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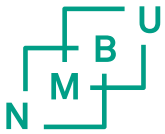

Master Thesis 2014
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Farm household vulnerability and adaptive capacity to the double exposure of climate change and structural change: A case study of a farming community in Western Norway

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Photo: Birgitte Zijlstra

In the dark of the moon, in flying snow, in the dead of winter,
War spreading, families dying, the world in danger,
I walk the rocky hillside, sowing clover.

Wendell Berry

Abstract

Norwegian agriculture is undergoing rapid structural changes leading to larger farm units and fewer farms, altering the context of farming and the capacity to respond to change. At the same time, climate change is manifesting as seasonal changes, warmer temperatures, and increased precipitation. This study applied a combination of contextual vulnerability and double exposure frameworks to assess current adaptive capacity and vulnerability to the combined effects of climate change and structural change in a rural community in Western Norway. This study employed a triangulation of research methods, covering case study interviews, informal observations and secondary data analysis, to get insight into the process of adaptation and deepen the understanding of how adaptive responses feed back on vulnerability and future adaptive capacity.

The objective of this study was to identify to what extent there is a disparity between structural changes in Norwegian farming and building climate adaptive capacity in agriculture. It is assumed that developed countries such as Norway have a high capacity to adapt to climate variability and change. However, this study found that farmers are vulnerable to changing climatic conditions because socioeconomic and political processes of change undermine climate adaptive capacity. Results further suggest that all farmer types, independent of scale, production type, values, and size, are to some degree vulnerable to a diminishing farming community due to the contagious nature of farm closures and lack of understanding among non-farmers. Moreover, this study found that the way in which farmers currently respond to other processes of change affect long-term adaptability of individual farm households and farming communities to future climate change. Policymakers should encourage a diversity of farm sizes rather than focusing on increasing production on a few large farms, particularly in the context of Western Norway where there are certain physical and social limits to the expansion of production that are determined by local contextual conditions such as topography, climate, and the culture of farming.

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1 Introduction

Climate change poses a major threat to global and regional food security and food production. The negative effects on crop yields, risk of food insecurity, and breakdown of food systems are linked to warming, drought, flooding, and precipitation variability and extremes (IPCC 2014). Climate change is already occurring, and several studies show that negative impacts of climate change on crop yields and food production has been far more common than positive impacts. Only a small number of studies show positive impacts of warmer temperatures on food production at higher latitudes, however, it is not yet clear whether the balance has been positive or negative (IPCC 2014). The negative effects of climate change on food production and food security is occurring in the context of increasing crop demands, reflected in FAO´s recommendation that global food production in 2050 should be 60 per cent higher than that of 2005/2007 to meet the increasing food demands of more than 9 billion people (Alexandratos & Bruinsma 2012; IPCC 2014).

While climate change is one of the most complex and challenging threats to food production and security, it is not necessarily the key driver of change (IPCC 2014). In reality, climate variability and change occur in the context of social, economic, political, technological, institutional and cultural processes of change (Leichenko & O'Brien 2008; O'Brien et al. 2007). The differential exposure and risk from climate change arises from non-climatic pressures and processes of change (Eriksen & Selboe 2012; Ford et al. 2006; Kvalvik et al. 2011; Leichenko & O'Brien 2008; O'Brien et al. 2007; Ziervogel et al. 2006). While it is generally accepted that poor and marginalised communities at lower latitudes are particularly exposed and vulnerable to climate change, non-climatic pressures can mean that developed nations like Norway are also vulnerable to change (IPCC 2014; Keskitalo et al. 2010).

Under the previous government (2009-2013) the Norwegian Ministry of Agriculture and Food established an ambitious goal of increasing Norwegian food production with one per cent annually the next 20 years. The goal of increasing food production with 20 per cent totally was set to meet the future food requirements of a growing population in Norway, and to maintain a level of self-sufficiency of 50 per cent (Meld. St. 9 (2011-2012)). In spite of these goals, food production in Norway, and in particular in Western Norway, has decreased in parallel with people leaving farming (Bjørnsen et al. 2010; Hillestad & Smedshaug 2013; Lie & Mittenzwei 2008). Norway´s self-sufficiency rate is currently below 40 per cent (when

balanced for imported feed concentrates), and the lowest in Western Europe (Bustnes et al. 2014).

Although many farmers in Norway, in particular in Western Norway, feel vulnerable to increased rainfall and believe that climate change may affect their production negatively, farmers currently face more immediate pressures related to changing agricultural policies (Kvalvik et al. 2011; Aasprang 2013). In 2013 there was a political shift in Norway, and the new government wants to reform agriculture to be more liberalised. The main goal of Norway´s current agricultural policy is cost-efficient food production (Regjeringen 2013). The new government aims at increasing production on fewer and larger farms, and the continuous trend of structural rationalisation puts small and medium-scale farms under pressure. However, the idea that 'one size fits all' is being questioned, and some studies have shown that Western Norway is not conducive for larger and more mechanised farm operations due to difficult climatic and topographic conditions (Bergslid & Lyche 2014; Skarbø & Vinge 2012).

There is an abundance of literature regarding the effects of societal change on smallholders in developing countries, but little on industrialised countries like Norway, because studies of agriculture and climate change have been conducted more at the aggregate or production level (Keskitalo 2010). What's more, there has been little focus on climate change adaptation as a social process, and the subjective, interior dimensions of adaptation and vulnerability have largely been overlooked in research (Eriksen & Selboe 2012; O'Brien et al. 2012). Moreover, Dixon et al. (2014:206) argue: "Trade-offs made at the farm-scale and how they impact on adaptive capacity also need to be explored fully; presenting data collectively at the farming system scale can mask farm-scale variations." The current case study is an attempt to explore these relationships in a rural farming community in Western Norway, with a focus on farmers´ and farm households´ adaptive responses to multiple processes of change, in particular those related to climate and structural change.

1.1 Objective of study and research questions

This study aims at addressing shortcomings associated with vulnerability and adaption studies in a developed country context; to get insight into the process of adaptation; and deepen the understanding of how adaptive responses feed back on vulnerability and future adaptive capacity. A starting point for this thesis was the following concluding observation from a

study on vulnerability and adaptive capacity in the agricultural sector in Northern Norway: "The current adaptive strategy for coping with political and economic exposure-sensitivities is rationalisation, which ironically opens up new exposure sensitivities" (Kvalvik et al. 2011:36). The objective of the thesis developed from this observation, and triggered a curiosity to explore more in depth to what extent this perception is true.

Objective

The objective of this study is to identify to what extent there is a disparity between structural changes in Norwegian farming and building climate adaptive capacity in agriculture.

Research questions

1. How do structural changes in agriculture influence vulnerability and farmers' capacity to adapt to increased climate variability in Rauma?

1.1 What are farmers' perceptions of climate variability and change in Rauma?

1.2 How are structural changes manifested locally in Rauma?

1.3 How are farmers adapting to the double exposure of climatic and structural changes?

1.2 Thesis structure

Chapter 2 provides an overview over climatic and structural processes of change in Norway with an emphasis on Western Norway. The chapter is divided into three parts: The first part is a description of the case study, the second part covers observed and projected climate change in Western Norway and effects of climate change on agriculture, and the third part is a description of structural changes in Norwegian agriculture, including the driving forces and effects of structural change.

The theoretical framework that was used for interpreting the data is presented in chapter 3. The first part of the chapter covers the concept of vulnerability, with emphasis on the contextual vulnerability framework and the concept of double exposure. The second part covers adaptation, core components of adaptive capacity, and adaptation as a social and values based process.

In chapter 4 the methods that were applied in this study and the qualitative research process are described and evaluated in light of ethical considerations. Included in this chapter is a

description of case study research, semi structured interviews, and the different steps of the research process.

In chapter 5 the data material is analysed using the frameworks of contextual vulnerability and double exposure. The results and analysis chapter is divided into four main sections, with each section addressing one research question. In the two first sections research questions 1.1 and 1.2 are addressed. These two sections encompass a description and analysis of climate change and structural changes in Rauma from farmers´ own accounts and perceptions, and identify the current contextual conditions in Rauma. The two final sections address research questions 1.3 and 1 and contain an analysis of how different farmers adapt to the double exposures of climate change and structural changes (identified as emerging sources of vulnerability), and how these adaptations affect vulnerability, farmers´ quality of life and capacity to adapt to future changes.

The discussion in chapter 6 is introduced with a figure that sums up the main findings from this study. In this chapter the dynamics and feedback loops between contextual conditions, adaptive responses, vulnerability and adaptive capacity are discussed, and different farmer strategies are examined in terms of long-term adaptability. The chapter is finalised with concluding remarks, suggestions for further research and implications for policy makers.

2 Background

2.1 Description of the case study

Rauma is a municipality located in Møre and Romsdal County and the third biggest agricultural centre in the county measured in farm numbers. Møre and Romsdal County is located at the Northern extent of what is called Western Norway (*Vestlandet*). Included in the region of Western Norway are the counties of Rogaland, Hordaland, Sogn and Fjordane, and Møre and Romsdal. Rauma has 7400 inhabitants, and the municipality covers an area of 1500 square kilometres, of which 50 per cent is situated over 900 metres above sea level. Rauma Municipality surrounds the fjords Romsdalsfjorden and Isfjorden and the mountainous areas of the Romsdal Valley. Tourism is important for the local economy, and the wild and rugged mountains attract a growing number of mountaineers, mountain climbers and skiers.

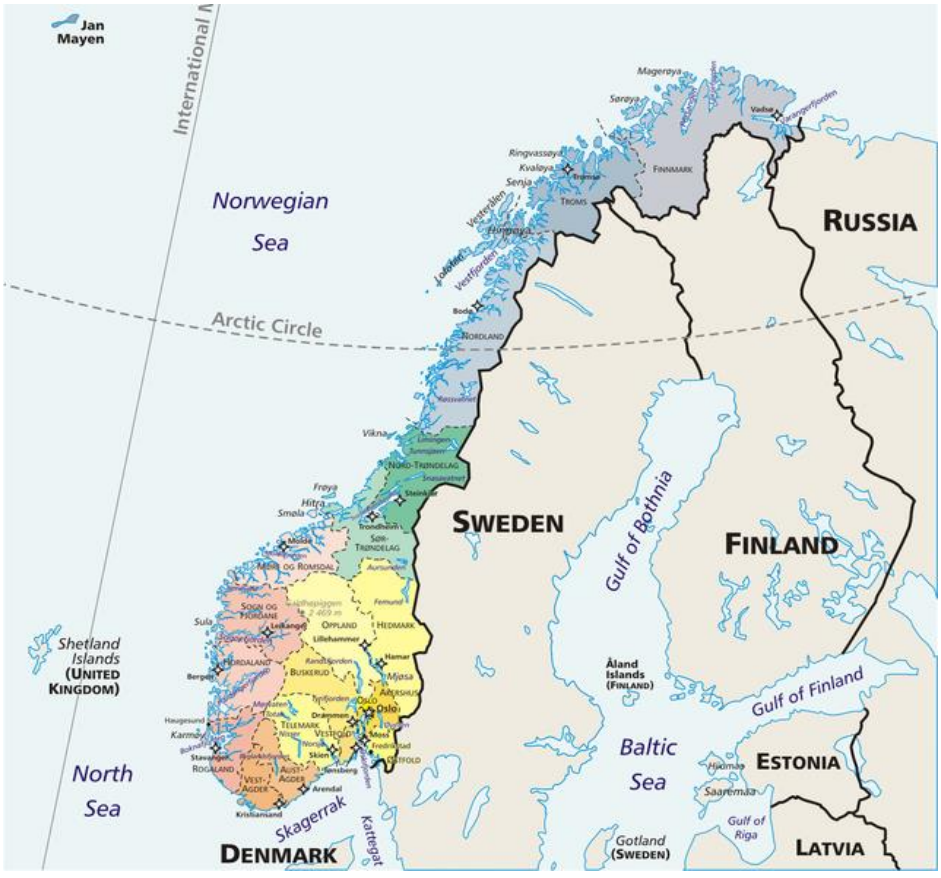

Figure 1: Map of Norway´s counties. Source: wikipedia.org

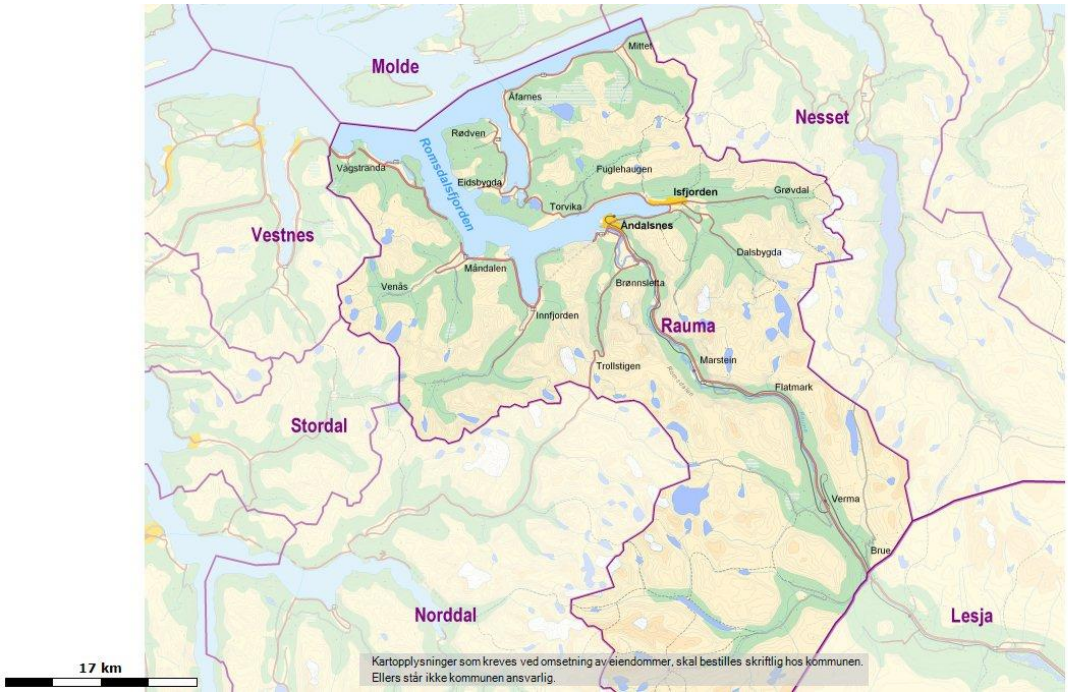

Figure 2: Map of Rauma Municipality. Source: (Rauma Kommune)

The special topography consisting of narrow fjords and high mountains create strong contrasts in the local climate, and these differences affect growing conditions. The climate ranges from coastal to continental to alpine within the Municipality of Rauma, depending on the location´s altitude and position relative to the ocean. Areas found at high elevations in the interior of Rauma are characterised by stable and snow rich winters, a short growing season and half of the precipitation of what they receive at lower elevations and closer to the coast. These locations commonly experience spring and summer drought, and rainfall can be a limiting factor for growth depending on local biophysical conditions such as topography, soil types and local wind phenomenon. The lower elevations in Rauma are characterised by coastal climatic conditions due to the proximity to the fjords; the precipitation levels are higher and the weather is more shifty than in the interior parts of Rauma. One characteristic local climate condition in Rauma is *Sjella*[1], an infamous local wind phenomenon that carries cold air from the mountainous plateaus surrounding the Romsdal Valley. The wind is particularly strong from late autumn to spring, especially when there is a high-pressure system, and nice, clear weather. *Sjella* is a big topic of conversation in Rauma, and the persistence of the wind (it can blow consistently for 1-2 months in a row) is of great nuisance to people residing in the wind-

[1] The information concerning *Sjella* stems from the personal experience of living and farming in a location situated in the path of *Sjella*. This local wind-phenomenon is one example of a local climate condition that is not included in general meteorological observations.

belt. In terms of agriculture this easterly wind can be problematic in terms of wind erosion but also positive as it dries up the wet fields and blows away the snow, making way for an early spring. *Sjella* creates strong contrasts in the local climate within a very small geographic region. For example, the temperature difference between Åndalsnes and Isfjorden (situated a few kilometres apart) can be up to 10°C in wintertime. Whereas Isfjorden is normally wind-still and cold, the temperature in Åndalsnes feels colder due to the strong wind from the Romsdal Valley.

The local geography and climatic conditions are particularly conducive for grass production and grass-fed husbandry, hence dairy and sheep are the most common production types. Many generations of farmers in Western Norway have adapted farming practices to marginal climatic conditions, and husbandry has been centred around grass production for winter feed and extensive grazing during the summer months. However, the traditional farming practices are changing with the new structures in agriculture (Skarbø & Vinge 2012). 5.7 per cent of the population in Rauma work in agriculture, forestry and fishing. In comparison, 15 per cent are employed in the industry. There are 202 man-hours (*årsverk* in Norwegian) directly connected to farm production in Rauma of which 106 man-hours are associated with dairy production; 8 with suckler cows; 80 with sheep; a total of 6 with pigs, poultry, grains and potato; and 2 with fruits and berries. The total number of farms in Rauma almost halved from 328 in 1996 to 177 in 2013. Of the 177 active farms 52 are dairy producers (Bondelaget 2013). In Rauma the average number of dairy cows is 24.4 per holding; the average number of sheep is 50.6 (more than one year old) and 21.8 (less than one year old) per holding; and the average number of pigs is 161 per holding (Statens Landbruksforvaltning 2014).

2.2 Farming in a changing climate

2.2.1 The characteristic climatic conditions in Western Norway

Without the combined heat transport in the ocean (The Gulf stream) and in the atmosphere (West wind belt/North Atlantic Oscillation) the average temperature in Norway would be 10-15°C colder. In wintertime temperatures along coastal Norway are 10 to 20°C above the average temperatures found at equal latitudes in for example Alaska, Greenland and Siberia (Hanssen-Bauer et al. 2009; Meteorologisk Institutt). These two climatic phenomena create conditions that are conducive to farming, including in the Arctic regions of Norway.

Three geographical conditions in particular shape the weather patterns in Western Norway: The high mountains near the coast, the fjords they shelter, and the moderating effect of the North Atlantic Ocean. The climate in Western Norway is characterised by high levels of precipitation and rapidly changing weather conditions. Coastal areas are milder and wetter than the mountainous areas in the interior parts of the region, and a 100-meter increase in elevation lowers the temperature with an average of 0.6°C. The topography and distance to the ocean similarly influence precipitation levels. The highest rainfall is found in the midrange between the coastline and the high mountains, where the air is pushed up and cooled down, creating humidity (Meteorologisk Institutt). Long fjords of seawater stretch far inland, creating microclimates that are much warmer than surrounding areas. In Norway as a whole the annual mean temperature is +1°C. Along the coast in Western Norway the annual mean temperature is + 6°C, while in the high mountains the annual mean temperature is −4°C. A growing season is defined as number of days of mean temperatures above 5°C. Certain pockets of Western Norway have the longest growing season in Norway, with up to 238 days. In comparison, the growing season in the high mountains is around 70 days (Hanssen-Bauer et al. 2009; Miljøverndepartementet 2010).

2.2.2 Climate variability and climate change in Western Norway

Western Norway is renowned for having a shifting and unpredictable climate by nature. However, meteorological data shows that global climate change is having a marked affect on this region as well, altering both short-term weather and long-term climate patterns (Hanssen-Bauer et al. 2009). Climate change is defined as "a change in the state of the climate that can be identified […] and that persists for an extended period, typically decades or longer" and is a consequence of both natural climate variability (e.g., solar cycles and volcanoes) and persistent anthropogenic changes (IPCC 2007:871). Climate variability, on the other hand, refers to "variations in the mean state […] of the climate on all temporal and spatial scales beyond that of individual weather events" and "may be due to natural internal processes within the climate system […], or to variations in natural or anthropogenic external forcing" (IPCC 2007:872). While climate change and variability are closely related, *variability* implies fluctuations more locally and on a shorter time-scale that can either enhance or counteract global climate *change* mechanisms (O'Brien et al. 2012).

In order to have a reference point for comparing current meteorological data with historical climate trends, the World Meteorological Organisation has established what is called the

'normal' period. It is defined as an average of the weather situation in a set period of 30 years, with the period of 1961-1990 currently used as the official normal period (Hanssen-Bauer et al. 2009; Meteorologisk Institutt). Figures 1 and 2 show annual mean temperatures and precipitation relative to the normal period of 1961-1990 in Western Norway.

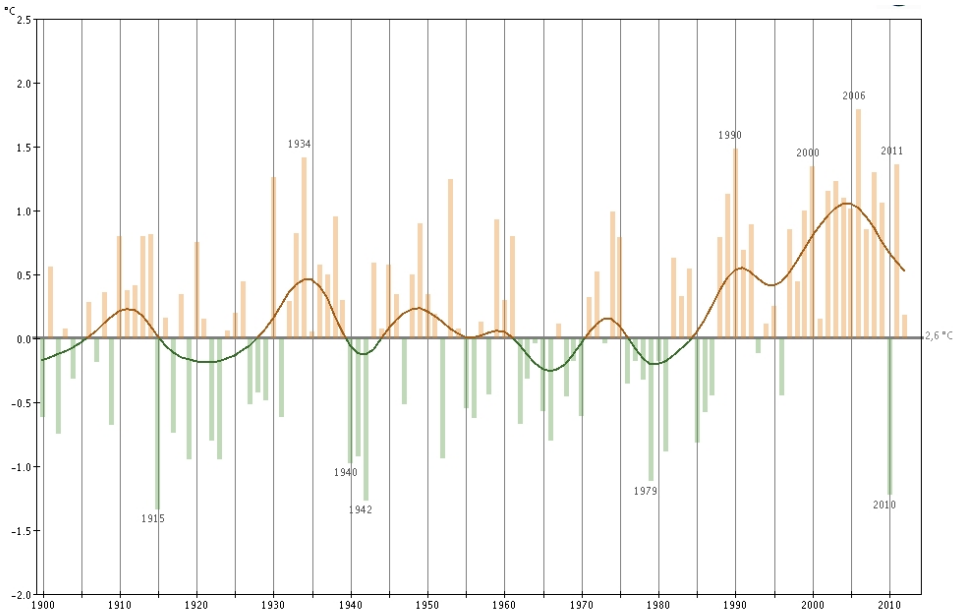

Figure 3 Temperature deviation from the normal period (1961-1990) in Western Norway. Source: (Meteorologisk Institutt)

Figure 3 shows that the temperature has increased steadily from 1988, and there is a tendency of continued warming. Observations from the Meteorological Institute of Norway show the same trend for all four seasons, however with great annual variability (Meteorologisk Institutt). Meteorological observations from 2011 are of particular interest for this study since 2011 was the "case year". 2011 is the third warmest year that has been registered since 1900; only 1990 and 2006 were warmer. The mean temperature in Western Norway was 1.3°C above normal in 2011 (Meteorologisk Institutt 2012). Due to rising temperatures the growing season in Norway has increased with one to two weeks compared to the normal period, and in some parts of Møre and Romsdal County with more than three weeks (Hanssen-Bauer et al. 2009).

