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HOW IS THE AGRICULTURAL SECTOR IN ROGALAND ADAPTING TO CLIMATE CHANGE?

PLANS AND PROCESSES – GLOBALLY, NATIONALLY AND LOCALLY

MARIANNE JEVNE BERGE

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AUTHOR: Marianne Jevne Berge

SUPERVISOR: Reidar Staupe-Delgado

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Preface

This master thesis marks the end of a 2-year master program in Energy, Environment and Society at the department of Media and Social Sciences at the University of Stavanger. The basis for this research originally stemmed from my great interest in climate change, adaptation and mitigation. The study focuses on the topic of climate change adaptation in agriculture.

I would like to thank my supervisor Reidar Staupe-Delgado for guiding me through the process of writing this thesis and providing valuable feedback.

Abstract

The purpose of this study is to investigate how the agricultural sector in Rogaland is adapting to climate change, and what factors affect decision-making in relation to this. Agriculture is especially vulnerable to climate change and adapting could reduce future impacts as well as benefit from arising opportunities. By using Rogaland county, a large agricultural county in Norway, I have seen how targets in international agreements are passed on to national and regional policies and plans, what factors affect decision-making in agricultural adaptation, and how the threat of climate change is interpreted by farmers and policymakers in Rogaland. These three questions are interrelated and can affect each other.

Ambitions and goals in international agreements are rarely literally mentioned in regional plans, but rather passed on through ideas and targets in national guidelines. Some international agreements and decisions are emphasized more than others, especially the sustainable development goals and the Paris agreement. Climate change adaptation is given more and more attention at the County Governor of Rogaland, and there is a wish to rather work with preventive measures than coping measures. Although agriculture is related to national food security, adaptation in agriculture is the individual farmers choice and not something the County Governor can instruct farmers to implement. The County Governor of Rogaland takes on a supporting role through grants, programs, compensation and support schemes.

The findings show that farmers in Rogaland acknowledge the threat of climate change and are aware of potential indirect and direct effects. Adapting to climate change and climate variability is understood as a process of continuously adjusting to changing conditions by implementing certain technologies, using government initiatives or alter different farm production practices. This process is influenced by external and internal forces mainly consisting of climatic stimuli in the form of heavy rainfall, socio-economic and political factors in the form of government initiatives and compensation schemes, technological innovations, and personal traits.

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1. Introduction

Climate change is widely recognized as a reality and as one of the major challenges the world is facing today (Brobakk, 2017). Its uncertainty also makes it a complex subject with influences on various aspects of our society in multiple ways. Most research on climate change has been concentrated on mitigation, and the reduction of greenhouse gas emissions in various sectors. This is visible in government policies as well. Nevertheless, growing attention has been given to adaptation and its importance for future resilience. Leading research organizations such as the Intergovernmental Panel on Climate Change (IPCC) have tried to map out possible climate change impacts, in addition to vulnerability and adaptation options for different areas in the world with a focus on global, sectoral (Part A) and regional (Part B) aspects (IPCC, 2014a; IPCC, 2014b). It is stated that, because of historic emissions, global warming and some of its effects are inevitable, regardless of mitigation progress (Berrang-Ford, Ford & Paterson, 2010; Barnett et al., 2015; Adger, Lorenzoni & O'Brien, 2009). Adaptation is therefore necessary to try to reduce damage on social and ecological systems. In accordance with this, several international agreements and decisions contain targets to increase climate resilience by enhancing climate change adaptation (CCA). Some decisions also focus on specific sectors, such as Decision 4/CP.23, the Koronivia Joint Work on Agriculture (KJWA) which requests parties to submit their views on issues related to agriculture and methods for assessing adaptation, adaptation co-benefits, and resilience (UNFCCC, 2017).

The research on CCA is extensive, but it tends to focus on the possibility of adaptation, how societies might adapt to climate change, and not as much on the adaptation actions themselves (Berrang-Ford et al, 2010). In Norway, these intentions to act are often found in policies with little documentation of actual adaptation action. Although Norway, compared to other countries, is both less exposed and better equipped to deal with climate change, warmer temperature and more rainfall could have considerable impacts on industries sensitive to changes in climate, such as agriculture (Kvalvik et al., 2011). Changes in climate could affect patterns of plant diseases and pests, and the spatial distribution of agroecological zones which could have significant impacts on agriculture and food production. Adapting to climate changes in agriculture will be important to reduce vulnerability and enhance food security.

To which degree farmers and policymakers perceive climate change as a threat will influence whether and how adaptation measures are considered and implemented. International

agreements reflect a top-down approach at dealing with climate change, and how these decisions are implemented in regional governance could affect local level adaptations. In addition to policy initiatives and climate change perceptions, is farm-level decision-making formed by various other factors as well. What these drivers and constraints are and how they interact will affect agricultural adaptation to climate change.

The problem statement I wish to examine in this research is therefore:

How is the agricultural sector in Rogaland adapting to climate change?

