows, may not be sent to the mountains (Rønningen et al., 2021). Last but not least, the farmers did not consider it likely that they would receive similar economic support in a comparable future situation.

5.2. *Implications for future farming and resilience*

Farmers do not seem to feel prepared to tackle a potential increase in the frequency of climatic shocks, and this lack of ability may result in even more farm abandonment in the future. Abandoning farming and renting the land to other farmers could be considered a strong transformative capacity, and farm exit may both strengthen and weaken other farms' resilience on a local level. Access to more land may enhance another's buffer capacity, while a decreasing number of farmers may weaken informal networks. However, continuous farm abandonment can leave entire regions without farming. Land abandonment is a widespread phenomenon throughout Europe – not least the mountain areas (Filho et al., 2017; Lasanta et al., 2017). Comprehensive abandonment and a declining agricultural sector may result in reduced self-sufficiency and – in the end – the collapse of the entire Norwegian farming system, meaning the whole farming system is not resilient.

Farmers mentioned the need for 'different' agriculture to be able to handle higher frequencies of extreme weather events such as droughts, even if they chose to believe that the dry summer of 2018 was an exception. Such different agriculture would require strengthening farmers' adaptive and transformative capacities. Farmers' decisions and strategies often combine different resilience capacities (Darnhofer, 2014), and what it means to be resilient at the farm level and what strategies it will take to become resilient will differ with context. Buffer capacity, adaptive capacity and transformative capacity 'clarify the need for a diversity of behaviours in order for a system to remain "dynamically stable"' (Ashkenazy et al., 2018, 212). Which behaviour is most important and reasonable depends on the context and may differ among farmers. Income outside farming may be a source that strengthens both buffer and adaptive capacity, with the latter being used for investing in adaptations to climate change.

Farmers make decisions based on their perceived space of opportunities (Darnhofer et al., 2010). The farmers' perception that politically induced structural changes within the agricultural sector are a greater challenge than climate change underlines how strongly agricultural policy steers activities at the farm level and how strongly farmers may feel locked into a pathway towards robustness. Thus, a change in mindset is needed not only at the farm level but also within the whole farming system, including the consumers who – as one farmer expressed, would hopefully appreciate food production more – but not least the political level. The task of becoming resilient should not be the sole responsibility of the farmers (Darnhofer, 2014).

An agricultural policy that responds to a crisis by providing economic support may seem justifiable and meaningful when considering political influence on the agricultural sector and the Norwegian government's aim of maintaining the country's degree of self-sufficiency. However, taking into account the possible increase in summer droughts, the support provided may give the illusion of being robust. Reliance on subsidies may reduce the farmers' perceived need to diversify, with diversification being one important strategy in tackling climatic shocks (Ashkenazy et al., 2018). Economic support may result in limited adaptation when provided without requirements for adaptation (Gundersen et al., 2016) and may reduce the perceived need for adaptation beyond continuous gradual adjustment. A lack of a perceived need for adaptation is one barrier to adaptation (Wolf, 2011). The direct experience of an extreme weather event and the resulting damage may make people more concerned about climate change; however, the experience may also show that damages caused by climate change are manageable due to, for example, the existence of a welfare state that takes care of those who are hit by an extreme weather event (Lujala and Lein, 2020).

A second important policy-related issue to consider in terms of resilience is large-scale production. While policies in many agricultural systems consider stability and production efficiency prerequisites to a farm's survival, strategies to reach high efficiency often lack flexibility and resilience (Schiere et al., 2012). For example, the increasing mismatch between heads of livestock and farmland available for fodder production makes farmers more dependent on purchased fodder. Moreover, large-scale production may reduce opportunities to use mountain resources and challenge farms' flexibility as the example of the introduction of automated milking robots shows. Automated milking robots which go hand in hand with larger herds seem to result in more intensive use of land close to the milking robot while the outfield areas are abandoned (Rønningen et al., 2021). However, in times of uncertainty and rapid change, activities that add diversity and flexibility to the system to take advantage of new opportunities are important (Darnhofer et al., 2010; Martin et al., 2013).

Large-scale production and its consequences for resource use may not only impact short-term but also future resilience. The current resilience at the farm level during 'normal' years is dependent on

external input factors, for example, feed concentrates and fertilisers. According to Rist et al. (2014), such resilience is coerced, dependent on anthropogenic input to maintain production levels. Relying on external and often long-travelled input factors implies that there are transboundary risks related to, for example, the loss of harvests elsewhere and supply chain disruptions, which are risks that may increase with climate change (Adams et al., 2021).

6. Conclusion

Despite being a resource-strong country with potential gains for agriculture in light of climate change, our study confirms that extreme weather events may put agricultural production under pressure in Norway. Nightingale et al. (2020) challenge the resilience approach for lacking consideration towards politics and social relations. Our case study shows, by taking into account the social, political and environmental framework in which farmers operate, that resilience is not a given state and independent of values but strongly context dependent.

To achieve long-term resilience in times of stability and disruption, climate change adaptation strategies within the farming sector need to be politically encouraged and economically supported in the same way as emission reduction, thus reducing reliance on economic support in times of crisis. Climate change adaptation strategies should embrace the fact that current resilience is coerced and thus should be based on an assessment of the risk of reliance on external resources. Agricultural cooperatives and extension services appear to be important actors who impact farmers' decisions on how to manage their farms and may play a central role in implementing specific measures.

Regulations for agricultural production in Norway and in countries that are politically impacted in similar ways (e.g. EU countries) need to make room for the flexible use of local resources. This may mean keeping less productive areas in use to be able to fall back on them in a crisis. Worries about contextual changes other than climate change, such as continuous political change, may draw farmers' attention away from potentially important adaptations to climate change and become barriers to adaptation and transformation.

CRediT authorship contribution statement

The article takes its departure in Synnøve Støverud Beitnes' master thesis. Kerstin Potthoff and Birgit Kopainsky have been supervised the master thesis. The main idea for the thesis, theoretical framing and methodological approach were developed in close communication among the three authors of this article. Birgit Kopainsky had a special responsibility for guiding theory development. Synnøve Støverud Beitnes carried out the fieldwork including conducting the interviews and did the analysis of the interview material. The article presents a compressed and further developed version of the master thesis. Kerstin Potthoff wrote most of the text of the article in close communication with the two other authors and prepared the figures.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.envsci.2022.03.019.

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