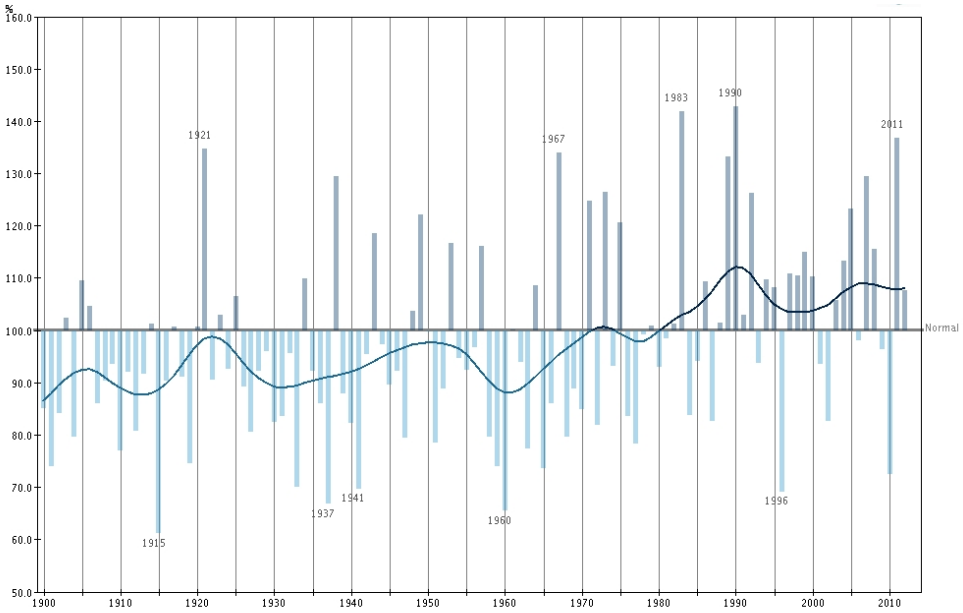

Figure 4 Precipitation deviation from the normal period (1961-1990) in Western Norway. Source: (Meteorologisk Institutt)

Figure 4 shows a steady trend of increasing precipitation relative to the normal period. Western Norway has had the highest rise in annual precipitation in Norway (5-10 %), with highest increase during the spring and winter months (Hanssen-Bauer et al. 2009). 2011 was the wettest year in Norway since national records began in 1900, and the amount of rainfall in Norway as a whole was 130 per cent of the normal. Western Norway as a whole received 135 per cent of the normal rainfall, and in some parts of Møre and Romsdal County the level was up to 150-175 per cent of the normal (Meteorologisk Institutt 2012).

It is more difficult to predict future climate changes at the local and regional level than to predict larger, global climatic trends. This is explained by the great natural variations found in local climate conditions, which are influenced by topography and vegetation, hydrology, wind patterns, and small changes in local atmospheric circulation, among others. In order to achieve a more detailed picture of climate projections with a practical value, global projections are scaled down to regional levels – this is known as "downscaling" of climate models (Hanssen-Bauer et al. 2009; Miljøverndepartementet 2010; O'Brien et al. 2012). Norway is divided into thirteen precipitation and six temperature regions in the downscaled models (Hanssen-Bauer et al. 2009).

Downscaled climate projections for Norway are divided into three categories: Low, mean and high projections (Hanssen-Bauer et al. 2009). The mean projection, showing mean value of downscaled temperature and precipitation, is shown in table 1.

Table 1 Observed and projected climate change in Western Norway compared with the normal period (1961-1990). Source: Hanssen-Bauer et al. (2009), table adapted from Skarbø and Vinge (2012),

Climate change	**1979-2008**	**2021-2050**	**2071-2100**
Increased temperature	+0.47°C	+1.7 °C	+3.1°C
Longer growing season	+1-3 weeks	+1 month	+1-3 months
Increased precipitation*	5-10 %	12 %	22%
Shorter snow season	Unclear trend	-1-2 months	-1-3 months

*In Møre and Romsdal County.

Table 1 shows observed and projected climate change compared with the normal period 1961-1990. The table displays mean values for Western Norway in general, with the exception of precipitation values, which are specific to Møre and Romsdal County.

Both short-term projections (2021-2050) and long-term projections (2071-2100) show that the climate in Western Norway can be expected to change considerably during this century. Regional downscaling predicts that the observed trends (1979-2008) of increasing temperatures, longer growing seasons and increased precipitation will be intensified throughout the century. It is important to note that there is considerable uncertainty associated with global climate models and even more so for downscaled projections (Hanssen-Bauer et al. 2009).

2.2.3 Effects of climate change on agriculture

Farmers have always had to manage uncertainty associated with climate variability (Faurès et al. 2010). In the near future, Norwegian farmers will have to adapt to both negative and positive effects of unprecedented changes accompanying a warming climate. It is expected that a changing climate will have direct as well as indirect effects on agriculture. Direct consequences of climate change on agriculture are associated with changes in production conditions, whereas indirect consequences follow changes in international conditions and new climate policies (Skarbø & Vinge 2012; Aasprang 2013). The focus of this study is the direct effects of climate change on agriculture, as will be described in the following section.

Longer growing seasons

Agriculture in Norway is characterised by a short growing season and difficult growing conditions, and temperature is a major limiting factor for plant growth. It is therefore expected that agricultural production in Norway will benefit from higher temperatures and a longer growing season following climate change. There will, however, be regional differences in the growth potential, and some areas may experience increased risk of drought during the summer months (Dannevig 2011; Miljøverndepartementet 2010; Skarbø & Vinge 2012). Improved growing conditions may lengthen the period for grass growth later into fall and provide opportunities for cultivation of new crop varieties. At Norway´s latitudes plant production fluctuates with the annual sunlight and temperature cycles to a larger degree than in other parts of the world (Miljøverndepartementet 2010). Hence, the number of daylight hours may be a limiting factor for increased plant growth in a warmer climate. Daylight conditions will not be altered by climate change, but the cloud coverage may change with increased precipitation and reduce insolation (Hanslin 2009; Aaheim et al. 2009).

Increased precipitation

Precipitation is projected to increase, in particular in Western Norway and in areas where rain is not a limiting factor for plant growth. Due to regional differences, some areas may experience summer drought, as the amount of rainfall is expected to increase mainly during fall and winter and less in spring and early summer when it is most needed (Hanssen-Bauer et al. 2009; Aaheim et al. 2009). The concept of average rainfall may be less important for farmers than its dispersion and distribution during the cropping season (Faurès et al. 2010). Hence, the projected increase in the frequency and intensity of heavy precipitation events can make harvesting and field preparation more challenging and cause crop damages, soil erosion, and increase in flood risk (Kvalvik et al. 2011; Miljøverndepartementet 2010; Skarbø & Vinge 2012). Wet soils are more easily packed and more susceptible to driving damages, and wet conditions may increase the damages caused by heavy equipment. Soil compaction damages and deficient drainage reduce plant productivity and yields, and affect the uptake of plant nutrients, in particular Nitrogen (Miljøverndepartementet 2010; Øpstad et al. 2013). More precipitation combined with less snow cover and shorter periods of ground frost may increase erosion and surface runoff, causing loss of topsoil and nutrients, and deterioration in water quality. Heavy precipitation in the form of rain in winter may cause ice to form on the ground and increase winter damage (Miljøverndepartementet 2010).

Pests and diseases

One advantage of farming in a cold climate is better animal health owing to fewer pest outbreaks and less use of medicine (Skarbø & Vinge 2012; Aaheim et al. 2009). The infection pressure is kept under control by the cold climate, geographically spread-out production and periods when grazing pastures are not used (Miljøverndepartementet 2010). The current trend of concentrating animal husbandry in centralised regions, combined with improved conditions for vectors (higher temperatures and humid conditions), may cause more frequent outbreaks of existing and new pests, viruses and fungal diseases (Miljøverndepartementet 2010). Animal diseases transmitted by ticks are already a major challenge in relation to animal health in Western Norway. The increased abundance of ticks and tick-borne diseases are associated with warmer temperatures, less snow cover and bush encroachment among other factors (Jore et al. 2014). Higher temperatures, wetter conditions, and longer growing seasons may also provide beneficial conditions for new weeds and increase the need for herbicides (Miljøverndepartementet 2010).

2.2.4 Summary

The climate in Western Norway has changed towards warmer temperatures and higher precipitation, and this trend is projected to increase. A changing climate brings challenges and opportunities for farmers in Norway; warmer temperatures improve the growing conditions and give rise to new pest and diseases, increased precipitation complicates harvesting and field preparation. Various processes of change, for example structural changes in agriculture, affect the capacity of farmers to adapt to the negative consequences and take advantage of opportunities associated with climate change.

2.3 Structural changes in Norwegian agriculture

Norwegian agriculture has gone through significant structural changes resulting in more than three out of four farms closing down since 1949 (Almås & Muirhead 2013). However, Forbord et al. (2014) state that Norway is one of the last European countries where the structural development of agriculture is strongly state regulated through legislation and economic instruments. As a result, Norway is still dominated by relatively small farms compared to other European countries where rationalisation processes have pushed the development towards larger farm units. Despite a shift towards alternative business models, resulting in larger farms and fewer farmers, family farming is still the dominant model in Europe (Milestad et al. 2012).

Structural change in agriculture refers to changes in "number and size of holdings, produced quantities per holding, distribution of productions between holdings and ownership of agricultural resources" (Hegrenes et al. 2000:5). *Structural rationalisation* is understood as structural development towards bigger farms and fewer farmers, and reflects a shift from owner occupation to renting (Forbord et al. 2014). This section covers in more detail the types of changes experienced in agricultural systems and the underlying forces pushing these developments, particularly those relevant to size, number of farmers and changes in farmland control.

2.3.1 Driving forces of structural change

Hegrenes et al. (2000) identify three main factors that influence decision-making and actions, and stimulate changes in the operation and organisation of farm holdings. Firstly, there must be incentives to change the organisation and production at farm level; secondly, farmers must be capable of making the adjustments; and thirdly, it must be legal to make the adjustments. A combination of factors, both related and unrelated to agriculture, shapes the process of structural change. The following is a résumé of some major forces contributing to structural changes in agriculture.

Economic growth. The main economic driving force in Norway is the oil industry. Low unemployment in general, a high demand for workers in the oil sector, high wages and costs of living have had a negative effect on the recruitment to agriculture (Hillestad & Smedshaug 2013). However, the oil economy can have both negative and positive impacts on agriculture. On the one hand, off-farm employment might be a first step out of the agricultural sector, but off-farm work could also facilitate the continuation of small-scale farming by supplementing household income with off-farm income (Hegrenes et al. 2000; Zimmermann et al. 2009). Growth in the oil industry has put the primary industries under pressure by increasing income levels in the Norwegian economy (Hillestad & Smedshaug 2013), and the high wages make it cost-efficient to reduce the number of man-hours in agriculture.

Technology. Increased efficiency demands in agriculture require technology that makes it possible to produce more, cheaper, and with less (physical) effort. In order to support the required investments in machinery for modern agriculture, it has been necessary to develop economies of scale, also identified as a key driver of expansion by Forbord et al. (2014). The

development of labour markets outside of agriculture, and declining rural populations, has made it increasingly difficult to get hold of seasonal help and substitute farmers (*avløser*)[2], and thus increased the demand for modernised equipment in order to work more independently (Zimmermann et al. 2009).

Human capital. Human capital refers to managerial qualities and level of schooling (Zimmermann et al. 2009). Higher educational levels may result in lower recruitment to farming, as many jobs for those with higher education are found in the cities. On the other hand, higher education may improve leadership qualities, which enable farmers to manage larger farm operations and entrepreneurial work, hence improving the capacity to adapt to changes (Hegrenes et al. 2000).

Market forces. Developments in the food markets and public expectations of reduced food prices have contributed to farm expansion (Forbord et al. 2014). Other factors, such as changing dietary requirements and trends, increased consumption of processed foods, goals of mitigating greenhouse gases from agriculture, as well increased concerns regarding food safety and hygiene, influence farm production and structure. Efficiency demands to reduce food prices and changing requirements concerning hygiene and animal welfare, may be too costly for small-scale farmers and drive structural processes towards bigger farm units (Bjørnsen et al. 2010; Hegrenes et al. 2000).

Policy instruments. The structure of farming in Norway is regulated through legislative and economic instruments to obtain certain policy goals. Legal instruments influence farmland control, whereas economic instruments regulate production, income and structural variables (Forbord et al. 2014; Meld. St. 9 (2011-2012)). The four overarching goals for Norwegian agriculture and food policy are food security, active agriculture in all regions of the country, increased value-creation and sustainable agriculture (Meld. St. 9 (2011-2012)). Within the frame of these main goals, farmers receive state subsidies with the aim to produce food on local resources, maintain cultural landscapes, rural settlements and employment, uphold a high degree of food sovereignty, and secure biodiversity and climate friendly productions (Hillestad & Smedshaug 2013; Meld. St. 9 (2011-2012)). Two core economic policies (subsidies) are the cultural landscape support (*Kulturlandskapstilskuddet*), which is provided

[2] Farmers in Norway receive a state subsidy to cover the cost of hiring what is known as an *avløser*, which allows them to take holidays or get extra help during high seasons.

as a fixed sum per land unit in all regions, and the agricultural land support (*Arealtilskuddet*), which is differentiated by type, size and regional localisation of production. These instruments include arable, grassland and animal production (Forbord et al. 2014).

There are three key legal instruments that control agricultural property relations and management. The Allodial Act (*Odelsrett*) is an ancient law that is mostly unique to Norway, which ensures that family members are prioritised buyers of farms (Gjerdåker, 2001; Lilleholt, 1998 cited in Forbord et al. 2014). The Concession Act also regulates acquisition of farm property and includes obligation of residency (*Boplikt*). Finally, the Agricultural Act regulates farm management (including leasing of farmland) to ensure best use of resources and enforces the obligation of farming (*Driveplikt*) to encourage rural settlement and active farming communities. These legislative and economic policy instruments are currently put under pressure due to the shift towards increasingly liberalised agricultural policies following the 2013 elections. Liberalised reforms work towards a "reduction in state regulation, promotion of individual choice, enforcement of private property rights and increased emphasis on market based solutions" (Peck and Tickell, 2002 cited in Forbord et al. 2014:10).

2.3.2 Effects of structural changes

Agricultural policies have both stifled and moderated structural changes, while multifunctional policies contribute to keeping farm units smaller by encouraging the development of a diversified agricultural sector. Despite these measures, and the aspiration to have a moderate development towards larger farm operations, non-agricultural factors such as low unemployment and the growing oil industry have stimulated structural changes towards larger farms and fewer farmers (Bjørnsen et al. 2010; Hillestad & Smedshaug 2013). The resent shift in Norwegian politics, towards increased liberalisation in farming, is further enforcing this trend.

Structural changes in agriculture have deep-rooted effects on farm households and on rural communities in Norway. When small farms close down and farms are consolidated into larger operations, rural areas lose economic, social and ecological functions related to farming (Milestad et al. 2011). In general, a reduction in number of farm holdings, larger farm operations, and changes to the cultural landscapes are the most visible effects of structural rationalisation. Other important effects include changes in farmland control (increased dependence on renting land), specialisation of production, and concentration of production

closer to the market ('urbanisation' of agriculture). The effects that are of most interest for adaptive capacity, in light of socio-environmental processes of change, are alterations in farm size, number of farmers and farmland control. These effects will be elaborated on in the following sub-sections.

2.3.3 Larger farms and fewer farmers

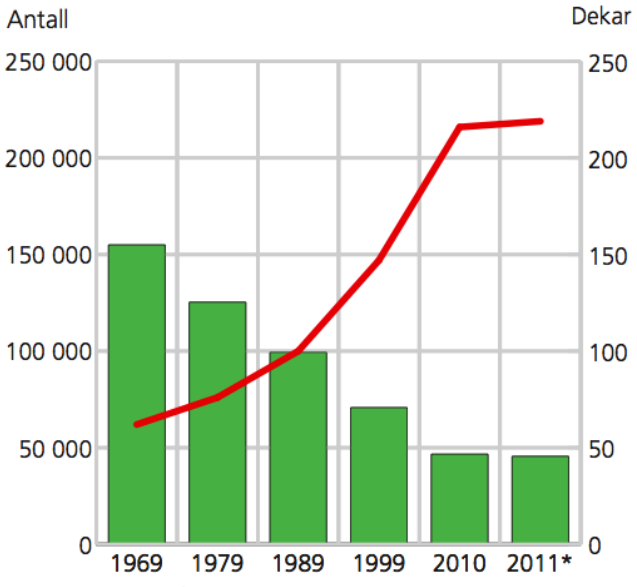

Figure 5: Number of farms (green) and average farm area per farm holding (red) measured in dekar (daa)[3]. Source: Rognstad and Steinset (2012)

As shown in figure 5 the number of farms have decreased substantially over the past decades. The figure simultaneously shows how farmland area per holding has increased. From 1959 to 2013 the number of working farms in Norway was reduced from 198 000 to 43 500. From 2012 to 2013 alone, the number decreased by 1 300 farms, that is 2.8 per cent in one year (Bjørlo & Snellingen 2013). As the number of farms declined, the remaining operations increased in size. From 1950 to 2011 the average farm size more than quadrupled, from 50 daa to 219 daa (Rognstad & Steinset 2012).

Modern Norwegian agriculture has gone through several periods of major structural changes, commencing with "The great shed" (*Det store hamskiftet*) between 1945 and 1975 (Hegrenes et al. 2000). The first period of change following WWII was initiated by the increasing use of the tractor. From 1959 to 1969 there was a particular decline in farms of less than 50 daa,

[3] Dekar (abbreviated daa) is a metric unit of area primarily used in the measurement of land in Norway. 10 dekar equals 1 hectare

resulting from an effort of the government to increase production efficiency, limit partitioning of land, and increase wages of farmers. During the 1970's, policies shifted emphasis to national food self-sufficiency while continuing to focus on farmers' incomes and welfare. This was a period of major investments in infrastructure and modernisation (Forbord et al. 2014). During these decades the number of farms fell steadily, including larger and larger farm operations. Presently, the reduction rate is slower, but the relative percent-wise reduction has intensified the past decades due to the fact that there are fewer farm holdings left (Lie & Mittenzwei 2008). Despite the dramatic decrease in number of man-hours going into agriculture, farmers have increased production substantially (Rognstad & Steinset 2012). By the end of WWII, the average Norwegian farmer produced enough calories for 5 people, whereas the average farmer in 2000 produced enough calories for 32 people (Almås et al. 2013).

Owing to less favourable natural conditions for agriculture, Western and Northern Norway have had the highest relative decline in farmland area and number of farms in Norway (Bjørnsen et al. 2010; Lie & Mittenzwei 2008). Farms in Western Norway have generally been small compared to farms in more central regions. Regions with a higher share of small farms are more severely affected by structural development because the smallest farms are usually closed down first. Factors such as local growing conditions, topography, and distribution of fields around the farm (*arrondering*), can make alternatives to closures less attractive than in high-productive areas where they have natural conditions for more intensive agriculture. Another aspect that affects regional development is the geographically differentiated development in meat and dairy production, which has been concentrated in valleys and mountainous areas after the implementation of the 'conduit policy' (*kanaliseringspolitikken*)[4]. The production of white meat and grain, on the other hand, has been centralised due to market forces (Bjørnsen et al. 2010; Lie & Mittenzwei 2008).

2.3.4 Changes in farmland control

Another important manifestation of structural change is alterations to land ownership patterns, which Forbord et al. (2014) define as farmland control. Within a period of 50 years (1959-2010) the extent of wholly owned farm operations has decreased from 87 per cent to 35 per cent of Norwegian farms, while during the same period farms falling under the category of

[4] *Kanaliseringspolitikken*: political incentive to concentrate husbandry and dairy production in areas which are conducive to grass production (for example Western Norway), and grain production in the flat areas in Eastern and Central Norway

mainly rented holdings (50.1-99.9% of land in operation) has increased from almost none to 23 per cent of all farms in Norway. (Forbord et al. 2014). In 2010 almost 50 per cent of the farmland was leased in Møre and Romsdal (Rognstad & Steinset 2012). Forbord et al. (2014:9) attribute the changes in farmland control to three key factors: "techno-economic development leading to a growing need for economies of scale, social norms curbing the transfer of farm properties outside of the family, and policy and legal instruments reducing the extent of property transfer." The rapid shift from traditional owner occupation to a predominantly rented land system has altered not only the agricultural landscape, but also the texture of the farming community (Milestad et al. 2011).

2.3.5 Summary

Shifting political, economic and societal priorities, market trends, rising costs and wages, and technological advances are the primary driving forces behind structural rationalisation in Norwegian agriculture. As a result, there has been a substantial decline in the number of farms and farmers, farms are bigger and more specialised, and the pattern of ownership and renting has changed. While structural change is nothing new to agriculture and some of these trends began several decades ago, the changes are increasingly altering the context for farming and its capacity to adapt to increased climate variability.

3 Theory

3.1 Vulnerability

The Intergovernmental Panel on Climate Change (IPCC) defines vulnerability to climate change as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes" (IPCC 2007:883). The way IPCC defines vulnerability; it is a function of exposure, sensitivity and adaptive capacity. Exposure is defined as "the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure or economic, social or cultural assets in places and settings that could be adversely affected" (IPCC 2014); "sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate variability or change" (IPCC 2007:881); and adaptive capacity (also referred to as adaptability) is the ability or potential of a system to adjust to climate change, to take advantage of opportunities and cope with the negative consequences (IPCC 2007).

The way in which vulnerability is framed has implications for the generation of knowledge and responses to the effects of climate change, and may also determine what is included in the political agenda (O'Brien et al. 2007). O´Brien et al. (2007) identify two main approaches to framing vulnerability. *Outcome* vulnerability is related to a natural science framing (treating nature and society as separate units), whereas *contextual* vulnerability is associated with a human-security framing (nature-society relationships). *Outcome vulnerability* (also referred to in the literature as "end-point" vulnerability) is described as the projected negative impact of climate change on a biophysical or social exposure unit after adaptation responses have been factored in. It emphasises technical measures as a means to limit negative outcomes of projected climate change (O'Brien et al. 2007).

This study applies the framework of contextual vulnerability (also referred to as "starting-point" vulnerability in the literature), which is described as a process-based and multidimensional approach to understanding vulnerability in view of climate-society interactions. In the contextual vulnerability framework climate variability and change occur in the context of social, cultural, technological, institutional, political and economic processes of change. These contextual conditions affect individuals´, communities´ and nations´ exposure to climate variability and change, and their capacity to respond to change (O'Brien et al. 2007). O`Brien et al. (2007) claim that contextual vulnerability has been far less visible in

science and policy debates than outcome vulnerability, and argue that it should be more included. This argument is strengthened by several local level case studies, which have demonstrated how contextual conditions have compounded the effects of climate variability and change, indicating that underlying causes of vulnerability should not be overlooked (Eriksen & Selboe 2012; Ford et al. 2006; Kvalvik et al. 2011; Leichenko & O'Brien 2008; Skarbø & Vinge 2012; Ziervogel et al. 2006).

3.1.1 Double exposure framework

An example of the contextual vulnerability approach is the *double exposure framework*, developed by O`Brien and Leichenko (2000). The framework was developed in response to perceived shortcomings of other impacts- and vulnerability frameworks that are separating vulnerability from climate change and other processes of change. The concept of double exposure demonstrates how global transformative processes, such as globalisation and environmental change, interact and influence one another, and create opportunities or obstacles for individuals, communities and regions. The double exposure framework is an integrated approach that draws attention to temporal and spatial linkages, feedbacks and interactions between the two global processes, often overlooked in separate discourses (Leichenko & O'Brien 2008). Leichenko and O`Brien (2008:47) describe three pathways of double exposure: Feedback, outcome and context double exposure. Of particular importance for this study is context double exposure, which describes how "new conditions associated with both global environmental change and globalisation may change the contextual environment and increase vulnerability to shocks and stresses of all types" The differentiated consequences of double exposure on individuals, communities and regions affect their capacity to adapt to change, and the most marginalised are often the most vulnerable in terms of climate variability and change (IPCC 2014; Leichenko & O'Brien 2008).

3.2 Adaptation and adaptive capacity

Adaptation to climate change is defined by the IPCC (2007:869) as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" Adaptation is a process of deliberate change, either in anticipation of (proactive adaptation) or in in reaction to (reactive adaptation) external processes of change (Nelson et al. 2007). Adaptation involves reductions in vulnerability, but also taking advantage of positive change that provides opportunity for innovation and development, however, there is little empirical evidence of adaptation

measures proactively exploiting the potential benefits of climate change (Berrang-Ford et al. 2011). Until recently, discussions of adaptation approaches was dominated by a focus on infrastructure and technological options to reduce vulnerability to climate change impacts (as in outcome vulnerability approach), paying less attention to the process of climate change adaptation (Nelson et al. 2007; O'Brien et al. 2006; Wolf et al. 2010). However, as multiple processes of change interact, climate adaptation cannot be seen in isolation from societal processes of change, and adaptation measures are seldom a response to climate change alone (Berrang-Ford et al. 2011; O'Brien & Wolf 2010; O'Brien et al. 2012).

Since changes are ultimately felt at the local and individual level, local adaptation is key in adapting to climate variability and change (Eriksen & Selboe 2012; O'Brien et al. 2012). Local adaptation is however an interaction between formal and informal processes at different scales. The emphasis on local adaptation can be problematic since adaptive capacity, a precondition necessary to enable adaptation (Nelson et al. 2007), and the local context in which adaptation occurs are shaped by socio-environmental processes which are not controlled at the local level (Eriksen & Selboe 2012). The challenging and complex problems of global processes of change require complex responses at international, national, community, household and individual level (O'Brien & Hochachka 2010), and research shows that formal responses depend on informal networks to be successfully implemented (Eriksen & Selboe 2012). The interaction between formal and informal processes is often not considered in formal policies and planning, leaving a gap between how adaptation actually takes place and formal adaptive strategies in terms of climate change (Eriksen & Selboe 2012; O'Brien et al. 2012).

3.2.1 Core components of adaptive capacity

Particularly important components of adaptive capacity are knowledge, learning, collaboration, social networks, flexibility and diversity. To illustrate how adaptive capacity is applied to this study, adaptive capacity and its components will be described with reference to agriculture and farmers´ adaptations.

Knowledge, past experience of climate variability, and previous responses to their local impacts are important characteristics of adaptive capacity. This type of knowledge is subject to non-climatic pressures (cultural, technological, political, socioeconomic) and characterised by being dynamic and changeable (Eriksen & Selboe 2012; O'Brien et al. 2012). Local

knowledge is generated through personal learning and experimenting over time and across generations, and through collaboration and discussion with other farmers, farmer organisations, distributors of technology, extension service and research stations (Darnhofer et al. 2010). Local knowledge is one of the most important aspects of adaptive capacity, but out-dated knowledge and blind trust in past experiences may be insufficient for adapting to changing contexts. Bernard et al. (2014:156) argue that "loss of relevance of existing knowledge under new circumstances, dominance of external, formal knowledge, and loss of effective intergenerational transmission and learning" can cause unsustainable farming practices. Hence, it is important to renew and update knowledge by combining research about the future, local knowledge, and experience about the past to shape adaptive capacity and responses to new risks, challenges, and uncertainty associated with a changing climate (Darnhofer et al. 2010; Folke et al. 2003; Kvalvik et al. 2011).

Social networks and collaboration are other important components of adaptive capacity and key for the exchange and generation of local knowledge. Pelling and High (2005:308) argue that "adaptive capacity is being reshaped through social relationships". Factors associated with structural changes, such as fewer farmers, changing demographic patterns, increased formalisation, new technologies and off-farm work may change the nature of collaboration, and threaten the transfer of knowledge, flexibility and adaptive capacity (Eriksen & Selboe 2012). On the other hand, engagement in off-farm work, non-farming activities and community organisations may enhance learning and increase adaptive capacity by including diverse information sources, differing worldviews and different understandings of phenomena (Darnhofer et al. 2010; Ziervogel et al. 2006). The components that constitute adaptive capacity can be threatened by contextual changes and adaptation to non-climatic processes of change. One example is the dramatic decline in farmers due to structural changes in agriculture, leading to a disintegration of social and professional networks (Eriksen & Selboe 2012; Kvalvik et al. 2011). An adaptation may be beneficial for an individual household or a community but can create negative externalities at other temporal and spatial scales (Nelson et al. 2007). Farmers adapt to multiple processes of change, and an individual adaptive strategy to socioeconomic and political changes may be to quit farming altogether. This response affects the texture of the local community and leave remaining farmers with fewer people to collaborate and exchange knowledge with (Eriksen & Selboe 2012; Kvalvik et al. 2011; O'Brien et al. 2012).

Structural changes in agriculture also affect diversity and flexibility, the two last components of adaptive capacity to be discussed here. Flexibility in relation to adaptive capacity is associated with daily decision-making (operational flexibility) and long-term planning of the farm operation (strategic flexibility) (Darnhofer et al. 2010). Adaptive capacity at the farm level is enhanced by flexibly organising collaboration, sharing of equipment, harvesting methods, and off-farm employment. Adaptive capacity is further enhanced by maintaining a diversity of resources from field to farm to community level (diversity of land resources, family labour, knowledge, networks), including a diversity of options for responding to climate variability and change (Cialdella et al. 2009). The diversity of options available, are shaped by the context of the farm (e.g. proximity to neighbouring farmers and a work market). Adaptive strategies come with the cost of managing trade-offs between short-term efficiency and long-term adaptability. Structural changes in agriculture pushes towards larger and more specialised farm operations that focus on efficiency and predictability, increasing productivity, optimising production, and minimising costs, often at the expense of flexibility and diversity (Darnhofer et al. 2010).

3.3 Adaptation as a social and values-based process

The social process and subjective, internal dimensions of adaptation have mostly been neglected in research (O'Brien & Wolf 2010; Wolf 2011). However, Adger et al. (2009) assert that adaptation is a social and political process, which is limited by perceptions, individual and cultural values, governance and institutions, as well as by ecological thresholds. Who and what are vulnerable, and who´s values count are important questions related to climate change adaptation. Since values are subjective, climate policies and responses that emphasise the values of one group may come in conflict with other people´s values (Adger et al. 2009; O'Brien & Wolf 2010). What is considered as effective and legitimate adaptation depends on what people perceive to be worth preserving and achieving (O'Brien & Wolf 2010; Wolf 2011). Although one of the main objectives of adaptation is to reduce vulnerability, the success of adaptation is determined by the sustainability of the responses on both social and ecological systems (Adger et al. 2009; Nelson et al. 2007). From a sustainability perspective it is key that adaptive responses don´t exacerbate vulnerability and make the climate problem worse at different temporal and spatial scales. Eriksen et al. (2011) outline four principles to guide sustainable adaptation to climate change: Recognize and address contextual factors that create vulnerability; acknowledge that different values and interests affect the outcomes of

adaptation; include local knowledge in adaptation; consider feedbacks and trade-offs between local and global processes.

3.3.1 Application of the double exposure framework in the context of Norway

There is often talk of winners and losers in relation to global processes of change. Norway has so far mostly been sheltered by the negative, and sometimes disastrous, consequences of global transformative changes, such as globalisation and climate change. However, the climate is changing with differentiated consequences for individuals, communities and sectors also in Norway, and Norwegian agriculture is undergoing substantial structural changes mirroring larger global trends and processes (Forbord et al. 2014; O'Brien et al. 2004). Darnhofer et al. (2010) state that the goal of government politics has been to offer farmers a stable context, through stabilised commodity markets and controlled imports, where changes were introduced gradually and in a predictable way. However, these gradual and predictable changes are now challenged by liberalisation and globalisation leading to interconnectedness of markets and sectors. Norway, like many other countries, including in the European Union, has witnessed a rise in support for neoliberal governance (Forbord et al. 2014). Free-market oriented political parties that advocate market liberalisation and 'freeing of farmers' (deregulation of agricultural policy by removing trade barriers and subsidies) gained increased support in the 2013 elections in Norway.

Despite the impression that Norway has high adaptive capacity in terms of climate variability and change, a study from the municipal level in Norway concluded that adaptation to climate change is still in its infancy in Norway (Dannevig et al. 2012). This indicates that there is no direct positive relationship between high adaptive capacity and actual adaptation taking place (O'Brien et al. 2006). A developed country like Norway score high on adaptive capacity determinants such as wealth, technology, infrastructure, institutions, information and skills (O'Brien et al. 2004). However, Keskitalo et al. (2010:588) state that such determinants "do not fully consider the contextual vulnerability dimensions of advanced industrial states". Several aspects affect adaptive capacity and limit adaptation in developed countries: Perceived immunity to the impacts of climate change; confidence in technology; disempowered attitudes; lack of awareness and sense of urgency about climate change impacts (Keskitalo et al. 2010; O'Brien et al. 2006; Wolf et al. 2009; Wolf 2011).

4 Methods

In this section the research methods that were used to address the objective and respond the research questions will be described. As highlighted by Thagaard (2013), to ensure quality and transparency in qualitative research, it is important to be explicit about the use of methods, and to document and critically evaluate each step of the process from data collection through the analysis and interpretation of data. This study employs a qualitative research method, covering case study interviews, informal observations and secondary data analysis, which will be described and evaluated in the following subsections.

4.1 The qualitative research approach

A qualitative research approach was chosen in order to get an in-depth understanding of local sources of vulnerability and adaptation processes through farmers' own accounts and descriptions. The main purpose of this study is to increase the understanding of how farmers currently adapt to the double exposure of climatic and structural changes in the farming sector. Studying local adaptation to climate variability and socioeconomic processes at present can deepen the understanding of how future adaptations may take place, since the factors that affect today´s responses are likely to affect responses in the future (Eriksen & Selboe 2012; O'Brien et al. 2007; Ziervogel et al. 2006).

4.1.1 Case study research

Yin (2014:16) defines a case study as "an empirical enquiry that investigates a contemporary phenomenon (the "case") in depth and within its real-world context." There is increasing awareness in the research community that vulnerability to climate variability and change is differentiated and that the extent of exposure depends on contextual conditions. The capacity to adapt to climate variability and change is not evenly distributed within countries due to non-climatic processes of change (Eriksen & Selboe 2012; IPCC 2014; O'Brien et al. 2007; Pelling 2011; Ziervogel et al. 2006). Developed countries such as Norway are expected to have high adaptive capacity in the face of climate change, when considering external and objective factors This assumption masks that there are local, cultural and subjective differences, within a country or a community, that are important in terms of adaptation (O'Brien & Wolf 2010). The high national level of adaptive capacity may have created a state of complacency toward the impacts of climate change and the barriers and constraints to adaptation (O'Brien et al. 2006). Kvale and Brinkmann (2009) argue that the study of a specific case may unfold extensive and in-depth descriptions hidden in quantitative research.

Hence, a case study approach may address the aforementioned limitations in vulnerability studies by uncovering local differences and creating a more nuanced picture of the adaptation process locally.

4.1.2 Selection and description of case study site

The Municipality of Rauma was selected as a case in part because of its positioning in Western Norway, a region characterised by small farm holdings and marginalised agriculture due to difficult topographic and climatic conditions (Hillestad & Smedshaug 2013). Rauma is a particularly useful case for illustrating a region that has to adapt to the double exposure of climatic and structural changes. The agricultural sector in Western Norway is particularly exposed to economic pressures due to its proximity to the oil sector and marginal farming conditions that are not conducive to large-scale production. Food production in Western Norway is declining faster than in the rest of Norway, agricultural areas are taken out of production, and the sector has problems recruiting young people in competition with better-paid jobs in the industry and the oils sector (Hillestad & Smedshaug 2013). Western Norway is already experiencing changing climatic trends. Due to rapid farm structural changes and changing climatic conditions, Rauma can thus provide an example of how farmers adapt to multiple processes of change in a developed part of the world.

Another reason why Rauma was of interest as a case study was because my husband and I were managing a farm in the area from August 2011 to January 2013. It provided a unique opportunity to study a place and its context over a longer period of time, in an in-depth and participatory manner, through following local events and farmers' deliberations and decisions in the face of those events. The experience of managing a farm guided me in my research and provided me with insight that I could not have achieved if studying it from a distance or from a strictly theoretical point of view. We were managing a small-scale farm of mixed production (chicken, sheep, goats, a donkey) and were fortunate to reside in an area where neighbouring farmers actively collaborated and socialised around farming and non-farming activities.

4.2 The research process

Thagaard (2013) describes the qualitative research method as a cyclic process where the different stages of the research process overlap. Since research is about studying something unknown, Thagaard argues that the research process should be flexible in order for the different stages to influence each other. The qualitative research method can be seen as a

parallel process of collecting and analysing data in light of existing theory. In this study the objective and research questions were adjusted as the understanding of the topic evolved with new insights from data collection and analysis. The following sections cover a discussion of the research process including ethical and quality perspectives.

4.2.1 Planning of study and recruiting key informants

In the preparation for this project, secondary literature from multiple sources was studied parallel to following debates in Norway´s national agricultural newspaper *Nationen*. Articles on agriculture in the local newspapers *Aura Avis* and *Romsdals Budstikke* provided insight into the current, local context for farming in Rauma. This study used a thematic guide previously employed in a case study of a mountain farming community in Øystre Slidre in Norway (Eriksen & Selboe 2012). The case study was part of the interdisciplinary research project PLAN (Potentials of and Limits to Adaptation in Norway) funded by the Norwegian Research Council (Eriksen & Selboe 2012; O'Brien et al. 2012). The current case study used a modified version of the interview guide employed by Eriksen & Selboe (2012) to reflect the local context and conditions of Rauma.

The data collection focused on key informant interviews of farm households. The key informants were selected with the help of Gerd Dale, the municipal agricultural officer (*Landbrukssjef*) in Rauma. Dale had worked in the same position over many years and knew the farmers and different locations in the municipality well. Dale helped identify informants that represented a variety of farmer types and geographic locations. The farmers were identified to cover different production types, farm sizes, gender, age and locations (covering every corner of the municipality) The informants were selected from the full list of farmers in Rauma, based on applications of production subsidies in 2011. The selection was finalised through a phone meeting (where the project was explained) and two physical meetings with Dale. The farmers were contacted by phone and informed that the municipal agriculture officer had suggested them as key informants for this project. I introduced myself as a student of international environmental studies, but also as a substitute farmer and newcomer to Rauma. The study project and interview process were presented, and place and date for the interview was set. A total of 18 people were interviewed, of which 17 were farmers and one was a project leader of environment, climate and energy in the Norwegian Farmers´ Union (*Norges Bondelag*).

In addition to the farmers suggested by Dale, five informants were identified using the snowballing method (Thagaard 2013). After each interview the informant was asked if he or she would recommend someone to participate in the case study. Since the interviews were conducted over a longer period of time, it provided more flexibility for farmers to pick a time that worked best for them. Therefore, the majority of the farmers that were contacted responded positively to participating in the study. Two farmers that were contacted through the snowballing method were unwilling to participate due to lack of time, and one farmer cancelled the interview due to family issues. I do not believe that this has affected the study findings substantially, however the participation of these three farmers could have contributed additional insights from a female and large-scale farmer´s perspective.

It is important for the reliability of a study that informants can trust that the interviewer follows the standard procedures of informed consent. This implies that the interviewees are informed about the nature and purpose of the study; about who has access to the interview transcripts; and how the data will be processed and stored. The participants were informed that they had the right to withdraw from the study at any time (Kvale & Brinkmann 2009). After consenting to participate in the study, an information sheet was sent out to the informant, including date and place of interview, information about the study, the nature of the interview process and broad themes included in the question guide (appendix 1). Informed consent also includes the principles of confidentiality. Qualitative interviews may contain personal and sensitive information, thus it was important to keep interview responses separate from names and other information that could help identify the informants to secure confidentiality. The principle of confidentiality applies throughout the whole research process from producing data to authoring and possibly publishing a report (Kvale & Brinkmann 2009). This study was reported to and follows the standards and requirements set by *Norsk Samfunnsvitenskapelig Datatjeneste* (NSD).

4.2.2 Case study interviews

The interview situation provides a unique possibility to get insight into the everyday life of the interviewee, and acquire knowledge on how the person experiences his or her life situation (Thagaard 2013). In this study the key informants were interviewed using semi-structured interview techniques. Kvale and Brinkmann (2009:3) define the semi-structured life world interview as a "purpose of obtaining descriptions of the life world of the interviewees in order to interpret the meaning of the described phenomena". Kvale and

Brinkmann further describe the interview situation as a structured conversation with a clear purpose and emphasise that knowledge is not collected, but rather produced in the interaction between the interviewer and interviewee (2009).

The interview guide was organised in thematic sections. Some themes were covered in all the interviews, whereas other themes were chosen to fit the farmer and production type. The main themes that were covered were: background information about the farm household and farming activities; climate variability and farmers´ adaptations in 2011; local knowledge; and local manifestation of climatic and structural changes in agriculture (appendix 2). 1 to 1.5 hours were set aside for the interview, but some sessions lasted up to 2 hours. After each interview there was an opportunity for the informants to add comments or additional information of importance to them. Sometimes two informants were interviewed in one day, or several in the course of a week. Other times the interviews were conducted weeks apart. Since farming is season and weather dependent, farmers were particularly busy during certain periods. The interview breaks allowed for a circular process of gathering data and triangulating the responses with other secondary sources. Fourteen interviews were conducted at the farm of the key informants and three at the farm I was managing, respecting the preference of the interviewees. The first four interviews functioned as pilot interviews. They were conducted together with my thesis adviser and the two of us discussed the interview process after each of the four interviews in order to improve both the interview guide and the interview technique itself.

4.2.3 Quality and ethics in qualitative research

The trustworthiness, strength and transferability of qualitative research are associated with the norms of validity, reliability and generalisation value of a study (Kvale & Brinkmann 2009). Reliability embraces the consistency and trustworthiness of a study and refers to whether a finding can be reproduced using the same methods. The concept of (internal) validity is connected to the analyses of data and the legitimacy of interpretations in relation to the real world. In other words, validity refers to whether a method investigates what it was intended to investigate (Kvale & Brinkmann 2009). External validity concerns generalisation of data, and whether the results can be generalised beyond the studied context. One critique of the qualitative research and case study methods is that context-specific knowledge cannot be generalised and transfer meaning to other cases. Each interview situation is context specific and unique because of the human interaction between interviewer and interviewee, thus a

replication of results is not possible (Kvale & Brinkmann 2009). Yin (2014:40) meets the critique stating that case studies provide an "opportunity to shed empirical light about some theoretical concepts or principles…" Background theory is important, not only for guiding and designing a case study, but also to help generalise data from the study in later stages of the process. Case studies hence have analytical and empirical generalisation value and may help develop theoretical understanding which can be of value in other contexts (Yin 2014). This case study may have a generalisation value, as Rauma represents a typical municipality in Western Norway. This case study may further provide insight into how farmers in developed country contexts such as Norway adapt and respond to multiple processes of change.

There are several ethical aspects to consider in case study research; an interview situation entails an asymmetrical power relation, not an open everyday conversation between equal parties; the researcher directs questions and follow up on the answers of interest to him or her; and the interviewer has monopoly on interpretation and production of the final document (Kvale & Brinkmann 2009). In this case study, the interviews were often initiated with the informants asking me about the owners of the farm I was managing. Although not an experienced one, I was at the time being a farmer and shared a personal interest for farming with the informants. I believe that this special situation created a more relaxed atmosphere and improved the balance of the interview situation.

Informed consent and confidentiality are important ethical aspects of research, and the question of confidentiality was particularly important in this case study. Rauma is a small, transparent community where 'everybody knows everybody'. When I arrived at an interview, the informant often commented that I had been visiting a friend, family member or neighbour. Acknowledging that these other acquaintances had been visited was important to retain a natural and open interview atmosphere. However, I was particularly careful to avoid mentioning what had been discussed in interviews with others, in order to protect confidentiality of responses. It was important to draw a clear line between interview responses and everyday conversations and discussions. Because I was living and farming in the case of study, I interacted with some informants prior to and after the interviews. I believe that living and interacting with famers in my case study helped to overcome an inside-outside barrier, in addition to providing an important source of data.

4.3 Triangulation

One approach to construct validity and ensure quality and objectivity in the research process is the method of triangulation. Triangulation is used to determine the consistency of a finding and is an important feature in increasing the quality of case study (Yin 2014). One very important aspect of triangulation in this case study was the information gathered through informal observations and conversations outside of the interview situation. This study further triangulated between multiple sources of evidence such as peer-reviewed academic articles, official government documents, statistical analysis, climate reports, newspaper articles, and key-informant interviews to increase its validity. Collaboration with neighbouring farmers was a very important part of the farming experience; lunches and dinners were frequently shared, and agriculture was often a topic of conversation. Much was observed and learned through conversations and informal observation. I attended various seminars on the topic of food production and climate change in Møre and Romsdal and one seminar in Oslo on structural changes in agriculture. The seminars are not referred to directly in the analysis but were very important for the preparation of the study, for guiding theory search and comprehending contexts and phenomena. The seminars were arranged throughout my stay in Rauma and formed part of a circular process of interviewing and analysing data. A major part of this study is related to structural changes and the effect of these on vulnerability and adaptation in terms of climate variability, a topic that was frequently discussed at the seminars.

4.3.1 Analysis and presentation of data

As described previously in this chapter, the analysis of information starts during the interviewing process, and the generation and analysis of data are parallel processes. In the analysis process, meaning is added to the story of the interviewees. Kvale et al. describe the analysis of transcribed material as a continuation of the conversation with the interviewees, "unfolding its horizon and possible meanings" (Kvale & Brinkmann 2009:193). No recorder was used during the interviews, but comprehensive notes were taken. The responses were transcribed shortly after each interview while memory was still fresh. After transcribing the interviews, the transcripts were searched for patterns. A 'raw data document' was created and divided into categories based on topics covered in the research questions and issues that emerged from the interviews. This allowed for a comparison of similarities and inconsistencies between the interview responses. The comparison emphasised variations

between different farmer types and in different geographic locations, but also discrepancies among comparable farmer types in similar locations.

Later in the process, meaning was added in the light of theory, and the interview responses were compared with similar studies. Validation can be strengthened in the process of confirming or disconfirming the interpreted data in view of comparable studies. Throughout the analysis process the transcripts were re-visited in order to recall the context of the interview responses. This is what Thagaard (2013) describes as re-contextualising. In the raw-data document the responses were de-contextualised, meaning that they were put in categories separated from their contexts. Another meaning of contextualising is 'thick descriptions', which situates and describes an event in its value-laden context. Thick descriptions not only describe the phenomena, but also the context so that the phenomena and interpretation of it becomes meaningful to the reader. To thicken an event means to provide a rich, dense and detailed description of a case (Kvale & Brinkmann 2009).

To protect the anonymity of the informants, farmers are identified more descriptively rather than by name or exact location of the farm. Whenever important for the interpretation of data, the location is described as interior or coastal/close proximity to the fjord. The function of the descriptions is to illustrate the context while at the same time protecting farmers' identity; hence the general rather than accurate or quantitative description is most appropriate. In some locations there are very few farmers, and giving the name of the place would give away the identity of the informant. Therefore all names and names of locations have been omitted from the text.

The 17 interviewed farmers are listed in table 2. In addition, Svein Guldal, who is project leader for the Norwegian Farmers´ Union (*Norges Bondelag*) in the field of environment, climate and energy, was interviewed at his office in Oslo 26.04.13. Guldal is also a farmer.

Table 2 List of interviewed farmers

Nr	Date	Age group	Gender	Local climate	Main production type	Number of animals*
1	*28.11.11*	60-69	M	Interior	Sheep	120
2	*28.11.11*	40-49	F	Interior	Dairy & sheep	6 cows + 50 sheep
3	*29.11.11*	40-49	M	Fjord	Sheep	100
4	*29.11.11*	50-59	M & F	Interior	Dairy & beef	80-100
5	*07.12.11*	50-59	M & F	Fjord	Dairy	40
6	*18.01.12*	60-69	M	Fjord	Dairy & grain	17
7	*08.02.12*	40-49	M	Fjord	Pigs & grain	270
8	*13.03.12*	30-39	M	Fjord	Dairy & beef	100-150
9	*13.03.12*	40-49	F	Interior	Dairy	18 cows +7 calves + 6 heifer
10	*15.03.12*	40-49	F	Fjord	Dairy & sheep	18 cows + 35 sheep
11	*17.03.12*	40-49	M	Fjord	Sheep	160
12	*19.03.12*	40-49	M	Interior	Sheep	90
13	*20.03.12*	40-49	M	Fjord	Sheep	45
14	*26.03.12*	60-69	F	Fjord	Sheep	24
15	*27.03.12*	60-69	M	Fjord	Sheep & potatoes	30
16	*28.04.12*	60-69	M	Fjord	Dairy & grain	20-24
17	*29.04.12*	40-49	M	Fjord	Dairy	19

*Number of sheep refers to winterfed sheep

5 Results and analysis

5.1 Climate variability and changing climatic conditions in Rauma

In 3.3.1 it was described how perceived immunity to the impacts of climate change, disempowered attitudes, lack of awareness and sense of urgency about climate change impacts can limit adaptation in developed countries. This section addresses research question 1.1: What are farmers´ perceptions of climate variability and change in Rauma? The section starts with a description of changing climatic conditions in Rauma from farmers' own perspectives, and is followed by interviewees' accounts of climate variability in 2011 and the effects on farm production.

5.1.1 Awareness of local climate variability and change from farmers' perspectives

The interviewed farmers were asked if they had noticed changes in the local climate the past decades, and if they could describe these changes. Their responses were based on their own observations as well as accounts from the older generation. The most frequently mentioned changes were higher average temperatures, milder winters with less snow, changing precipitation patterns, less defined seasons, and longer growing seasons.

Several of the interviewees described how the seasons had changed. One farmer commented that they used to have distinct seasons, but lately fall and winter, and spring and summer had merged. Similarly, a dairy farmer commented that the summers used to be longer, but presently spring and fall season had stretched out. Due to the seasonal changes, there was a general perception that the growing season had become longer. Interviewees further described how the seasonal precipitation patterns had shifted, and one sheep farmer said: "We get more precipitation in spring and fall, so it rains at other times than summer." Several interviewees had observed that winters and snow conditions were currently less stable and that precipitation in winter more often fell as rain, which was uncommon before. This is exemplified by the comment of a sheep farmer from the interior part of Rauma: "We used to have winters, but we don't anymore. It is milder and there is less snow." The interviews reflect, however, that there is great variability from one year to another. The winters of 2010 and 2011, for example, were described as particularly snow-rich. Farmers´ perceptions, as portrayed above, correspond with meteorological observations from Western Norway and future predicted climatic trends as described in section 2.2.2.

Farmers' perceptions vary from perceiving climatic variations as part of natural fluctuations or as a sign of climate change. The following quote from a sheep farmer illustrates this: "There are no dramatic changes in the weather. We've had two bad summers, but the previous 5-6 summers were good. There are no big changes." A sheep farmer at a higher elevation said: "We have measured the weather at the farm since 1896, and there have been large fluctuations in weather and precipitation. Fall and winter seasons have become milder, with the exception of 2009 and 2010." On the other hand, other interviewees acknowledged that there had been changes, as reflected in the comment of a sheep farmer living close to the fjord:

> "The weather is more unstable and there are bigger variations. We can have 10 degrees and pouring rain in February and big dumps of snow in May. The extremes of the weather types are greater than I recall to have experienced earlier."

People's understandings of longer-term changes are often shaped by their perception and personal experience of recent events (Keller et al. 2006). One farmer commented that it is hard to trust people´s memory when it comes to weather events, also exemplified by the following comment from a small-scale dairy farmer: "Some say that it is wetter now, but my dad said that it could rain all summer in the 80s, which made it difficult to harvest the grass." A sheep farmer similarly commented: "The old people say that it was always like this, but I remember the nice summers that we used to have."

Interview responses reflect that there have been large fluctuations from one year to another; nevertheless the general perception was that overall average temperatures and rainfall had increased the past decades. Annual climate variability may affect farmers´ view of climate change as a phenomena, and this may in part explain interviewees´ differing responses and perceptions of climatic changes (Aasprang 2013). Awareness and acknowledgement of climate change impacts largely determine how proactively farmers will adapt and make changes in their practices. The interviewees were asked to describe what they knew about climate change, and whether climate change was something they were concerned about in terms of farming. Although interviewees described changes in the climate, several responses reflect a lack of awareness and sense of urgency about climate change impacts, as exemplified by the comment of a sheep farmer: "One has to believe in climate change, but farmers don't account for it." Another medium-scale farmer with mixed production said: "I know little. We have to expect more weather, milder climate, more rain, more storms and extreme weather, if one believes in that." Other interviewees acknowledged, and were aware of, climatic changes

but felt disempowered by their impacts, as exemplified in the following comment by a large-scale farmer of mixed production:

> "They predict higher temperatures and wetter summers, and the predicted climate change will not suit this type of production. Global environmental change influences the operation. I feel impotent and I believe that something should be done at a national level."

A young, large-scale dairy farmer described how the local glaciers had diminished year by year, and that the snow in 'the hole' was gone, yet he believed that climate change was "a hysteria created by the media to scare people".

Farmers in Rauma have experienced episodes of extreme weather, like the hurricane Dagmar that destroyed huge forest areas in December 2011, and frequent episodes of local flooding and landslides. However, interviewees commented that these episodes have not had a major impact on agriculture, and they did not appear to be distressed about extreme weather. Interviewees commented that farmers in other parts of Norway are more vulnerable to extreme weather as their operations are larger and less flexible, and because the farms are situated along rivers and lakes that are prone to flooding. A small-scale sheep farmer believed that climate change was not an issue for Rauma, and commented:

> "Farmers are worse off with Glomma [Norway´s longest river] rising with two meters next to their grain fields. We are well adapted here because we have small units and not very mechanized operations compared to farmers in Eastern Norway, which suffered big losses this year."

Keller et al. (2006) found that direct experience with extreme weather is a key factor in individuals accepting that extreme weather is a personal risk. Hence, accepting that one is at risk of exposure is not merely a function of knowledge and information. Although agriculture in other parts of Norway has been more affected by recent extreme weather events, Western Norway has its own vulnerabilities when it comes to changing weather patterns, such as steep terrain combined with increased precipitation or pests and diseases connected to warmer temperatures.

Sheep farmers across Rauma were concerned with the increase in tick occurrence among livestock due to increased precipitation and higher temperatures, and some to the point that it threatened the continuation of farming. A small-scale sheep farmer said: "Ticks and loss to predators can stop the operation. I am not strong enough to watch so many animals die in the mountains and at the farm." A sheep farmer in another village confirmed how neighbouring

farmers had stopped farming due to high losses of sheep to tick borne diseases. These responses suggest that direct experience with increased tick occurrence might be raising farmers´ awareness about the connection between climate change and the increase in tick populations and tick-borne diseases, as reflected in the following comment by a small-scale sheep farmer: "The climate is the reason for the increase in ticks. Last year, after two seasons of cold winters, only one sheep died because of ticks." Another sheep farmer was concerned that a warmer climate would increase the occurrence of pests and new viruses carried by ticks: "Heat periods make pests flourish. Climatic changes have altered the tick population and the composition of microorganisms. We'll see more of that in the future, and it may become a challenge and increase medicine use."

5.1.2 Observations and experiences from 2011

The interviewees were asked to describe the weather of 2011 and their descriptions serve as a foundation for studying present household adaptations in terms of climate variability and change. All the interviewed farmers responded that the winter was exceptionally cold and snow-rich, and spring and early fall were extremely wet. They further described that the challenging weather conditions in 2011 culminated with the destructive storm, "Dagmar", which swept over Western Norway during Christmas. The storm was particularly destructive for the forest industry, buildings and infrastructure.

Temperature

The description of the winter season of 2010/2011 from a dairy farmer located in a valley bottom is typical of the interview responses: "It was very cold the two past winters. It is normal with a week below -10°C, but this year we experienced two months below -20°C." It was mentioned that also 2010 was cold and snow-rich, and the interviewees expressed that the winters of 2010 and 2011 were exceptions to the current winters, resembling the 'real' winters of the past. None of the interviewees commented on temperature variation during the other seasons in 2011.

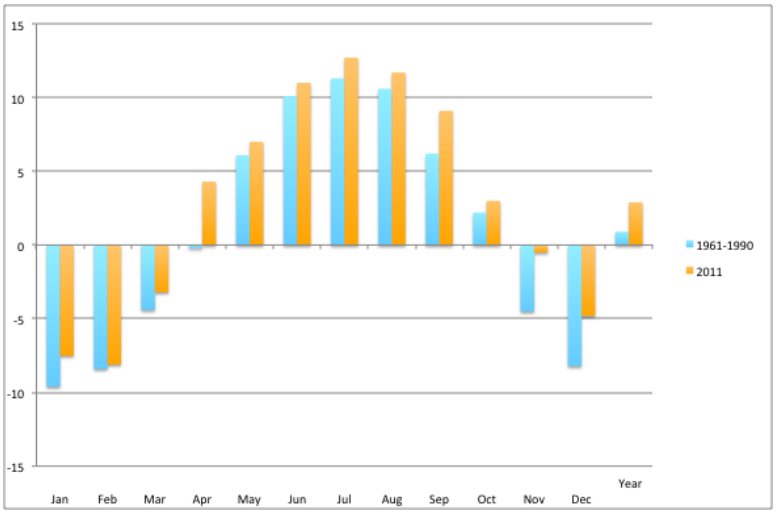

Figure 6: Monthly mean temperature (in degrees Celsius) compared to the normal period (1961-1990) in Bjorli/Lesjaskog. Source: (Meteorologisk Institutt 2013)

Figure 7: Mean monthly temperature (in degrees Celsius) during 2011 compared to the normal period (1961-1990) in Åndalsnes. Source: (Meteorologisk Institutt 2013)

Figures 6 and 7 show temperature data from Åndalsnes, which is located along the fjord, and from the interior and upland village of Verma[5]. Both graphs show that 2011 was warmer than the normal period, with the difference being much more extreme for Verma where 2011 was more than twice as warm as the normal period. April, November and December for both locations were particularly warm, whereas February and March were colder than normal in Åndalsnes, but not in Verma. These may be the months interviewees refer to when they say

[5] Meteorological observations from Bjorli and Lesjaskog were used here, as there are no weather stations in Verma. These are the two nearest weather stations to Verma and are located in Lesja Municipality, just over the municipal border from the village of Verma. Lesjaskog station has weather data only from the 'normal' period whereas Bjorli has data only from 2010 onwards. They are located about nine km from each other at approximately the same elevation.

that the winter of 2011 was more like a 'real' winter of the past. Otherwise, it is not evident from the weather statistics for these two locations that the winter of 2011 was exceptionally cold; certainly not with two months of -20° C. One explanation is that local climates vary dramatically from village to village where only a few kilometres distance can mean a temperature difference of 10°-20°, especially in winter. Åndalsnes is located right along the path of the wind phenomenon *Sjella*, which despite its ferocity during winter, actually contributes to raising winter temperatures relative to villages that lie outside its path. Without the wind cold, heavy air settles in the valley bottoms when there is high pressure.

Precipitation

Seasonal variations in precipitation are of particular importance for farming activities and were a popular interview topic. 2011 was characterised by extremely wet conditions, and interviewees, independent of location, stated that 2011 was wetter than average. At one farm in the case study, generations of farmers have been measuring precipitation and temperatures since 1896, and the current farmer described 2011 in the following way: "I have not seen this much precipitation the past 30 years." This is in line with meteorological observations showing that 2011 was the third wettest year in Western Norway since 1900 (section 2.2.2.)

Concurrent with farmers' descriptions of 2011, figures 8 and 9 show that the total precipitation level increased significantly in 2011 compared to the normal period from 1961-1990. Again, as with temperature, the amount was almost double for the interior and upland region. In Verma, January, March and April show high levels of precipitation, which fell as snow. This region is normally prone to spring and summer drought, and it can be difficult to get the grass to sprout and to dissolve artificial fertiliser without watering. Farmers expressed that it was not a problem in 2011 since May was wetter than normal. Rainfall in June, July and August is critical for the ability to harvest, and rainfall more than doubled during this period making it difficult to harvest. Rainfall in September and October is in turn critical for field preparations. Since farmers could not access their fields due to the wet conditions in late fall 2011, many farmers got permission to apply manure beyond the final application date in October.

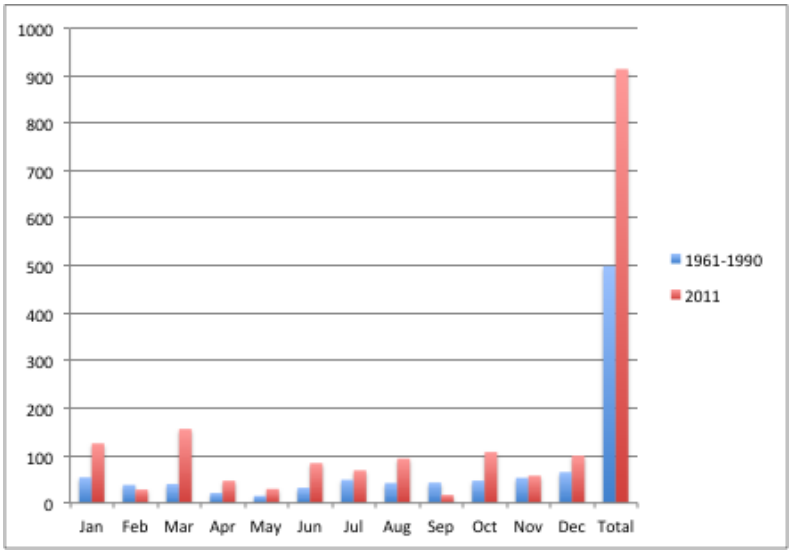

Figure 8: Mean monthly precipitation (in mm) during 2011 compared to the normal period (1961-1990) in Bjorli/Lesjaskog. Source: (Meteorologisk Institutt 2013)

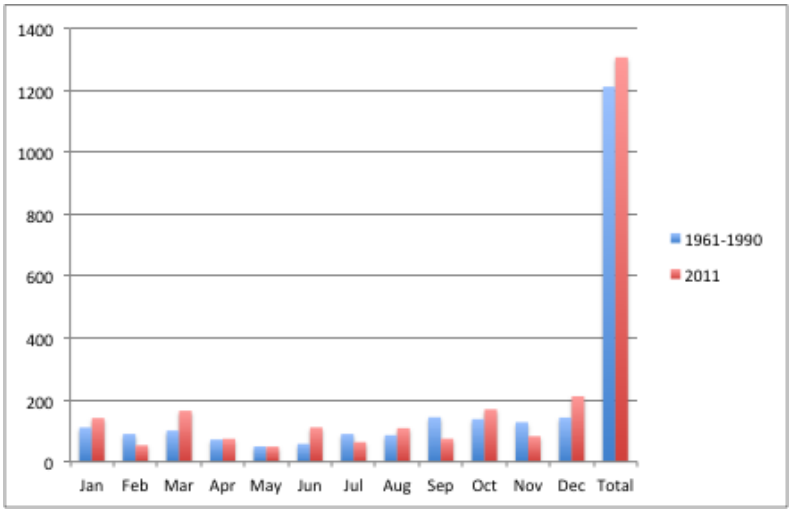

Figure 9: Mean monthly precipitation (in mm) during 2011 compared to the normal period (1961-1990) in Åndalsnes. Source: (Meteorologisk Institutt 2013)

Near the fjord, March came with high levels of snow. April and May did not deviate from the normal period, but in June the precipitation level was about 50 per cent higher than the normal period. The precipitation level in July, on the other hand, was lower than normal. The total precipitation level was only slightly higher than the normal period, but interestingly farmers in this area expressed that it was extremely wet in 2011, as exemplified by a dairy farmer: "2011 was the wettest year I can remember, and it shows in terms of driving damages to the fields. I could not harvest until the middle of September". Although the average precipitation level in 2011 was not much higher as compared to a normal year, interviewees may have perceived 2011 to be unusually wet because it rained steadily throughout the

harvesting season. Furthermore there were not enough sunny days for the fields to dry up, and farmers had problems accessing their fields late into fall. This explanation is supported by the comment of a sheep farmer, who said that there was moderate rain a lot of days. Another farmer from this area commented that it rained from when they let the sheep out in May until October. In terms of farming activities it is not simply the amount of precipitation that matters. In fact, average rainfall may be less important than the dispersion and distribution of rainfall during the growing season (Faurès et al. 2010).

5.1.3 Effects of 2011-conditions on farm production

The cold winter continued into the months of spring, and most of the farmers were delayed in their field preparations. Farmers living in areas where spring normally comes early managed to prepare the fields, however delayed, as illustrated in the comment of a grain and dairy farmer: "It was a late, cold spring. I started field preparations and sowing later, in the middle of May, but usually I am done around the first of May". The farmer added that once they were done with sowing and application of fertiliser, the rain came and washed it all out, and they had to reapply fertiliser later. The farmer further explained that when nutrients from fertiliser, manure and lime run off, it results in lower yields and economic losses. In other locations, where the frost persisted, there was little time to apply manure and prepare the fields before the rain started in May (see figures 8 and 9). Some were not able to get out on the fields at all, and it was particularly difficult on steep terrain, as one large-scale dairy farmer experienced: "Field preparation normally takes a week, but I could not perform the field preparations last year. I run the farm harder now; I cut earlier and use more chemical fertiliser."

The main challenge for household farming activities in 2011 was the higher than normal precipitation levels, and the timing of the precipitation. In order to secure good feed quality and minimise run-off of nutrients from the silage, farmers explained that they ideally need three consecutive days of clear weather to harvest the grass. A larger scale dairy farmer in the lower part of Rauma commented: "This year there were only two days of clear weather in a row, and we could not make it out on the fields to cut." All of the interviewees were delayed from one up to three weeks for the first and second cutting, and some farmers were not finished until late August or September with second and third cutting. A medium-scale dairy farmer said: "We were delayed 10 days with the first cutting and 14 days with the second, but not as delayed as other farmers."

Whereas there was a general agreement that the quality of the grass was strongly reduced in 2011, farmers had different perceptions concerning the grass quantity. Precipitation can be beneficial for grass growth, particularly in areas prone to drought. Some farmers reported that they harvested higher quantities of grass than normal, however the nutritional value was poor as the grass was old, coarse and full of water when they could finally make it out on the fields to cut. Additionally, interviewees added that the lack of sunshine lowered the quality and edibility of the feed, as expressed by a sheep farmer: "The grass looked good, but there was no nutrition in the feed. The sun gives sugar to the grass, but there was no sun." Some farmers attributed the bad grass quality and low volume to the difficult winter, as exemplified by the comment of a small-scale sheep farmer: "The quality of the feed was poorer not just because of the summer weather, but because of the two hard winters. It was frozen far into the ground, and when the snow melted we suffered from ice damage."

The poor feed quality had negative consequences for sheep and dairy farmers alike. Several farmers reported cases of illness in their flock of animals, as illustrated in the comment of a dairy farmer: "It was a bad winter due to the inferior feed quality. The cows would not give milk, and many animals have suffered from disease and bad udder-health." It was commented that milk production was lower due to inferior feed quality, and a few dairy farmers had problems filling their milk quotas. Dairy farmers analyse their feed to ensure good milk quality and get advice from Tine[6] and the extension services to supplement with the right amount of concentrates for optimal feeding. In 2011 the added cost of concentrates due to inferior grass quality, in addition to lower milk production, was an economic loss for many dairy farmers.

Sheep farmers stated that there was an increase in meningitis, and believed that this was caused by the wet conditions and soil bacteria in the feed. One sheep farmer recalled: "There was a lot of precipitation all summer. Both the hay and the round bales[7] were of bad quality as the grass was old when it was cut. It may be the reason for the meningitis." Sheep farmers in different parts of Rauma reported both lower and higher slaughter weights than normal. Despite the common perception that wet summers improve mountain grazing, and are positive for slaughter weights, many sheep farmers had a different experience in 2011. A sheep farmer

[6] Tine is a farmer owned cooperative and the largest dairy company in Norway.
[7] A common method to conserve grass for animal feed is to compress and ferment grass in round bales packed in plastic.

said: “The old farmers say that a wet season is good for the mountain grazing. This year the slaughter weight was lower than last year. It was not a good season.” A sheep farmer from a different location gave a similar comment: “The sheep were skinny when they came down from the mountains. The grazing in the mountains was poor and the lambs were small when they came back.”

Effects of 2011-conditions on farmers

The weather situation in 2011 had consequences beyond the agronomic impacts. Despite managing the situation seemingly well, the delays, prolonged tension from not knowing when the weather would clear up, and never being able to take time off, added a lot of stress on the farmers. Several interview responses reflect the impacts on social life and farmers´ wellbeing as illustrated by a grain farmer: “I can feel the depression when lying in bed, waiting for the clouds. I easily get ‘weather sick’.” Interviewees commented that they were fed up from having spent the entire summer waiting for the weather to clear up. They worked less efficiently as the weather continued to interrupt and delay the work they had started, impeding participation in social activities. A grain farmer expressed how he felt about the situation: “I was feeling socially amputated. I did not sleep well, and it was challenging to watch the grains that were ready to be harvested out in the rain”. Expressions like *weather sick, socially amputated* and *depression* reflect the effects of the weather on emotional and social wellbeing.

5.1.4 Conclusion

Farmers’ descriptions and perceptions of local climate variability and change correspond with observed and projected changes in the climate for Western Norway. However, interview responses show that there are local manifestations of climate variability and change that may not be captured in the projections for Western Norway as a whole. The interviewed farmers in Rauma were negatively affected by the tough winter and high level of rainfall throughout the growing season in 2011, with negative consequences for farm production and farmers´ wellbeing.

5.2 Structural changes in Rauma

Norwegian agriculture has undergone significant structural changes since the 1950’s, generally moving towards larger farms, fewer farmers, more specialised productions and

increased dependency on leased land. These trends have significantly altered the farming landscape and the texture of communities in Rauma with consequences that affect farmers´ capacity to adapt to climate variation locally. Interviewees were very aware of the changes and had a range of opinions regarding whether these changes are positive or negative. This section responds to research question 1.2: How are structural changes manifested locally in Rauma? The impacts and drivers of structural change locally and how interviewees perceive these will be described in the following sub-sections.

5.2.1 Manifestations of structural change in Rauma

The local manifestations of structural change takes several forms, including a dramatic decline in dairy farms and shift towards larger units over the past couple of decades. Figure 10 shows a dramatic decline in number of dairy farms and an increase of animals per unit for Møre and Romsdal County, which is reflected by the trend in Rauma where the number of dairy farms was reduced by more than 50 per cent from 1995 to 2012. During the same period, the average number of cows per holding almost doubled, from 12.1 to 21.5 head. The total number of farms operating in Rauma almost halved from 328 farms in 1996 to 178 in 2012 (Bondelaget 2013).

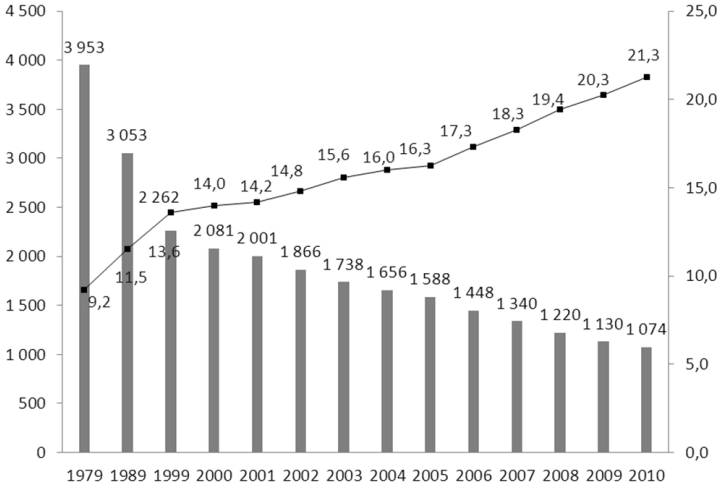

Figure 10: Structural development in dairy production in Møre and Romsdal County 1979-2010. Columns (left axis) show number of farms and the line (right axis) shows number of cows per farm holding. Source: (Resultatkontrollen for budsjettnemda in Folstad & Rye 2012)

To meet the increased production and efficiency demands, farms are becoming larger and operations more specialised. Interviewees described how farms were commonly self-sustained, with a diversity of animals and a small patch of grains for proper consumption, just one or two generations ago. Farming in Norway has commonly been combined with other

sources of income, such as fishing and forestry, and many informants commented that the previous generations could not live off sheep production only, although some dairy and pig farmers could. Despite the trend of specialisation in agriculture, several interviewees still retained some degree of diversity. These farmers had a mixed production of dairy and grains, a few kept a mix of sheep and cows, whereas others had invested money and labour in hydropower, sawmills, forestry and tourism.

Changing ownership structures in agriculture is another important aspect of structural change that has major implications for adaptive capacity. Due to the topography in Western Norway and the fragmentation of the fields, farmers commonly manage multiple leasing contracts and drive long distances in order to secure enough grass for the animals. In Møre and Romsdal County close to 50 per cent of the farmland is leased (Rognstad & Steinset 2012), and 16 out of the 17 farmers that were interviewed managed more than one leasing contract.

5.2.2 Perceptions of change

Interviewees expressed differing perceptions of structural change in agriculture locally, and comments were mostly related to economy, but also to ideology. In general, interviewees that were farming in a more traditional and small-scale manner were critical of the development towards bigger farms and fewer farmers, as exemplified by a small-scale sheep farmer: "It is the wrong path to become bigger, it is more vulnerable to have a few big farms than many, small farms." Another sheep farmer similarly expressed that it was wrong that farmers had to go bigger and bigger to have the same income as 20 years ago. Even farmers of larger-scale productions were critical of the development, as reflected in the comment of a dairy farmer: "Going big is not the way to go." The farmer was of the opinion that large farms and joint farm enterprises wind up with bigger workloads and lower income.

For some farmers it was a lifestyle and value choice to stay small, as reflected in the following comment:

> "We have an extreme degree of self-sufficiency, and have all we need of meat and vegetables. We have very low operation expenses as we built everything ourselves. Our private economy and income is in practice the absence of loans."

However, despite their strong conviction to stay small, the interviewee asserted:

> "Big units are sensible. My way of farming is not realistic. I am not critical of milking robots, knowing how hard it is to get a substitute to achieve a liveable working schedule. It is important to reduce the time spent in the barn, and farming has to be economically sustainable."

The above comments suggest that several interviewees were critical of the structural development towards bigger farms, and the comments further reflect that investing in larger farms and new equipment does not necessarily lead to increased income. However, perceptions differed, as reflected in the comment of a young farmer that had invested in a joint farm enterprise: "It ruins the continuation of farming that the small-scale farmers sit on the land. One has to go bigger for it to be profitable."

5.2.3 Local drivers of change in Rauma

The main driving forces of structural change were covered in section 2.3.1. These driving forces are a combination of market forces and political, social, technological, and economic conditions. In addition to political and economic drivers of change there are individual and household specific reasons why farmers chose to expand production, become part-time farmers or quit farming overall. Some adaptations contribute to rationalisation towards bigger farms and fewer farmers, whereas other adaptations maintain a more diversified structure and smaller farm units. Depending on the outcome, the adaptation measures taken by one farming household will impact other farmers, and their capacity to adapt to change, positively or negatively. Farmers' attribution of local drivers of change, as revealed through the interviews, will be discussed in the remainder of this section.

The oil economy

Rauma is situated in close proximity to the offshore oil industry, which is a major force in the Norwegian economy, with consequences for agriculture. As mentioned in section 2.3.1 an important driver of change is economic growth and low unemployment, also exemplified by the comment of a mixed grain and dairy farmer:

> "The problem with young people that want to take over the farm is that they have their friends and networks in the oil industry. They compare themselves to others and expect to have access to material goods and vacation that a farmer cannot afford or doesn't have time for."

The quote reflects how farming is competing with the industries for the younger generation, in line with observations made by Hillestad and Smedshaug (2013). People with farming backgrounds are attractive in other professions due to their versatile skills and willingness to work long hours, and the past 40 years of agriculture and forestry have provided other industries with 150 000 employees (Hillestad & Smedshaug 2013). On the other hand, access to off-farm employment may contribute to the continuance of small-scale farming as it in effect subsidises farms that don´t provide enough income to sustain its operations and

household expenses.

The new generation of farmers

Some interviewees commented that there is a generation shift in farming, and that buildings and infrastructure dating from the 1970's currently need upgrading to meet new production and efficiency demands, as well as animal welfare requirements. Therefore, new generations of farmers have had to decide whether to go bigger, change the farm operation, or quit farming. As reflected in figure 10, several opted for the last alternative, leaving more land available for farmers that were ready to expand production. A small-scale mixed producer said that there had been a massive closure of dairy farms in his village, and that two big robot units had increased parallel with more land becoming available for rent. This trend is reflected in figure 10 showing that farms are becoming bigger in parallel with farmers quitting.

An alternative to quitting or expanding was to change the type of production, and become part-time farmers. Some farmers made changes due to practical reasons, as exemplified by a farmer that had gone from dairy to sheep: "I stopped producing milk as it was hard work and difficult to find a substitute in a declining farming community." Similarly, a small-scale mixed sheep and dairy farmer highlighted that future modifications depend on her family situation. The farmer would not be able to continue with dairy cows when the parents were no longer able to help out on the farm.

Other farmers made changes based on personal worldviews, values and lifestyle, and some interviewees expressed that keeping sheep was a better alternative than investing big and expanding dairy production. This is exemplified in a village in Rauma that housed multiple dairy farms just one generation ago. As of 2011 this village had an active community of young farmers, but all the cows were replaced by sheep, and in particular the Old Norse breed. This breed was rescued from extinction in the 1990s, and being a low maintenance animal it became increasingly popular with the younger generation. In addition to maintaining a cultural landscape, which was considered important, this type of production allowed the farmers to have enough time for off-farm work and to cultivate activities that were important to their life quality and wellbeing. A young sheep farmer, who had studied and lived outside the village for many years, explained how he chose a production type that suited him better:

> "It was not an option to have milking cows because it is physically demanding and I have seen how it wore out my father. I would have had to modernize the farm very much and renew the operation building to continue with dairy."

Furthermore, having grown up helping out at the farm, he could not support how the dairy production maximised from day one, and he chose what seemed to him a more natural way of farming. The farmer said he could have lived of the farm if he chose to be a full time farmer, but he would rather have a diversified life.

Several interview responses reflect that farmers emphasise other factors than profit maximising, such as value of farming, working independently of others, maintaining cultural landscapes and producing food on local resources. These factors may contribute to the survival of more small-scale farms than if profit maximising was the main attribute of farming. This is in line with Milestad et al. (2012), who found that farming is more than outcome and income maximisation, it is also about personal preferences and acceptable workloads. Farmers' goals will evolve, as will their preferences and perceptions, and the means to achieving these goals will change with new opportunities in markets, technology and consumer preferences.

5.3 Combined effects of structural change and climate change

There are indications that farmers in Western Norway may benefit from the observed changes associated with climate change, such as increased temperatures and longer growing seasons (Miljøverndepartementet 2010). On the other hand, interviewees reported higher occurrence of ticks and tick-borne diseases, winter-related damages to grass production, and increased precipitation levels. However, it is not climate change per se that makes farmers vulnerable. The positive and negative effects of climate change will be differentiated and unevenly distributed, depending on the local context of farming. Structural changes alter the context of farming, and the following section analyses the effects of structural changes in relation to the observed and projected increase in rainfall, which is of particular concern for farmers in Western Norway.

5.3.1 Changing pattern of farmland control

As described in section 2.3.4 the pattern of ownership and renting has changed as a result of structural changes. For a number of reasons, leasing is not necessarily perceived by farmers as negative (Forbord et al. 2014), but increased dependency on leased land may create negative externalities such as longer driving distances; less incentive to maintain and invest in leased

land and drainage; and reliance on equipment that is not adapted to local conditions (Kvalvik et al. 2011; Skarbø & Vinge 2012).

Drainage

A major concern associated with leasing is the low incentive to maintain and invest in drainage, since badly drained soils significantly increase the vulnerability of agriculture to climate change (Miljøverndepartementet 2010). Most of the drainage was added before the 1980's and was dimensioned for lightweight equipment and different climatic conditions than what have been predicted for the future (Bergslid 2012). Several interviewees commented that the old drainage systems were destroyed due to heavy tractors, low maintenance and increased levels of precipitation. Some interviewees remarked that investments in drainage were needed due to increased rainfall, as exemplified in the following comment made by a medium-scale mixed producer: "Both our own land and the land we lease should have been better drained. It is wetter now and we need to improve the drainage system."

Bergslid (2012) outlined three major impediments for investing in drainage: Increased use of leased land; unstable and short leasing agreements; and high investment costs. Several interview responses similarly suggest that short leasing contracts reduced farmers´ incentive to invest in drainage. A small-scale sheep farmer said: "I prioritise my own land and will only do the most needed work with a five year contract." Another farmer gave a similar comment: "I have a leasing contract that runs for a year at the time, but I need to have a long-term contract to make investments". A few interviewees leased land without a written contract, and, as one farmer explained, they could not invest time or money without a contract.

Although many interview responses suggest that farmers are unwilling to maintain and invest time and money in leased land when they have short leasing contracts, there were comments contrasting the above statements, as the remark of a medium-scale dairy farmer: "We apply the same amount of fertiliser to our own and the leased land." Another comment from a medium-scale mixed farmer: "I have an oral contract. The soil quality is good, but the pasture is old. I have to do something about it, and it's ok to invest in leased land." The interview responses do not identify why some farmers invested and maintained leased land, while other farmers did not, but one explanation may be found in the relationship and degree of trust between owner and renter. Another explanation may be related to the individual farmers´ confidence in the future farming situation. Investment is often driven by a motivation for

farmers to hand down the farm in a better state to the next generations, as compared to how they inherited it.

Modern technology

Due to long driving distances, increasing farm sizes, and high demands for efficiency, farmers have invested in fast and heavy equipment that can carry big loads of grass and manure. Farm equipment is often imported from continental Europe where the machinery is adapted to larger farm sizes, and where they farm under very different conditions from Western Norway. Hence, the modern tractors and harvesting equipment are not adapted to small farm sizes, local topography, soil types and climatic conditions in Western Norway (Skarbø & Vinge 2012). This is reflected in the comment of a large-scale mixed producer in Rauma: "Small farms are not suitable for big equipment. My father is 80 years old, and he says that all the grass used to get cut. Now half of the area has grown back." Some farmers commented that areas that are difficult to access with large and heavy equipment go out of production, and that entrepreneurs would not take the time or risk to cut field edges and sloped fields (if wet). These findings correspond with Bergset et al. (2014), who estimated that approximately 30 per cent of the rented farmland is subject to bush encroachment in Northern Norway (a region which is also characterised by small farm sizes).

If the climate becomes wetter in accordance with future climate change projections, there may be fewer days suitable for harvesting and field preparation. A medium-scale dairy farmer said: "We were less vulnerable to wet conditions when we used the old harvester and not the modern equipment that is heavy and can destroy the fields." Badly drained soils are more susceptible to compaction and driving damages (Øpstad et al. 2013), and after the wet 2011 season, some interviewees expected to have to plough and re-sow damaged fields. Open tracks, caused by driving damages, provide the perfect conditions for weeds to establish; if the soil is damaged, it gives the pioneer plants, the weeds, competitive advantage. Weeds thrive in mechanically damaged soil, in particular under wet conditions, and as a consequence some farmers expected to use more herbicides in the future.

Driving distances

Another effect of structural changes and increased reliance on renting land are long driving distances. In Western Norway the fields are dispersed between narrow fjords and high

mountains, and large-scale farmers in this region manage multiple leasing contracts and drive long distances to get enough land for grass production (Bergslid & Lyche 2014). If one farmer manages the same area of land that was previously maintained by several farmers, the timeframe for performing field preparations becomes marginal even with efficient equipment. The combined effects of long driving distances due to leasing, increased precipitation, and a more unpredictable climatic situation, puts a lot of pressure on the farmer and further marginalises the timeframe for harvesting and application of manure. In turn, spending hours on the tractor in solitude adds to sources of vulnerability associated with stress and loneliness.

A large-scale dairy farmer that leased land from nine different landowners, up to eight kilometres from the farm, recalled that 2011 was particularly challenging due to the high rainfall: "We spent a whole month on the second cutting. We cut the entire summer and finished the first of September. We had one week off in July." The farmer expressed that he was pessimistic in terms of future farming if the conditions of 2011 resembled a normal year.

It is not only the large-scale farmers that lease land and spend more time on the tractor. A small-scale mixed producer said:

> "We lease land at five different locations, but there is no advantage in having fields in different places. The milking barn is 8 km from the farm, and we have to go twice a day during calving."

The farmer commented that the long distances were particularly challenging and time consuming during bad weather and in wintertime when the steep roads were icy.

Another aspect of leasing is the cost of driving. The demand for grass has increased with farm sizes, and some farmers currently earn their income as grass producers. A small-scale farmer commented that her neighbour worked as an entrepreneur and produced round bales for sale, and said that he drove tractor loads of 18 round bales at a time, for 100-110 kilometres to where he sold them. Due to the long driving distances, and the price of diesel, the cost of grass increases relative to the cost of concentrate feed, as one sheep farmer described:

> "The cost of grass increases more than the price of concentrates. Many farmers have to drive to the neighbouring village to cut grass and pick up round bales, and it increases the costs of driving, particularly for the ones leasing land."

A large-scale sheep farmer, who also worked as an entrepreneur, commented: "There is a market balance related to leasing of land. It is cheap to lease land, but it is not free to harvest it all."

5.3.2 Conclusion

In this section it was analysed how increased precipitation, larger farms, more leased land,

less investment in land drainage and heavier equipment interact and affect farming. These factors contribute to reduce the quality of the land, increase expenses, make farming more laborious, and ultimately threaten long-term food production and farming livelihoods.

5.4 Adaptive responses to the double exposure of climate change and structural changes in Rauma

In this section research question 1.3 will be addressed: How are farmers adapting to the double exposure of climatic and structural changes? The following section starts with an analysis of how farmers adapt to changing climatic conditions, as exemplified by farmers´ accounts of household adaptations in 2011. The section continues with an analysis of the differing effects of double exposures on various farmer types, and how it affects their capacity to adapt to climate variability and change.

5.4.1 Farm household adaptations in 2011

The way that farmers manage climate variability in Rauma was investigated by examining farm household adaptations in 2011. A general observation was that interviewees were delayed in their seasonal work, but a combination of accessing labour and equipment at the right time, and timing of harvest and field preparation activities was key for managing the particularly wet conditions in 2011. Farmers demonstrated considerable adaptability in the face of climatic and structural changes; however, differences in coping strategies used by farmers in 2011 illustrate that there are several factors contributing to adaptive capacity at the farm level in Rauma. Four factors were identified as key to successful adaptation: local knowledge; social networks; collaboration; and diverse and flexible options for responding to change. These are described in the following sub-sections.

5.4.2 Local knowledge

Interviewees´ experience and local ecological knowledge was key in responding to the wet conditions in 2011, and for planning farm household activities. This was especially important in dealing with the problem that farmers experienced in accessing their fields in 2011 due to the amount and timing of precipitation throughout the growing season. Generally, farmers need at least 2-3 days (sometimes more depending on the local soil conditions and weight of equipment) of dry weather for the fields to dry sufficiently before they can drive on them. Some summers, such as the wet 2011 summer, have very few dry periods of sufficient length. Using local knowledge, such as about the soil, to time activities according to weather

conditions was key. A traditional dairy farmer said: “My father is incredibly good at doing things at the right time. He has a lot of experience.” Compaction and driving damages from harvesting under wet conditions affect soil structure and growing conditions negatively, and reduce yield quantity and quality. Consequently, farmers had to plan the harvest in terms of feed quality; while at the same time considering the long-term effects that driving has on soil fertility and yields. Interviewees considered the soil properties and carrying capacity of their fields before entering with heavy equipment, and attempted to minimise driving where it did most damage, as exemplified by a medium-scale dairy farmer: “If it is wet I drive on the fields with good carrying capacity and take the bog soil last. In 2011 we did not cut where there was bog.” The farmer added that since the harvesting equipment is heavier now than previously, they had to let the soil dry up to prevent long-term damage.

A small-scale organic farmer similarly explained that he minimised driving to prevent negative long-term effects, such as weed problems, following driving damages. The farmer further clarified: “It is important not to fight so hard. It is better to lose some grass, and buy extra feed, than to damage the soil structure.” Despite the efforts of minimising damage, several interviewees reported compaction and driving damages after the 2011 season, and some expected consequences on long-term measures, such as soil fertility. A comment given by a medium-scale grain farmer illustrates that it may add a lot of strain to farmers´ work to do things differently, and that adaptation is not always straightforward:

> “It is hard to adapt. One tries not to drive on the soil when it is too wet, and not until it is completely necessary, in order to prevent compaction damages. But it is difficult to do things differently, especially in terms of grain production.”

The quote suggests that adaptation to climatic uncertainty and potential longer term changes is a complex process, which does not happen automatically, and that high adaptive capacity does not necessarily translate into adaptation as previously suggested by O`Brien et al. (2006). The interviews show that even if farmers can adapt to wet conditions, it may have social, environmental and economic costs.

Ziervogel et al. (2006) found that seasonal forecasts were used as an adaptive strategy to respond to climate variability in South Africa. Similarly, interview responses show that farmers actively followed weather forecasts, often from different sources, to plan field preparation and harvesting activities. Experience and local ecological knowledge enabled farmers to interpret the forecasts, and the wind direction was of particular importance to

assess whether it would rain or not. Responses suggest that weather forecasts enhance adaptive capacity and enable farmers to perform tasks in a timely fashion. However, access to this type of information could also have a negative dimension. A medium-scale grain and dairy producer described how he normally would check the weather forecast several times a day, and expressed that having access to too much information added stress to the situation. He further explained:

> "I did not use to work Sundays, but now I am driven by the weather forecasts. We were better off before when we didn't know so much about the weather. It is a stress-factor and controls the day".

5.4.3 Social networks and collaboration

In section 2.2.3 social networks and collaboration were identified as core components of adaptive capacity, and key for organising farm household activities. In the same section it was described how the dramatic decline in the number of farmers due to structural changes, may result in a disintegration of social and professional networks. This is in line with interview responses reflecting that with fewer people involved in farming, it was increasingly difficult to access labour and organise collaboration within and between households. Consequently, farmers organised work in such a way that they could manage the tasks on their own, or alternatively found other reliable solutions. This sub-section will cover the following adaptive strategies: individualised farming, engagement in formal collaboration, joint farm enterprises and shared common pastures, mutual assistance and family participation.

More individualised farm operations

Interview responses show that the most important strategy for coping with climate related stress was to harvest at the right time to secure good feed quality. Therefore, it was key to have access to harvesting equipment when the weather was ready. It was a common strategy for farmers at all scales, and of all production types, to keep their own harvesting equipment if they did not hire entrepreneurs to do the cutting. Many interview responses reflect that farmers have always kept their own harvesting equipment, but commonly shared machinery that was less frequently in use. A large-scale dairy farmer explained how they adapted to climate variability in a declining farming community:

> "We have mechanised enough in order for one person to do the cutting. It is not easy to find someone that can help, as they are all occupied with their own harvest. One has to organise to be independent of others."

Likewise, another medium-scale dairy farmer who was particularly challenged by long driving distances to the leased fields, and the topography and geographic conditions at the farm, expressed:

> "Since we are extra vulnerable in terms of weather, we cannot allow ourselves to be vulnerable because of equipment not being available at the right time."

The above quotes suggest that one strategy for coping with the double exposure of climatic and structural changes was to become independent of others. This strategy was more predominant among medium and large-scale dairy farmers than farmers of smaller and more diversified productions. However, one small-scale farmer of mixed production had purchased a lightweight round bale press to increase adaptive capacity in the face of change. The farmer explained: "You have to wait long to get 3 full days [of good weather] for harvesting, besides no entrepreneurs will take on work in such steep areas." Interviewees generally expressed that it should not be necessary for one farmer to sit on all the expensive harvesting equipment alone, but added that it was challenging to share machinery, particularly during unpredictable and intense weather periods. The comment given by a medium-scale dairy farmer exemplifies that going independent required a high investment for the household: "We invest regularly and have good equipment. We could have lived of the farm if we had kept the old equipment." Due to the high investment costs, the spouse had to take on off-farm work to subsidise the investments.

Another local farmer, originally from another European country, had a different explanation to why farmers went independent:

> "Where I come from it is common to share equipment, also among the large farms. In Norway the farmers can afford to buy what they need. Norwegian farmers fear that the equipment can get ruined, which may turn into a conflict between neighbours. You can think like that if you can afford to."

Despite the high investment costs, some large-scale farmers preferred to keep their own equipment to be less vulnerable to climate related stress, but also to prevent friction and disagreement with the neighbours, as the above comment suggests. For that same reason, several of the interviewees expressed that they preferred to lease out equipment or sell favours rather than sharing equipment, though it was common to share machinery that was rarely in use. A medium-scale sheep farmer was of the opinion that sharing could create frictions among neighbours, and said:

> "It is best to own the harvesting equipment in order to cut the grass at the right time and to prevent getting annoyed about how the others maintain, clean and repair the equipment."

The farmer expressed that he would rather lease out equipment to neighbours and believed that is was better to have one responsible owner and keep clear responsibility lines. Interview responses further reflect that farmers kept track of hours when they assisted each other mutually. Leasing and hired assistance commonly had fixed prices, facilitating collaboration and reducing the potential for conflicts. The interview responses referred to above reflect that farmers maintained adaptive capacity through social networks, and by cultivating a good relationship with their neighbours. This is in line with Eriksen and Selboe (2012), who found that the maintenance of collaborative relations was a key value and aspiration in itself.

Formal collaboration

Interview responses suggest that a combination of factors has contributed to increased formalisation of collaboration: with fewer people involved in farming it is difficult to get hold of seasonal workers and substitute farmers to relieve the workload, farmers lease land and have larger areas to cut, the household engages in off-farm work, and for many farmers it is too costly to invest in modern technology, such as the round bale equipment.

An alternative strategy to becoming more independent was to engage in formal collaboration and hire entrepreneurs[8] for harvest and field preparations. Farmers of all scales engaged entrepreneurs to make round bales, though a few large-scale farmers kept their own round bale equipment. The round bale technology is efficient for harvesting large areas within a short timeframe, and it facilities the transportation of grass from leased fields back to the farm. A mixed producer said: "Nowadays people hire entrepreneurs to do the cutting. They do it fast, and one can better use the sunny days." With a small window of time available for harvesting, one would expect delays and a waiting line of farmers. However, after the extremely wet season in 2011 no interviewees that hired entrepreneurs to cut the grass complained that they had to wait for the service. This may be an indication that formal collaboration formed part of well-functioning social networks and was built on trust and informal relationships.

Interview responses indicate that there is increased formalisation and a higher degree of individualised farming among medium to large-scale farmers, particularly during grass harvest and field preparation. However, interviewees would still communicate with each

[8] In this study entrepreneur refers to contractor. Entrepreneurs are commonly hired for harvesting grass, pressing round bales and for other farming activities.

other, collaborate around other farm activities, and assist each other in cases of emergency or illness. This illustrates that social networks and active farming communities are highly important even with a higher degree of formalisation and individualisation in farming. This is consistent with other research: Eriksen and Selboe (2012:166) found in Øystre Slidre (a farming community further east in Norway) that "formal and informal collaboration relations remain closely interdependent." A declining farming community, however, can put informal relations and social networks under pressure and threaten the success of formal collaboration as an adaptive strategy (Eriksen & Selboe 2012).

Joint farm enterprise and shared common pastures

One of the interviewed dairy farmers was part of a joint farm enterprise (*samdrift*), and four dairy farmers shared common pastures (*fellesbeite*) during the summer months to relieve the workload and facilitate socialising and collaboration with other farmers. A medium-scale dairy farmer explained that he had morning meetings on the phone with the other members of the common pasture, and at less busy times of the year the shared coffee breaks were an important part of the day. The farmers conferred with each other, even if they did not work together physically, and the phone meetings were important for planning and performing household activities in a timely fashion. The meetings and participation in the common pastures were also a response to reduced household collaboration and increased loneliness among farmers, as reflected in the comment of a medium-scale diary farmer:

> "There is no socialising here in the village, but we share long food breaks at the common pasture where we discuss topics related and not related to farming."

A mixed grain and dairy farmer stated that the common pasture made it liveable as a dairy farmer, as he could take four months 'off' from the animals and do other activities during that period. He commented:

> "The common pasture is the key. If I were not part of the arrangement I would have stopped producing milk. Common pastures are hard to combine with big farm units, though."

Sharing a common pasture is a less intimate arrangement than entering a joint farm enterprise, and some farmers were frightened by the idea of working so closely with other people. A large-scale dairy couple explained why they chose to be independent when they invested in a new barn:

> "We work well with the neighbours, but don´t want to share the barn. Many figure out that after a while, but then it is too late. It is difficult to step out of a joint enterprise

> when they have built expensive barns. They are left with big loans and many animals, but there is only enough income for one farmer."

A young dairy farmer chose to start a joint farm enterprise when his father suffered from illness and he was left alone with responsibility for the farm. The joint farm enterprise gave him the opportunity to expand production while sharing the investments. Moreover, it gave him enough free time to take out parental leave and to take on other work in his free time. The farmer further emphasised the importance of collaborating with someone that he could trust fully:

> "It gives more freedom, and it is good to have someone in the barn who has the same interest in doing a good job. That is no guarantee with a substitute who is there to earn money and not to increase production."

This way of collaborating was important for exchanging knowledge and for problem solving, as reflected in the following comment: "I learn something new every day as we discuss among the two of us. But it is like a marriage, and we quarrel."

Mutual assistance and family participation

The interviews showed variations in how small, medium and large-scale farmers adapted to the combined effects of climatic and socio-economic changes. The main difference was how they engaged in, and organised, collaboration between and within households. Interviews suggest that farmers of a smaller scale and more diversified structure engaged more people (neighbours and family) in farming activities. However, there were exceptions, and some small-scale farmers adapted to increased climate variability by hiring entrepreneurs to make round bales for them, as in the case of a sheep-farmer:

> "Unpredictable weather requires efficiency with proper equipment. We cannot have time-consuming equipment. We used to make only hay, which is better for the sheep, but it is more time-efficient, and less weather dependent, to make round bales."

Interview responses reflect, however, that it was more common for small-scale farmers to diversify and prepare feed in a combination of ways, especially during periods of unpredictable weather. Various small and medium-scale sheep farmers prepared a combination of hay, silage and round bales in 2011. A sheep farmer explained that he had to make more silage in 2011 due to the wet conditions, as the equipment to make hay bales was heavy and would ruin the fields. The different harvesting methods were organised through farmers´ social networks, and the adaptive strategies were a combination of formal collaboration, mutual assistance between neighbours and family collaboration. A small-scale

dairy farmer gave an example of family participation during the particularly difficult conditions in 2011:

> "We got the grass in because of the timing of the harvest. Others in the village did not manage. We were many that worked around the clock, and it was great! My father cut the grass, I evened it out and my son kept working until midnight."

Another traditional sheep and dairy farmer similarly expressed the importance of involving the family: "My parents are active in the running of the farm. It means everything! We have several helping hands." Later in the interview the farmer added: "It should not be permitted to farm alone."

The interviewees were asked to reflect on whether more difficult climatic conditions would affect collaboration. A small-scale sheep farmer reasoned:

> "I need more help during bad weather. If I dry grass on the ground to make silage I can work alone, but if I make *hesje*[9] I need help from others that want to collaborate. The *hesje* can be made in pouring rain."

There were few farmers in Rauma that still set up *hesje* to dry hay. In order to make hay farmers need three consecutive days of stable weather to dry the grass on the ground and it is rarely the case in Western Norway. As reflected in the above comment, the *hesje* can be set up in rain; however, it is work intensive and requires the help of others. A medium-scale sheep farmer explained that he and his neighbour worked closely together and assisted each other mutually when they produced hay in an old-fashioned and more traditional manner.

Another small-scale sheep farmer believed that difficult weather would increase formal collaboration with entrepreneurs, as reflected in the following comment: "I will make less hay and base production on round bales. I believe that bad weather will increase collaboration." In general, the farmers that continue to farm in a more diverse and traditional manner believed that bad weather would increase collaboration. A large-scale dairy, on the other hand, assumed that farmers would collaborate less. He responded: "If the future brings more bad weather, it will result in more individualised farm operations at the expense of collaboration".

[9] *Hesje* is the Norwegian word for hay drying frames or drying stands. It is a traditional way of collecting grass in Norway, in particular in areas where the climatic conditions were too wet for drying grass on the ground. This way of preparing winter-feed is no longer common due to modernisations in agriculture.

5.4.4 Diversity and flexibility

Diversity and flexibility are associated with daily decision-making and long-term planning of the farm operation, and were the two final components of adaptive capacity discussed in section 3.2.1. The section described how maintaining a diversity of resources from field to farm level, including a diversity of options for responding to change, could enhance adaptive capacity. This sub-section begins with a description of field level diversity, which is followed by an account of how farmers applied flexibility in their adaptive strategies.

In section 5.3.1 the negative effects of leasing, particularly in light of climate variability, were highlighted. However, some informants expressed that having access to a diversity of fields could enhance flexibility and adaptive capacity. The comment of a mixed sheep and dairy farmer illustrates this: "We own and lease areas around the farm, down in the valley and in the mountain areas. The fields vary and we benefit from that." A large-scale dairy farmer expressed that they felt less vulnerable in terms of precipitation as they had access to enough land, including a diversity of soil species, to buffer against the wet conditions. The farmer said:

> "We have bog and sandy soil, so it doesn't matter much whether it rains or not, it is always good one of the places. We lease 6 ha that is good when it is wet."

Another medium-scale dairy farmer explained that it could be an advantage to have fields extending from sea level up to higher elevations, and facing in different directions, in order for the grass to mature and be ready for harvest at alternate times. When organising the harvest, having fields at different levels and growth stadiums could relieve some of the time pressure of harvesting fields that were distributed over a large area. However, several other responses suggest that leasing and managing several, unconnected areas of farmland make farmers more vulnerable to high precipitation levels due to the long driving distances and a marginal time frame for harvesting and field preparation.

The above section showed that there was a difference between large farms and farms of a smaller scale in how they organised harvesting activities. Whereas the first group of farmers seemed to be locked in more fixed strategies, and were less flexible because of the farm size and type of production, several medium and small-scale farmers seemed to maintain and include a higher degree of diversity and flexibility in their coping strategies. The comment of a small-scale sheep farmer illustrates this:

> "I am less vulnerable than the ones that invest a lot. I have few possibilities of investing, so I need to find smart alternatives and solutions."

The farmer was further of the opinion that: "Small-scale farmers can adapt since they have a different worldview in terms of living standard." The farmer felt less vulnerable because he cultivated flexible strategies, and he believed that small-scale farmers´ differing worldviews, which is focusing less on a high material living standard and high productivity, made them more adaptable to change. A medium-scale sheep farmer gave a similar comment:

> "I have old, lightweight equipment that allows me to cut when it suits me. The farmers who hire entrepreneurs have bigger problems as they use heavier equipment that damage the fields. Anyone who has flexible solutions with lightweight equipment is better prepared for wet conditions than the ones who hire entrepreneurs.

Responses given by some larger-scale farmers similarly reflect that they believed that big and heavy machinery could make them less adaptable and more vulnerable to climate variability and change. A large-scale dairy farmer reasoned: "We were less vulnerable to wet conditions when we used the old harvester. The new equipment is heavy and can ruin the fields." While modern technology such as modern harvesters and other equipment may enable adaptation by completing tasks quickly and facilitate management of climate stress in the short term, it may harm long term adaptive capacity through lock-in into high investments and heavy machinery that damage the soils. This observation is in line with previous suggestions by Darnhofer et al. (2010) that adaptive strategies come with the cost of managing trade-offs between short-term efficiency and long-term adaptability.

A medium-scale dairy farmer who had invested a lot of money and intensified production, reflected on efficiency versus adaptability:

> "If 2011 resembles a normal summer in the future it will have consequences for this type of farming. It is better to be smaller and more flexible. That will secure the survival of the farm and be more profitable in the long run."

However, the same farmer asserted that lighter equipment would lead to lower capacity and reduced production. A small-scale dairy farmer was of the same opinion: "It is more robust with small and flexible units compared to one large, uniform farm unit." These perceptions correspond with findings from other studies. For example, Kvalvik et al. (2011) found that "adaptation to requirements for more efficient agriculture reduces the farmer´s adaptive capacity to cope with the future exposure-sensitivities of wetter autumns."

The farmer quotes referred to in this sub-section show that some farmers believed that

sustaining diversity and flexibility from field to farm level could enhance adaptive capacity and reduce vulnerability in the face of multiple processes of change. These farmers´ reflections are interesting, considering that one significant consequence of rationalisation is specialisation, rather than diversification and flexibility (Darnhofer et al. 2010). However, many factors affect decision-making at the farm level, such as political incentives, economy and efficiency demands, as well as changing social processes influencing collaboration. Milestad et al. (2012) uphold that "Whereas efficiency takes advantage of existing favourable conditions, adaptability sustains the long-term survival by maintaining high compatibility in the face of a changing environment."

5.4.5 Conclusion

The analysis in this section shows that factors such as local knowledge, collaboration, social networks, flexibility and diversity were key for successfully adapting to the double exposure of climate variability and structural changes. Interview responses show that farmers adapt so as to manage farm household activities in a timely fashion, while at the same time fostering liveability and wellbeing in a declining farming community. These findings correspond with Milestad et al. (2012:365) who argue that "Farmers face the triple challenge of ensuring liveability, making efficient use of their resources, and keeping their farms adaptive so as to find responses to both external and internal drivers of change." In particular, the interviewed farmers sought to uphold exchange of information and labour through various types of collaboration, though this is increasingly formalised. At the same time, there was a trend of individualisation in terms of equipment ownership. However, the study discerned two distinct types of farmer strategies: those who invested in equipment to carry out tasks fast, and those who invested less to keep costs down but at the same time retain flexibility. The findings suggest that short-term efficiency in managing climate stress such as wet conditions may undermine longer-term adaptive capacity.

5.5 Adaptation as a social and values-based process

Section 5.4 analysed how farmers and farm households in Rauma currently adapt to the double exposure of climatic and structural changes. Contextual vulnerability focuses on feedback loops between responses to change, contextual conditions and larger processes of socio-environmental change; that is, the way these influence each other in multidirectional ways (O'Brien et al. 2007). It is important, therefore, to investigate not only how people respond to multiple pressures but also how these pressures and responses affect people's quality of life, vulnerability, and capacity to respond to future changes. In this section

research question 1.1 is addressed: How do structural changes in agriculture influence vulnerability and farmers' capacity to adapt to increased climate variability in Rauma? The section starts with an analysis of emerging vulnerabilities in Rauma, from the perspective of the interviewed farmers, and continues with an account of farmers´ counteracting efforts to sustain adaptive capacity in Rauma.

5.5.1 Emerging sources of vulnerability in Rauma

Vulnerability refers to the propensity of harm to much more than just food and economic security, and includes factors such as sense of belonging, respect, social and cultural heritage, wellbeing, and control over one´s destiny (O'Brien et al. 2007). That is, high adaptive capacity and diverse strategies to manage change do not necessarily mean that negative consequences are avoided altogether or that people do not feel vulnerable. The degree to which farmers felt vulnerable to climatic and structural changes in Rauma diverged according to farmers´ differing values and motivations for farming. Structural processes have pushed the development towards fewer farmers, and this trend is reinforced by agricultural policies moving towards increased liberalisation. This study found that in spite of farmers´ efforts to adapt to multiple processes of change, several emerging sources of vulnerability in the farming community in Rauma could be identified. This development may be disfavouring smaller-scale farmers´ values and what they perceive to be worth preserving and achieving. Emerging social vulnerabilities are divided into four main themes: Declining farming communities, collaboration and knowledge, off-farm employment, and farming culture and succession.

5.5.2 Declining farming communities

When people choose to abandon farming, the remaining farmers have the option to continue as before, to quit farming as well, or to expand production by taking advantage of newly freed up land. Informants perceived the declining number of farms either as an opportunity that could benefit their operation, or as a threat to the kind of farming they valued and the future they believed in. Their perceptions differed according to type of production, geographic location, personal values, and their motivation. Several interviewees commented that it was easier to give up farming when other farmers quit, and large and small-scale farmers alike used the word *contagious* when describing how they experienced the declining farming community. These findings from Rauma correspond with results form a survey of farmers in Norway, where they found that it is more socially accepted to quit farming when neighbouring farmers quit, and that farm closures have a contagious effect on the remaining

farmers. One out of five farmers in the survey responded that they became sad and depressed when neighbours closed down production (Storstad & Rønning 2014).

A small-scale farmer of mixed production remarked:

> "It is extremely important that other people in the area farm. It is important for the milieu that someone understands what you are doing and for the community feeling. It is contagious when someone gives up farming."

The same interviewee had experienced that farmers who resigned were often unwilling to discuss agriculture again, and expressed that it was sad if no one was interested in what the others were doing. A medium-scale mixed producer similarly commented:

> "It is incredibly important that people in the local community farm. It is a premise that others share the same interest and that you can see that they have to do the farm chores as well. The farmers I talk with feel the same."

Expressions like *extremely important*, *incredibly important* and *a premise* reflect the value of the local community to farmers. Moreover, the above comments reflect the importance of aspects such as community feeling, mutual understanding and shared interest for adaptability, wellbeing and the continuation of farming. During times of adversity, such as the difficult 2011 season, the significance of mutual understanding, sense of commiseration, and community support should not be underestimated. These important aspects may be put under pressure when the farming community is declining. Kvalvik et al. (2011) found that in several communities in Northern Norway the number of farms are reaching a critically low level, and the subsequent decline in professional and social networks are affecting farmers´ livelihood negatively.

Although many responses suggest that farmers felt vulnerable to a declining farming community, it was not the case for all of the interviewees. In fact, farmers that have invested and expanded in recent years depend on more land becoming available for leasing or buying. A dairy farmer who recently had invested in a joint farm enterprise commented: "The other farmers are competitors. There is little grass in the village, and I have to invest more to continue. I am happy that the others abandon farming." During the same interview, however, the young farmer added:

> "I have support in the local community and they think that it's great that I expand and manage the farmland. I can never get enough support, it is very important."

Unlike farmers that felt vulnerable to changes in the local community, the young farmer perceived it as an opportunity and a prerequisite that the small-scale producers gave way to

farmers that were ready to invest. He explained that he expected to invest further in ten years to meet the increased costs of production, and was of the opinion that it ruined the continuation of farming that the small-scale farmers were 'sitting on' their land (though many are actively running the land). Nevertheless, having support in the local community was vital also to him.

Interviews suggest that local geographic, climatic and social conditions are factors that influence how farmers consider the development towards fewer farms. Interview responses from highly productive and central areas indicate that young people were ready to invest, but waiting for land to become available in order to do so. This is reflected in the comment of a small-scale mixed producer: "Two large milking robot units in the village have increased production in parallel with more land becoming available for leasing. There has been a massive rationalisation, but nothing is left fallow." In more remote areas, where there is enough land available to rent but it is either marginalised or unsuitable for larger scale production, the development was perceived as more worrying and possibly a threat to the continuation of farming. This tendency is also confirmed in other studies (Bjørkhaug & Wiborg 2011; Lie & Mittenzwei 2008).

If the farming community becomes too watered-out, it may reach a tipping point when it is no longer attractive for the remaining farmers to continue for both social and professional reasons, as reflected in the comment of a small-scale mixed farmer: "It affects us that we are the only ones left that produce milk. We want to quit as well but it provides a reasonable income. It is more interesting with a bigger milieu." These findings from Rauma are confirmed by other research showing that farm closures reduce the interest of the remaining farmers to carry on, and can trigger a 'domino-effect' of farm closures (Bjørkhaug & Wiborg 2011).

A small-scale farmer believed that it was important *who* abandoned farming, stating that if the most dynamic farmer quit it would leave a void in the local community. Each locality in the study comprised a distinctive culture and composition of farmers, and it may be that diversity in the farming community contributes to a more interesting dynamic locally, as exemplified by the comment of a small-scale farmer: "There is a good environment in this community, because we have one huge farm and a mix of large and smaller farms." More importantly, the composition of farmers and the social and cultural characteristics of a place may influence how farmers adapt to change. The quotes referred to in this sub-section suggest that the

dilution of active farms could weaken the milieu and affect the texture of the local community, which in turn alters the context for responding to socio-environmental changes, including climate change.

5.5.3 Changing patterns of collaboration, knowledge transfer and learning

The nature of collaboration has changed with fewer people involved in farming. Section 5.4.3 showed that the structural development towards larger and more specialised farm operations has resulted in more individualised farming and increased formal collaboration. Collaboration and social relations are important, not merely for professional reasons and to maintain desirable production levels, but also for wellbeing and quality of life, as reflected in the comment of a small-scale mixed farmer: "None of my neighbours farm organically, so in terms of agronomy the local community is not so important due to differences in how we farm. But socially the local community is important." When asked how collaboration had changed over the past decades, farmers responded very differently, as exemplified by the two contrasting comments to follow. A small-scale sheep farmer said: "Because of the rationalisation everything is bigger, but there are fewer farmers. It means less collaboration." A small-scale dairy farmer living in a remote part of Rauma, on the other hand, argued:

> "There used to be less collaboration. Back then they were supposed to own everything they needed. It is during my days of farming that neighbours started collaborating. There has been a development toward more collaboration."

Another small-scale mixed farmer living remotely agreed, stating that: "There was not more exchange of knowledge before. People were more closed back then and are more open now." Several other interviewees supported the impression that there was less collaboration, arguing that less shared equipment meant less collaboration. The small-scale dairy farmer quoted above was, however, not alone in reflecting the opposite opinion. The disparity in the responses reflects a great diversity among different farmers and between farming communities. There may be less collaboration in the forms that used to be prevalent among small-scale farmers, while some large-scale farmers have to collaborate more because they have not yet invested in the larger equipment that is necessary for completing tasks on this scale and rely on hiring entrepreneurs. There is a concern that disintegration of social and professional networks, and less collaboration between and within households, will interrupt the transfer of knowledge and reduce adaptive capacity in the face of climate variability and change (Bjørkhaug & Wiborg 2011; Eriksen & Selboe 2012; Kvalvik et al. 2011).

In addition to direct farmer-to-farmer interaction, knowledge is generated through formalised networks. For example, many farmers used the extension services actively, and the majority had memberships in different organisations and farmer cooperatives, and stayed updated by reading magazines, attending seminars and workshops. The following quotes provide descriptions on how a large-scale mixed farmer and large-scale dairy farmer sought knowledge:

> "I meet other farmers during the growing season. The extension service arranges farm visits so that we can learn from each other. The participation in organisations is important for socialising and the professional field."

> "We have meetings through the production service in the municipality and the Farmer's Union arranges mandatory and voluntary workshops. There is still a good professional milieu in the municipality. We discuss with each other how to do things. It would be sad to be the only farmer."

Eriksen and Selboe (2012:164) argue that increased formalisation in the farming sector can have a positive effect "for the uptake of more scientific, formal agricultural knowledge into local knowledge." An issue strongly related to the changing patterns of collaboration and knowledge transfer is increased dependency on off-farm employment, which will be elaborated on in the following sub-section.

5.5.4 Off-farm employment

Another key aspect of structural change, which has put informal collaboration under pressure, is increased dependency on off-farm employment in agriculture (Eriksen & Selboe 2012). It is increasingly demanding to break even, as the costs of labour, fertiliser, diesel and concentrates increase relative to farm income, and many farmers are currently hugely indebted due to high investment costs (Hillestad & Smedshaug 2013; Lie & Mittenzwei 2008).

Findings from Rauma suggest that in order to secure enough income to cover investments and operational costs, farmers had taken off-farm work (mostly sheep farmers), were involved in paid seasonal work, or had diversified economic activities connected to their farm operation (for example agricultural contracting, tourism, hydro power, forestry and sawmill). Off-farm work may be a concern in terms of long-term sustainability and adaptability as less time is dedicated to farming tasks. Moreover, Eriksen and Selboe (2012) suggested for the case of Øystre Slidre that the trend of fewer people involved in farming collaboration within and between households may lead to a reduction in the transfer of knowledge within families and

between farmers. Interview responses from Rauma illustrate both positive and negative aspects in relation to off-farm employment. A mixed producer, who continued to farm in a traditional manner, commented on the time pressure of having an off-farm job:

> "There are few people who farm as laborious as us, and this operation takes more time. We lease land and cut in many different places, but it is hard to combine with a fulltime job. It is very labour intensive."

Other interviews indicate that farmers that took on off-farm work had flexible working hours, in order to manage weather dependant activities, or otherwise collaborated with entrepreneurs during harvest and field preparation. For example, some farmers worked as teachers, and took summer holidays, whereas others were self employed and engaged in low-season work. Importantly, in addition to providing much needed income, off-farm employment offered a highly valued venue for socialising as farm work had become increasingly lonely. A large-scale farmer of mixed production said: "It is lonely being a farmer. It is good to have a job on the side and to share lunch with other people."

Although no interview question approached the issue directly, few farmers commented on the negative effects from off-farm work. However, some farmers (mainly dairy producers) were concerned that the women were less engaged in the farm routines and increasingly involved in non-farming activities. This was reflected in the comment of a medium-scale dairy farmer:

> "The biggest problem is that one is alone regarding everything. The women have their own profession, and there are few farms where the wife is at home. It is easier to run the farm if the family is engaged in the operation."

Whenever the farmer or the spouse diversified income opportunities and worked outside the farm, they could provide an extra income to make future investments to the operation so as to increase adaptive capacity in relation to climate variability and future climatic changes. For example, investing in drainage would increase farmers´ adaptive capacity to the projected increase in precipitation. Furthermore, an additional job could function as an economic buffer, to relieve stress and increase wellbeing, if the harvest should fail or if repairs and investments were required.

However, the price families pay may be increased loneliness and frictions within the household. One interviewed couple made a conscious effort to reduce these vulnerabilities by actively creating a work place for both. They described their situation as follows:

> "Our main project was to create a working place for both. Many farmers work alone, and it is lonesome work. It becomes a collision of lifestyles when one works outside

> the farm. We experienced little family life and got the worst from two lifestyles. Now we can better exploit the benefits of running a farm even if it means working afternoons and nights."

This dairy household had managed to increase their wellbeing and reduce vulnerability in the face of socioeconomic processes of change by leasing land and expanding production. By 1995 the dairy farm made enough income to employ both husband and wife. On the other hand, their experiences from 2011 showed that they were particularly vulnerable to precipitation because of the topography of the farm and the distance to the leased fields. The couple reported that they harvested grass of lower quality due to winter damage, the volume of the second harvest was 50 per cent of the normal yield, and the third harvest gave lower yields due to driving damages from the two previous cuttings. They further summed up how lower milk production, weed problems succeeding driving damages, loss of nutrients due to run-off, and high diesel costs (due to excessive driving because of the unpredictable weather), lead to a pure economic loss in 2011.

5.5.5 Psychological well-being and the changing culture of farming

Increased time pressure and efficiency demands, high debt, failed harvests due to climatic conditions, farmers' changing position in society, and loneliness are some of the factors contributing to mental health problems among farmers (Ribsskog 2013). Research shows that male farmers have significantly higher levels of anxiety and depression than any other group of workers, and that female farmers are also more depressed than non-farming women (Sanne 2004). Interview responses suggest that farmers felt increasingly lonely as a result of reduced collaboration within and between households, and the growing sense of loneliness affects wellbeing and vulnerability in the face of change. A medium-scale dairy farmer explained his everyday situation in the following way:

> "The kids are in school and my wife is working. When they are participating in activities I have to do the farm chores. I have dinner ready for when they come home, but then my wife is tired, and she doesn't feel like talking. They just finish the dinner quickly to go off to some activity. It is lonely being a farmer."

A sheep shearer described experiences with emerging mental problems like this:

> "It was common that people stopped by unannounced to get a cup of coffee and chat. Now many feel lonely. I have sheared sheep the past 50 years and felt like a social worker for the old bachelors. It is easier to give up when they don't see any future in farming, and there is no one to take over after them. I have seen mental problems and mismanagement among male farmers."

It is not just farmers who are negatively affected by the increased stress and loneliness of

farming. These feelings spread to other family members, including the next generation, which is reluctant to take over the operation after witnessing how their farming parents struggle.

As several of the interviewed farmers pointed out, activities and meetings used to accommodate to farmers' working hours, but at present other people´s work schedules set the time for activities. Such a consideration for farmers´ working schedules indicates how central farming used to be to the local community (Bjørkhaug & Wiborg 2011). Activities for the kids at school and social gatherings used to take place after the farm chores, in order for the farmers to participate in the events. Several dairy farmers expressed a concern that they could no longer partake in their children's activities. A medium-scale dairy farmer described the situation in the following way:

> "My daughters have seen that their father worked all the time, and that he had no time to participate in activities in the course of the years. Most of what is organised by the school takes place during the time we work in the barn."

Another medium-scale dairy farmer described that after the schools had merged and centralised, his kids had friends in neighbouring villages and spent less time playing around the farm. This development may interrupt intergenerational transfer of knowledge and learning, and affect long-term adaptability. Furthermore, as described earlier several interviewees felt that farming had become a lonely profession, and feared that less family participation could influence future farm succession negatively. Other research suggests that children follow in their mother´s footsteps, and that she sets the premise for children´s interest in the farm(Hovde et al. 2011). Therefore, with less women engaged in the operation of the farm, there may be negative effects on succession and the exchange and transfer of knowledge between generations.

Disinterest among the next generation may also affect farmers´ willingness to invest in the farm operation, as reflected in the following comment given by a medium-scale mixed producer: "If I continue with milk I will have to build a new barn, and there is no point in making investments if the kids don´t want to take over the farm." The farmer further pointed out: "Farmers who know that the next generation will take over invest." Willingness to invest may be important in terms of long-term adaptability and securing farm survival, however high investment costs can also make farmers more vulnerable.

In general, issues of dignity, social cohesion, and cultural identity are central to the way

people are affected by structural changes. They play a critical role in the psychological wellbeing of farmers, in their willingness to invest in the future, and in the willingness of the next generation to follow in their parents' footsteps. Social vulnerabilities that are emerging from structural changes may threaten the adaptive capacity of farmers against climate change, but as results show farmers are also responding to the new social realities.

5.5.6 Adaptive responses to emerging sources of vulnerability

The interviews reveal that farmers were not passive in the face of changes in the community and culture of farming, including collaboration, knowledge transfer, and social and family networks, and made an effort to maintain these functions. For example, new forms of social organisation emerge as a response to the loss of direct farmer-to-farmer contact and weakened knowledge transfer between generations. One way to strengthen social networks was to communicate through the Internet, which provides a new arena for both work related and social interaction, and has been compared to the old milk ramp (Huseby 2012). Farmer blogs and Facebook groups, for example 'Network for female farmers' and 'Friends of Norwegian agriculture', represent new social arenas where the members can discuss politics and share experiences and feelings associated with being a farmer (Huseby 2012). An organic sheep farmer explained how neighbours collaborated to manage the loss of sheep to wolverines, and confirmed that communication and the exchange of knowledge has changed with a new generation of farmers:

> "As the older farmers have been replaced, we communicate more through email. There is always an email related to farming when I open the inbox. We communicate differently than 10 years ago. We can give and receive quick updates, and we upload pictures on Facebook."

This reorganisation of social relations may in part compensate for the loss of direct contact and contribute to continued knowledge generation, and in turn adaptive capacity. However, not all farmers interact in this way, and it may not be a substitute for face-to-face interaction. Concerning more sensitive cases like mental health problems, the anonymity of the Internet may facilitate openness. As a response to depression among farmers, the Norwegian´s farmers Union (*Bondelaget*) established the web page *godtbondevett.no* (the address roughly translates to 'farming common sense') where farmers can share experiences and seek advice about depression and mental health.

Most of the farmers acknowledged the importance of sustaining venues for communication and exchange of knowledge, and some had gone through efforts to do so. The local store has

always been an important meeting place and institution in the villages, providing a setting for informal conversations and sharing of knowledge. Many of the villages that were visited throughout this study had lost their food markets to the bigger towns several years ago. Where they still had a village store, they said they made an effort to support it, arguing that it was an important place for socialising and connecting, as summarised in the following quotes: "We have conversations at the local store, so I support it" (small-sale farmer), "Meeting places and the exchange of knowledge is important to keep updated", and "The local store is important, it means a great deal"(medium-scale farmer).

The value that farmers and local people add to their meeting places, was also reflected in the efforts of a group of seven women that started a traditional bakery to support their local supermarket, buying all the ingredients they needed from the store, and selling freshly baked goods to attract customers. A small-scale mixed farmer said: "We started the business to save the local food store which is an important meeting place."

The environment for collaboration and knowledge transfer has changed with the altered structures in agriculture, but it is less apparent whether it has resulted in a knowledge drain or not. It may be that a new generation of farmers has found other ways of communicating in a changing farming context, and thus manage to enhance adaptive capacity through learning and the sharing of experiences through new, informal channels. The interviews revealed that the Internet has become an important source of information for several of the farmers, as illustrated by the following quote from a farming couple in Rauma (medium-scale dairy farmers): "We are self-taught farmers and used Internet as a source of information. When my father stopped farming he was done and would not speak of it anymore."

Several of the farmers who inherited the farm from their parents emphasised the need for adapting knowledge from older generations to their own needs. A young sheep farmer explained the importance of learning while at the same time finding his own way:

> "You have to think for yourself and not just copy the elders. Then you will stagnate. You have to adapt the farm to your own life and opportunities. There is an interesting intersection between generations and traditions, and there are good opportunities here with the combination of old knowledge and young people without experience. You find smart solutions when you think for yourself."

A large-scale dairy farmer similarly commented: "It used to be harder to make changes when the older generations and more people were involved in the farm operation." Depending on

the changes being made, and the effects of the changes, one can discuss whether or not that is positive in terms of adaptive capacity and vulnerability.

Comments cited here reflect that there is not necessarily a drain of local knowledge. Rather, they suggest that some farmers are using new channels of communication and learning to combine traditional, local knowledge with modern scientific understanding in order to adapt to the new conditions. These efforts are critical in shaping adaptive capacity at the local level, but whether or not they work in the long run and in the face of climate change will remain to be seen.

5.5.7 Conclusion- What if 2011 became the normal year?

The high precipitation levels and altered precipitation patterns that farmers experienced in 2011, are consistent with climate change projection for the region (section 2.2.2). Concurrent with these projections, 2011 could be an indication of how the future climatic scenario for farming would look like in Rauma. Interviewees were therefore asked to describe how they would be affected if 2011 resembled a normal year. Their responses reflect concerns related to both agronomic and social matters (collaboration). A particular concern was the effect of wetter conditions on harvesting activities, and a small-scale farmer predicted that it would be more problematic to make hay if the future looked like 2011. Other aspects that were mentioned were increased weed establishment, higher occurrence of pests, trampling damages caused by heavy cattle, lower grass quality due to delayed harvests, compaction damages and negative economic impacts. These concerns reflect the difficulties that many farmers faced in 2011, and suggest that the interviewed farmers expect more of what they have already experienced if the climate changes towards more precipitation in the future.

6 Discussion

The overall objective of this thesis was to identify how farmers currently adapt in the context of climate change and structural changes in agriculture and to answer the question: How do structural changes in agriculture influence vulnerability and farmers' capacity to adapt to increased climate variability in Rauma? By studying farmers´ adaptations in a municipality in Western Norway the aim was to gain insight into current sources of vulnerability and local adaptive responses in a developed country context. The purpose of this study was not to identify how climate variability and change alter the biophysical conditions for farming, but rather to illustrate how farmers´ adaptations to multiple pressures feed back on adaptive

capacity and vulnerability to climate variability and change. The main research question will be answered during the course of the discussion.

6.1 Framework of contextual vulnerability and double exposure

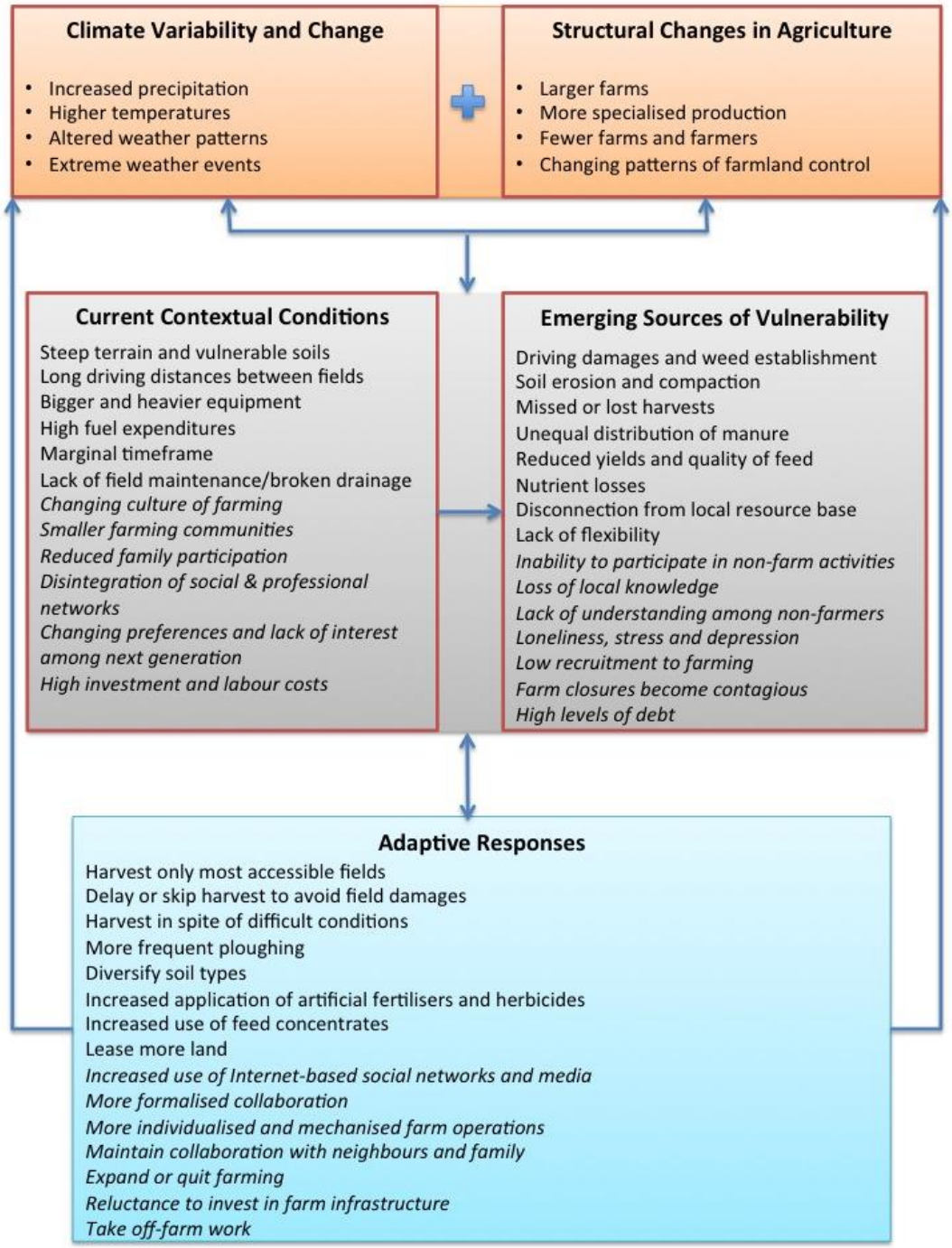

Figure 11: Contextual vulnerability in Rauma: Key findings from the case study

Figure 11 sums up key findings from this study and illustrates the current, local context of farming in Rauma Municipality based on farmers´ own accounts and perspectives. Figure 11 was modified from the contextual vulnerability framework figure of O`Brien et al. (2007:75) to include the dimension of double exposure (Leichenko & O'Brien 2008) at the individual farm household level. The orange box at the top illustrates higher-level processes associated with climate and structural change. These global processes of change transform farming system structures and functioning at the community and individual level, and are largely outside the control of individual farmers or communities. Moving down a level, the items listed in the box titled "current contextual conditions" (grey box, left frame) illustrate some of the current realities farmers face in Rauma as described by the interviewees themselves. These are the culmination of local conditions and historical processes of change, which in turn influence farm households´ degree of exposure to current climate variability and change and the ability to respond to future pressures. Figure 11 further illustrates how current contextual conditions and the double exposure (combined effects) of climatic and structural changes open up emerging sources of vulnerability at the individual farm household level (grey box, right frame). Examples of farmers´ adaptive responses to changing contextual conditions and emerging sources of vulnerability are listed in the blue box. These responses affect long-term adaptability at the level of the individual farm household and community level both positively or negatively. The blue arrows show temporal and spatial linkages and feedback loops between responses to change, contextual conditions, vulnerability and larger processes of change.

6.2 Multidirectional interactions and feedback loops

Climate variability and change occur in the context of structural changes, and structural changes in agriculture influence agronomic and social aspects of adaptation. The traditional farming practices have changed with the new structures in agriculture, and interview responses suggest that the development towards larger farms has made farmers more exposed to increased levels of rainfall. This is reflected in the emerging sources of vulnerability associated with contextual conditions such as longer driving distances, big and heavy equipment, and under-dimensioned drainage systems. The development towards fewer farms and farmers is associated with social aspects (contextual conditions) such as changing culture of farming, reduced family participation, and disintegration of social and professional

networks, which affect farmers´ capacity to adapt to climate variability and change on another level.

Larger farms and more specialised production

Overall the interviews revealed that a combination of topography and soil type, heavy equipment, inadequate drainage and more rainfall opened up new sources of vulnerability such as driving damages, increased weed-establishment, soil erosion and compaction, nutrient losses, reduced yields and inferior feed quality (grey box, right frame). Different farmers responded differently to reduce these sources of vulnerability, with each response feeding back on the capacity to adapt to future pressures. The interviews reflected five key adaptive responses to increased precipitation: 1) not access the fields at all; 2) postpone harvesting and field preparation until conditions had improved; 3) harvest and prepare the fields in spite of the difficult conditions; 4) only harvest the most accessible fields and leave field edges and steep terrain uncut; and 5) maintain flexibility in harvesting techniques (e.g. silage and *hesje*; use of older and lighter equipment) and diversify resources from field to farm level.

The different responses are characteristic for certain farmer typologies. In general, farmers that had expanded their operation and become more specialised had large areas to cut and were more inclined to harvest in spite of non-optimal conditions and only harvest the most accessible fields. Farmers of smaller operations that had less area to cut, farmers that had more than enough grass or farmland relative to the number of animals, or had an economic buffer (for example off-farm work) could afford to postpone harvesting or not harvest at all, and instead buy feed for the winter. An alternative, less rigid response was to diversify harvesting options and use a combination of modern technology and traditional methods to cope with climate-related stress.

Modern harvesting techniques, such as the round bale technology, are efficient for securing feed for the winter, which is particularly important if the farmer has large areas to cut. Combined with wet conditions and badly drained soils, however, harvesting with heavy equipment may have serious long-term consequences, which are summed up in the grey box (right frame) in figure 11. Furthermore, interview responses indicate that entrepreneurs are unwilling to cut field edges and sloped fields as it is time consuming and risky, particularly under wet conditions. Lower productivity and reduced yields are a serious long-term consequence of damaged soil structures and broken drainage, and an important buffer

capacity is lost when farmland goes out of production. This loss of productivity must be compensated for one way or another, whether by increasing fertiliser use, ploughing more often, repairing drainage, or using more feed concentrates. Another response to lowered productivity is to access more land through leasing or buying to maintain high production levels and secure enough income.

Changing patterns of farmland control

The altered pattern of ownership and renting is another outcome of structural changes. The increased rate of leasing farmland is both a response to a growing demand for economies of scale and an outcome of farm closures; in other words, it is both a driver and effect of structural changes in agriculture. Farmers can adapt and respond to lower productivity, and to increased efficiency and productivity demands by either 1) expanding and investing (lease or buy farmland and equipment); 2) staying the same size and diversifying income sources; 3) quit farming.

Figure 11 illustrates how increased dependency on renting land, in combination with climate variability and change, opens up new sources of vulnerability associated with contextual conditions such as long driving distances, a marginal timeframe, and low incentives to invest in field maintenance and drainage. This finding is supported by Bergslid and Lyche (2014), who estimated driving distances for farmers that had expanded production in a community in Western Norway. They used the example of a 'typical farmer' that had invested and expanded production to 60 dairy cows. The farmer was managing 50 separate field patches dispersed on 15 different farms to access enough grass for feed. Bergslid and Lyche estimated that this particular farmer would drive 4200 km, equalling the distance from Molde (the administrative centre for Møre and Romsdal) to Morocco, in order to spread manure on all the fields twice a year. This farmer was not a unique case; Bergslid and Lyche estimated driving distances for other large-scale farmers to be 2500-4500 km in the course of a year. In comparison, the driving distance for a farm of average size (25 dairy cows), with all the fields surrounding the farm, was estimated to be 100 km (Bergslid & Lyche 2014).

These concrete examples show that expansion through leasing or buying, in combination with increased rainfall, open up new sources of vulnerability, in particular in a context similar to that of Western Norway where farm operations are relatively small and fields are fragmented due to topographic conditions and ownership patterns. In the short-term, driving is an

economic cost and eats up time that could be spent on other farm chores. It also contributes to increased wear and tear of equipment, necessitates the use of larger equipment, leads to uneven distribution of manure, and other agronomic consequences. On a more personal level, driving long distances can add to already high levels of stress, loneliness, and depression for farmers, particularly when they are pressed for time or work alone.

What's more, long driving distances feeds back to higher-level processes of change and has long-term consequences. Increased emissions contribute to further climate change and uneven distribution of manure leads to nutrient losses. The high investment costs of the equipment and fuel mean that harvesting grass becomes more costly than importing feed and further de-couples farming from the local resource base. Farmers and farm communities become more vulnerable due to increased stress levels, increased dependency on inputs, and fluctuating markets. In turn, adaptive capacity is compromised due to reduced levels of collaboration and the lack of time needed to practice good agronomy, which lead to reduced yields and necessitate access to even more land and even more driving.

However, leasing land is not solely negative. Leased land can give higher adaptive capacity if strategically selected. Strategically selecting fields may give greater flexibility and diversity given that fields are not too far from the farm and if they are selected to complement each other. For example, certain soil-types are better in wet years whereas others are better in dry years. A range of slope aspects (i.e., facing north or south) can extend the harvest season so that not all the grass is mature at the same time. Another advantage of leasing land is that it does not require a large capital investment and gives farmers flexibility to increase production even if they don't own enough land.

If the farm operation is no longer economically viable, and it is not an alternative to invest and expand, an alternative adaptive response is to quit farming. While this response may benefit the individual farmer and farmers that are waiting for land in order to expand, it can also have negative consequences for the adaptability and wellbeing of neighbouring farms and the local community. Quitting farming can also be contagious and trigger other farm closures. Finally, it may reduce food self-sufficiency at the national level in the long run.

Fewer farms and farmers

The trend of fewer farms and farmers is both an outcome and driver of structural change in agriculture. On the one hand, farm closures make more land available for expanding farm operations to rent or buy, feeding back on the larger process of structural change. These larger farm operations become more mechanised and depend on larger equipment to handle the increased scale, which in turn reduces the need for human labour. At the same time, as shown in Figure 11, the development towards fewer farmers open up new sources of vulnerability associated with a changing culture of farming, smaller farming communities, reduced family participation, and disintegration of informal and professional networks (grey box, right frame). These emerging vulnerabilities further drive the closure of farms by making farming less attractive for all scales. This finding corresponds with other research (Bjørkhaug & Wiborg 2011; Storstad & Rønning 2014). Findings from this study reflect four key adaptive responses to these contextual conditions and emerging sources of vulnerability: 1) farming operations become more individualised and mechanised; 2) rely on more formalised collaboration; 3) organise collaboration within and between farm households and maintain a diversity of resources from field to farm level; 4) leave agriculture altogether.

The interviewed farmers who had invested, expanded and specialised production in order to benefit from scale effects commonly responded to new contextual conditions by becoming more independent or engaging in formal collaboration (hiring entrepreneurs). While key responses 1 and 2 might increase farmers´ adaptive capacity in the short run by allowing them to efficiently harvest grass or spread manure, the interviews suggest that these responses make farmers vulnerable to loneliness, depression and stress as described in the previous section. Moreover, interview responses suggest that these adaptive responses may threaten the exchange and transfer of local knowledge, intergenerational transmission and learning, reduce the practice of informal collaboration, and undermine flexibility – all of which may contribute to further farm closures, disappearing farming communities, and reduced recruitment of new farmers. These findings correspond with two other case studies of marginal farming communities in Norway (Eriksen & Selboe 2012; Kvalvik et al. 2011).

Response 3 was more common for farmers that were not hugely indebted due to high technological investments. This response is associated with a lifestyle choice and other values and motivations than profit maximising and optimised production. Interview responses reflect

that this way of farming is more labour intensive, and dependant on the involvement of more people in the farm operation. Labour is expensive in Norway when compared with subsidised inputs, and unless the farm has access to cheap labour (family members or informal collaboration) it may be a cost-inhibitive way of farming.

However, The interviewed farmers that represented this category showed less evidence of vulnerability related to agronomy and few commented on loneliness and depression being an issue. Rather, they emphasised how rewarding it was to work with neighbours or family members during the difficult conditions in 2011. Their strategy is to stay small in order "to master the system" and leave "room for manoeuvre" (Milestad et al. 2012), referred to in the interviews as having several helping hands, utilising traditional harvesting techniques, engaging family participation, and having old, lightweight equipment to fall back on. This last category of farmers preserves different values and aspects of farming than those that have expanded. However, a more diverse and less intensive way of farming may not be economically viable in today's economy and often survive only with the aid of off-farm income. These farms may be less efficient in the short run, but maintain a higher level of adaptive capacity in the long run and possibly increase wellbeing and life quality, which is important to prevent farm closures.

6.3 Short term efficiency at the cost of long term adaptability

> When the focus of managing a farm is to optimise the production system […] the result tends to be a farm that is well adapted to the current context (market demand, price ratios), but not necessarily flexible. A farm that strives for autonomy, e.g. in fodder supply and replacement heifers, and whose production level is adjusted to the agro-ecological context is more likely to be able to buffer shocks (Milestad et al. 2012).

Results from this and similar studies suggest that while modern farming technologies such as round baling may improve efficiency in the short-term, they may compromise long-term adaptability. As mentioned previously, round bale technology allows farmers to harvest fodder even when conditions are not optimal and are in theory a timesaving technology. This corresponds with Keskitalo et al. (2010) who found that for the case of the Nordic countries and Russia, technology used by entrepreneurs in other primary industries had great importance in terms of time savings and risk management, but also for managing resources more efficiently, for higher outcomes and profitability. However, this equipment is a major investment that needs to be paid off by increasing productivity and expanding. The same can be said for other types of equipment that increase efficiency but push farm operations to be

more specialised. In practice, expanding the operation and increasing productivity are often achieved by renting land that is located far from the farm and necessitate driving long distances, which has been shown to be problematic. Specialised farms become less flexible when it comes to changing conditions, and interviews show that large, heavy equipment and long driving distances affect long-term adaptability by making farmers more vulnerable to increased rainfall. Farmers are also made more vulnerable to fluctuations in market prices and input costs such as diesel and fertiliser.

Under "perfect" condition these farmers may be able to use the resource base more efficiently; that is, if fields were located in close proximity to the farm, fields were properly managed and maintained, the number of animals was adjusted to fit the land area, and the climate was stable. In reality, these conditions are rarely perfect. Farm operations focused solely on production optimisation tend to lack the diversity and flexibility in their strategies that enable them to handle variable conditions and are dependent on imported input factors, which can make them vulnerable to surprises and unforeseen change (Milestad et al. 2012). This is why developed nations such as Norway may be vulnerable due to having resources locked up in infrastructure in spite of having the means and resources to adapt (Keskitalo et al. 2010). As Nærstad (2013) argues, there may already be too few farmers in Norway to farm sustainably and to exploit the areas that are suitable for agricultural production, and that more farmers are needed to fulfil Norway´s potential as an agricultural nation.

7 Conclusion

The objective of this study was to identify to what extent there is a disparity between structural changes in Norwegian farming and building climate adaptive capacity in agriculture. Through triangulation of methods it was possible to confirm that results from this case study are consistent with other studies from a variety of contexts. Results suggest that despite having access to resources and a high degree of adaptive capacity, structural changes are in fact undermining the capacity of individual farmers in Rauma to adapt to climate change through a variety of mechanisms both agronomic and socio-economic. Long driving distances, bigger and heavier equipment, and more specialised production combined with increased precipitation are associated with damaged fields and lower yields as well as stress, loneliness, and time pressure. There is also a social dimension. Interviewees commented on the importance of having a community of farmers with whom they can collaborate and who understand what they are going through. All farmer types, independent of scale, production type, values, and size, are to some degree vulnerable to a diminishing farming community due to the contagious nature of farm closures and lack of understanding among non-farmers.

This study suggests that maintenance of small-scale farming is important for the multifunctionality of agriculture, the social texture of rural communities, the viability and continuation of farming, efficient use of local resource base, and ensuring the future food production. A balanced mix of larger and smaller farms and production systems encourage the exploitation of different resources and fill different niches in the agro-ecosystem. In reality, small and medium-scale farmers cannot feed Norway alone, but their existence plays an important role for the adaptive capacity of the farming community by passing on knowledge and engaging in informal collaboration. Farms at all scales, including large farms, are vulnerable to policies that only emphasise large-scale production at the cost of small-scale farms.

Another conclusion from this study is that adaptive responses to the double exposure of climate and structural changes may feed back into further structural change in a kind of vicious circle, leading to some farmers becoming even more vulnerable to climate change and leading to the disintegration of farming communities. Responses that focus on cost-efficient food production and increasing productivity can undermine long-term adaptability.

Agricultural policies should therefore consider internal, social dimensions of adaptation, and not only technological adaptations.

This study also demonstrates how important it is to consider context when researching agriculture and implementing policies, such as when assessing vulnerability and adaptive capacity to climate change. For example, in the context of Western Norway there are certain physical and social limits to the expansion of production that are determined by local contextual conditions such as topography, climate, and the culture of farming. In another context these conditions will be different and the outcome of a similar assessment may give different results. National agricultural policies should acknowledge local contexts.

In general, adaptive capacity is enhanced by maintaining a diversity of resources from field to farm to community level, including a diversity of options for responding to climate variability and change. Policy recommendations and responses to socioeconomic and political processes of change should not make the climate problem worse or reduce the capacity to adapt to a future of uncertainty and change.

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9 Appendices

Appendix 1

Klimaendringer og tilpasning i marginale jordbruksområder
Nøkkelinformantintervjuer Rauma kommune 2011

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Introduksjon av Studien til Informanten

Jeg er i ferd med å avslutte en master i internasjonale miljøstudier ved universitetet i Ås. Masteroppgaven min er en del av et større prosjekt, PLAN, som ser på tilpasning til klimaendringer i Norge (http://www.sv.uio.no/iss/forskning/prosjekter/plan/). Prosjektet er planlagt avsluttet i 2012. Studiet ser på hvordan lokalsamfunn forholder seg til klimavariasjoner og endringer i områder som er klimatisk marginale. Det er stor klimavariasjon innad i Rauma kommune, og jordbrukere har ofte mye kunnskap om hvordan de må tilpasse jordbruk og andre aktiviteter til lokale betingelser. Samtidig påvirkes lokalsamfunnet av en rekke endringer, for eksempel i økonomiske betingelser for jordbruket, redusering av antall bruk, økonomisk politikk, naturforvaltning, inn- og utflytting etc. Gjennom denne studien ønsker vi å forstå bedre hvordan folk balanserer hverdagsaktiviteter og ulike typer næring i møte med totalen av slike klimatiske og ikke-klimatiske forandringer.

Jeg vil gjennomføre 20 nøkkelinformantintervjuer med jordbrukere i forskjellige deler av kommunen, og jeg ønsker i den forbindelse å be om din deltakelse som nøkkelinformant. Intervjuene vil forløpe som samtaler og åpne diskusjoner om utvalgte tema. De vil dekke temaer som mangfold i hvordan folk driver jordbruk, hvordan folk takler og tilpasser seg klimaforholdene, endringer fra år til år og over tid, turisme, lokalkunnskap, lokale institusjoner, økonomiske betingelser og offentlig politikk. Jeg vil ta opp ett til to temaer per intervju, og hvilke temaer som blir valgt vil variere med nøkkelinformantens bakgrunn samt hvilke temaer som har blitt dekket under andre intervjuer. Diskusjonen vil få løpe fritt, og informasjon som er interessant for prosjektet kan følges opp med flere spørsmål. Jeg kommer til bruke en intervjuguide som har blitt benyttet ved tidligere intervjuer i Øystre Slidre i Valdres.

Deltakelsen i intervjuet er frivillig, og du kan velge å ikke svare på spørsmål som du føler er sensitive. Du har også rett til å trekke tilbake samtykke til intervju i etterkant. Prosjektet er meldt til Personvernombudet for forskning, Norsk samfunnsfaglige datatjeneste AS. Alle opplysningene vil bli behandlet konfidensielt, og det er bare undertegnede og undertegnedes veileder Siri Eriksen (forsker ved Noragric, Universitetet for Miljø og Biovitenskap) som vil ha tilgang til de innsamlede opplysningene. Alle informantene vil være anonyme i alle presentasjoner og rapporteringer i forbindelse med prosjektet. Ved prosjektslutt

avidentifiseres alle innsamlede opplysninger. Det betyr at navn og intervjuer holdes helt adskilt. Opplysningene vil beholdes i opptil ti år i tilfelle det blir aktuelt med videre datainnsamling i Rauma eller ved fordypning i temaer som tas opp i denne studien. Jeg vil derfor gjerne be om ditt samtykke til at vi (Årolilja S. Jørgensrud og Siri Eriksen) oppbevarer og bruker intervjudata som beskrevet over.

Jeg vil be om noe informasjon om informanten i begynnelsen av intervjuet, men hovedvekten av spørsmålene dreier seg om lokalsamfunnet, med eksempler fra dine egne erfaringer der det er nyttig. Det kan være aktuelt å delta i eller observere dagligdagse aktiviteter for eksempel i fjøs eller på beite. Dette vil i tilfelle avtales med informanten. Jeg vil analysere informasjonen fra alle nøkkelinformantintervjuene samlet for å bedre forstå hvordan lokalsamfunnet tilpasser seg klima- og samfunnsmessige påvirkninger. Funnene kan bli presentert i faglige tidsskrift samt i møter med andre prosjektdeltakere i PLAN.

Vennligst ta kontakt per telefon eller e-post dersom du har spørsmål om studien eller intervjuet.

Med vennlig hilsen Årolilja Svedal Jørgensrud

Informasjonen i dette brevet er utarbeidet fra informasjonsskrivet som ble sendt ut av Siri Eriksen og Elin Selboe (forsker ved Universitetet i Oslo) i forbindelse med deres nøkkelinformantintervjuer i Øystre Slidre.

Appendix 2

Spørreskjema om tilpasning til lokalklima

Dato:

Informantnummer:

Kommune:

Geografisk område av kommunen:

Navn på bygda:

Intervjuer:

A. Bakgrunn

1. Mann/kvinne:
2. Alder 18-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80+ :
3. Hvor mange bor på gården og tar del i drifta av gården:
4. Viktigste jordbruksaktiviteter:
5. Viktigste hverdagsaktiviteter:
6. Antall dyr:
7. Total størrelse:
   a) dyrket mark:
   b) egen jord/leid jord:
   c) beite:
   d) skog:

B. Husholdningens medlemmer

1. Hvor er du oppvokst (kommune/bygd)?
2. Dersom du ikke er oppvokst her: Hvor lenge har du bodd her?
3. Hvorfor flyttet du hit?
4. Har du tidligere flyttet bort og kommet tilbake hit?
5. Hvor gammel er gården?

6. I hvor mange generasjoner/ fra hvilket årstall har gården vært i denne familien?
7. Når tok du over gårdsdriften?
8. Fikk du gården på odel eller kjøpte du den?
9. Hvis du kjøpte gården, hvordan fikk du kjøpt gården?
10. Var forrige generasjon med i overgangen da du tok over gården?
11. Hyrer dere noen ganger inn sesonghjelp eller har dere hatt annen permanent hjelp?
12. Hvor ofte har dere avløser i løpet av et år?

C. Jordbruksaktiviteter

1. Har dere lagt om driften de siste åra? Hvordan?
2. Ranger de viktigste årsakene til forandringer eller tilpasninger i driftsform og i daglige gjøremål;
   a) landbrukspolitikk
   b) lokale sosiale forhold
   c) økonomi
   d) vær/klima
   e) teknologi
   f) marked/forbrukertrender
   g) personlig livsstil
3. Var disse aktivitetene de samme ifjor?
   a) type aktivitet
   b) hvem som deltok
   c) hvor varene ble solgt
4. Har dere planlagt å legge om i framtiden?
5. Kan du si noe om lokale utviklingstrekk i landbruket de siste 5-20 årene
6. Hvordan påvirker markedsforholdene drifta av gården?

Melk:

7. Har dere økt eller redusert melkekvotene ?
8. Skal dere øke/redusere framover?
9. Varierer mengden melk produsert fra år til år?
10. Hva er årsaken til variasjonene?

D. Andre økonomiske aktiviteter i husholdningen

1. Er jordbruksaktiviteter eller jobb viktigst når det gjelder
   a) økonomi
   b) tidsbruk
   c) personlig interesse og verdi
1. Har dere endret økonomiske aktiviteter
   a) det siste året
   b) de siste 5-10 årene
   c) hvorfor?
   d) Har dere tenkt å endre økonomiske aktiviteter i framtiden?

E. Sårbarhet, tilpasning og effekter av sesongen som var

1. Hva kjennetegner været her i området sammenliknet med andre steder i kommunen?
2. Hva er de viktigste sesongvariasjonene i klima i området og hvordan varierer sesongene fra år til år?
3. Hva er de viktigste værfaktorene som påvirker gårdsdrifta?
4. Velger dere produksjonsform etter lokale værforhold?
5. Er det noen klimahendelse i bygda eller unormalt/ekstremt vær du kan huske?
6. Kan du forberede deg på slike hendelser? Dyrker du andre sorter, endrer beiting eller justerer andre økonomiske aktiviteter?
7. Hvordan søker man å løse slike problemer? Hvor henvender man seg?
8. Hva slags ekstern støtte får du for å takle slike hendelser (myndighetene, hjelp fra naboer/familie, bondeorganisasjoner etc)?
9. Hvor får dere informasjon om hvordan sesongen vil bli?
   a) Værmelding/lokale værstasjoner:
   b) kommunen/myndighetene:
   c) andre organisasjoner (bondelaget):
   d) forskningsstasjonen:
   e) lokale værtegn:
10. Hvordan bruker du denne informasjonen?

Året i fjor

11. Visste du på forhånd hvordan sesongen i fjor skulle bli?
12. Hvordan forberedte du deg i tilfelle på det?
13. Hvordan var været annerledes i fjor i forhold til et normal år og hvordan påvirket det drifta av gården?

	Kvalitet	Kvantitet	Annet
Kvalitet og kvantitet 1. slått			
Kvalitet og kvantitet 2. slått			
Kvalitet og kvantitet 3. slått?			
Fikk dere pakket rundball i tide?			
Mer/mindre tørrfôr/ rundball enn normalt			
Kvalitet på rundball, jordbakterier			
Konsekvens kvalitet/ kvantitet melk			
Konsekvens for størrelse på bestanden/ sykdom			
Konsekvens for slaktevekt/ kvalitet			
Bruk av kraftfor?			
Våronn og innhøsting			
Jordarbeid			
Endret aktivitet eller mer arbeid			
Måtte du utsette aktivitet til neste år eller avlyse?			
Økonomiske konsekvenser?			
Konsekvenser for innsats i andre økonomiske aktiviteter			
Konsekvenser for sosiale aktiviteter			
Konsekvenser for investeringer			
Konsekvens for eng/ jord			
Langvarige konsekvenser			

Tilpasninger og erfaringer

1. Hva var det viktigste dere gjorde for at det gikk bra i år/ viktigste tilpasningen? Hva gjorde dere i stand til å gjøre dette sammenliknet med andre som ikke fikk det til?

2. Er det andre tilpasninger dere gjerne skulle gjort i stedet men som ikke var mulig?
3. Har noen av disse tilpasningene negative konsekvenser på kort eller lang sikt?
4. Hvor mange av tilpasningene er basert på eget initiativ og erfaring og hvor mye er basert på bestemmelser eller anbefalinger fra myndigheter, bondeorganisasjoner eller forsøksringen?
5. Føler du at personlige erfaringer når frem og kan ha innvirkning på kommunale/ sentrale bestemmelser?
6. Har du blitt kontaktet i etterkant av spesielle klimahendelser som har hatt betydning/ konsekvenser for jordbruket?
7. Har du merket noen endringer i værforhold over de siste tiårene?
8. Har dette ført til endringer i driften
   a) nye arbeidsoppgaver
   b) dyrker andre sorter
   c) driver dere på en annen måte?
9. Har det hatt andre konsekvenser, på økonomiske aktiviteter, på det sosiale liv?
10. Dersom det har vært endringer i været, hvorfor påvirker det eventuelt ikke driften, økonomiske aktiviteter eller det sosiale liv?

F. Gras, fôr og frø

1. Hvilke jordstykker bruker dere, inkludert dyrket mark, beite og skog?
2. Hvordan varierer jordstykkene økologisk (hvor i landskapet er de)?
3. Dyrker dere forskjellige typer gress/fôr de forskjellige stedene?
4. Bruker du lokale frøsorter eller hvor kjøpes de fra?
5. Har dere endret hvilke typer gress/fôr/avling dere dyrker?
   a) siden ifjor?
   b) 5-10 år siden
6. Hvorfor (nye arter som nå lar seg dyrke, tilgang på frø, pris, klima)?
7. Har dere tenkt å endre type gress/fôr/avling?
8. Hvor får dere tilgang til frø (kjøpe, naboer, forskingsstasjonen)?
9. Er det lett å få tilgang på de frøene du trenger?
10. Hvordan bestemmer du hvilke frø du vil bruke?

11. Hvordan bestemmer du hvor husdyr skal beite og når?
12. Hvordan får folk den viktigste informasjonen og kunnskapen om dette (fra eldre generasjoner, fra utdannelse og kurs, fra myndighetene, fra naboer, fra kommersielle selskap, fra organisasjoner) ?
13. Har gården dyrkningsmessige utfordringer som jordsmonn, topografi etc?

G. Dyrket Areal

1. Dyrker dere et større eller et mindre område enn ifjor eller for 5-10 år siden?
2. I tilfelle, hvorfor har dette endret seg?
3. Planlegger dere å dyrke mer eller mindre område framover?
4. Kan dere dyrke opp mer av eget land eller dyrker dere alt som er dyrkbart?
5. Er det greit å få leid beite eller områder til å dyrke fôr?
6. Er det flere i området som leier eller forpakter jord enn før?
7. Leier dere jord?
   a) er den tilstrekkelig drenert?
   b) ligger den langt fra gården?
   c) leier dere av den samme grunneieren?
   d) får du gjort nødvendig jordarbeid på alle jordstykkene?
   e) varierer innsatsen på egen jord og leid jord?
   f) dyrker du all tilgjengelig jord av den jorda du leier?
8. Er jordbrukere som har lite eget land spesielt sårbare for økonomiske eller klimatiske påvirkninger?
9. Har har dere vanligvis nok fôr fra egen produksjon eller må dere kjøpe?
10. Hvor mange ganger (feks i løpet av siste 10 år) har dere kjøpt fôr?
11. Er det greit å få tak i?

H. Lokal kunnskap og informasjonskilder i jordbruk

2. Hvilke nye teknologier eller typer jordbruk/skogbruk har kommet i lokalsamfunnet de siste 10, 20, 30 årene (såkorn, skogbruk, fjøstyper, utstyr, driftsformer etc) ?
3. Hvem introduserte disse teknologiene eller hvor kom de fra?
4. Hva vet du om klimaforandringer?

5. Er det noe du tenker på i drifta av gården/fremtidig drift av gården?
6. Har du erfart en sammenheng mellom dårlig vær og økt bruk av kraftfor?
7. Har du erfart en sammenheng mellom dårlig vær og redusert jordarbeid?
8. Vet du om andre i bygda eller kommunen har slike erfaringer?
9. Hvis været blir mer likt fjorårets våte vær/mer ustabilt, vil det påvirke måten du driver landbruk på i fremtiden? I tilfelle på hvilken måte?
10. Tror du at dårlig vær vil øke eller minske samarbeidet innen landbruket?
11. Hvor viktig er det for drifta av gården at det er andre som driver landbruk i området?

I. Stølsdrift og beite

1. Driver dere støl eller fellesbeite?
2. Hvor?
3. Flytter dere på stølen om sommeren?
4. Eventuelt hvor lenge?
5. Får dere stølstilskudd?
6. Har dere endret stølsdriften de siste 10 årene?
7. Hvordan er kvaliteten på beitet (her nede og på fjellet)?
8. Hvordan var beitet iår?
9. Har beitet endret seg i dalen eller på fjellet de siste tiårene?
10. Er det privat eller statsalmenning?

J. Samarbeid og organisering

1. Er dere medlem i
   a) samdrift
   b) stølslag
   c) beitelag
   d) sankelag
   e) jaktlag
2. Hvor lenger har dere vært med og hvor mange er med?
3. Deler dere driftsutstyr med andre? Hva slags og med hvem?
4. Har det blitt mindre/mer deling av driftsutstyr enn før?
5. Får/gir dere hjelp av naboer til feks å slå eller har dere annet type samarbeid i løpet av

sesongen?

6. Hvem får man kunnskap, råd og hjelp fra hvis det oppstår problemer?
7. Driver naboene eller lokalmiljøet med utveksling av kunnskap?
8. Finnes det en bra kunnskapsbase for jordbrukere her i bygda/kommunen?
9. Hvor ofte benytter du deg av slik informasjon?
10. Var det mer eller mindre hyppig før?
11. Har du medlemskap eller verv i lag og/eller organisasjoner?
12. **Hvor viktig er lokalsamfunnet for drifta av gården?**

Samdrift

1. Hvorfor valgte du å starte med samdrift?
2. Har du samarbeid med andre utover samdriften?
3. Hvilken arbeidsfordeling har dere?
4. Føler du at du har bedre forutsetninger for å drive (jorda) optimalt under denne samarbeidsformen?
5. Hva føler du er de største fordelene og ulempene ved å drive sammen?

K. Investeringer og begrensninger?

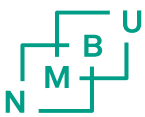
1. Når var siste investering i
   a) driftsbygninger
   b) maskiner
   c) annet utstyr
2. Har dere fått tilskudd til investeringene?
3. Trengs nye investeringer framover?
4. Er det andre begrensinger på å få gjort ønskede investeringer feks tid eller offentlige regler?
5. Har myndighetene eller andre aktører satt igang prosjekter eller satsinger i kommunen i det siste?
6. Får du ny informasjon eller kunnskap fra slike prosjekter?
7. Har du merket negative effekter av slik satsing?

L. Sosioøkonomisk status

1. Informantens utdanning (bakgrunn/nivå), evt. etterutdanning:
2. Husholdningens samlede brutto årsinntekt (kategori á 100 000kr):
3. Er det noe du ønsker å tilføre som vi ikke har diskutert i løpet av intervjuet?

Appendix 3

Setting up *hesje* in Rauma Photo: Birgitte Zijlstra



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