In relation to this, the research questions I will look closer at will be as follows:

- How is the threat of climate change interpreted by farmers and policymakers within the agricultural sector in Rogaland?
- How are international agreements, such as the KJWA decision, implemented in regional governance?
- What are the main factors influencing farmers decision-making in agricultural adaptation to climate change?

Climate change refers to changes over longer periods of time, such as changes in mean temperature or precipitation normals (CSIRO, n.d). Glantz (1994) describes these long-term processes and their changes as creeping environmental problems or phenomena (CEPs). CEPs are usually not much worse from day to day, and transpire across disciplines and continents (Glantz, 1999). Due to the time scale, most sectors are argued to be reasonably adaptable to changes in average climate conditions, especially compared to changes in the frequency or magnitude of climate variability and extremes (IPCC, in Kurukulasuriya & Rosenthal, 2003). Nevertheless, as changes in climate are gradual, they are often viewed as less immediate threats, and can be hard for societies to discover before it poses a serious threat.

Adapting to changes in climate is not new. However, the pace and range of climate changes and climate variability have changed. This has led to an emerging acknowledgment that the weather is no longer 'natural' (Adger, Lorenzoni et al., 2009). With unnatural weather patterns and climate variability follows the uncertainties of impacts, societal responses, and the interaction between systems. However, a certainty is that changes in climate will happen, and that the overall expected changes, like temperature increase, are occurring. How and when the

agriculture adapts to these changes will therefore be crucial for future vulnerability, and to the degree future impacts will have on the sector.

In agricultural adaptation, multiple actors (producers, industries, governments) are involved with different levels of influence. Adapting to climate change is complex, and measures must correspond to the impacts and changes occurring at the location of interest. Types of adaptation can be public or private, indirect or direct, and vary in terms of the intent, form and type, and timing and duration of employment of the adaptive measure (Smit & Skinner, 2002). The divide between private responsibility and public roles distinguish the types of adaptation which comes from different actors, and how they are implemented (Wreford, Moran & Adger, 2010). Although several adaptation measures might be suggested by research institutes and governments, the decision to adapt lies with the farmer or agricultural business. Yet, the farmers' private responsibility and decision-making for adapting to climate change are highly influenced by policy intervention. The farmers' decision to adapt and which strategy or option to use will, therefore, be influenced by various political, economic, and social drivers and constraints.

Agriculture is particularly sensitive to climate conditions, and a vulnerable sector to the risks and impacts of climate change. Adaptation in agriculture is therefore important to reduce the vulnerability of agricultural systems to risks associated with climate change (Smit & Skinner, 2002). Adaptation options in agriculture vary substantially based on several factors such as the involvement of different actors, the purpose, the geographical location of the farm, form and scale of impact, and type of agricultural production (Kurukulasuriya & Rosenthal, 2003). The type of adaptation option implemented is important to also fit the different impacts, as they could be from both climate variability, consisting of more rapid changes over a shorter period of time, or from gradual changes in average climate conditions, such as increased average temperature. Choosing which adaptation option to implement can, therefore, be a difficult decision as it depends on multiple factors.

The important role of adaptation as a policy response by the government has been recognized internationally and adaptation is now integrated into several international agreements (Smit & Skinner, 2002). Article 2.1b, for example, of the Paris Agreement, states that parties must increase climate change resilience and develop greenhouse gas reduction strategies "in a manner that does not threaten food production" (p. 3). In addition, has the KJWA decision been

acknowledged as an important step forward in the negotiations on agriculture within the UNFCCC (FAO, 2020). These agreements demand member parties to take action, which is visible in plans and strategies on national, regional, and local levels. As climate change covers multiple areas in society, cooperation across sectors will be necessary to achieve a robust agriculture. This can be challenging as there are several factors and elements influencing adaptation, and aspects to consider.

As a sector dependent on climate, and sensitive to climatic changes, agricultural adaptation will be especially important to reduce future vulnerability (Smit & Skinner, 2002). Farm-level decisions will depend upon and be influenced by various aspects and factors which will be either motivating or constraining in the process of agricultural adaptation. Determining what these are could uncover to which degree the various factors influence farm-level decision-making.

1.1 Delimitations of the study

Climate change is a broad topic that touches several aspects of society. It is therefore necessary to define the boundaries of the study. Discussions of climate change often focus on preventing further greenhouse gases or adapting to the changes. This is especially applicable to cases like agriculture, which is sensitive to changes in climate, but also contributes to greenhouse gas emissions. Both aspects are important in climate change work. This study will mainly concentrate on climate change adaptation but will mention greenhouse gas mitigation and reduction where relevant. This study's focus is on agriculture, defined as the cultivation of agricultural and horticultural crops as well as animal husbandry, excluding forestry which sometimes is included in the definition of agriculture. The study does not go in depth on one agricultural area but looks at the agricultural sector as a whole to get an understanding of how adaptation occurs in Rogaland. Although looking into one production area could provide a more detailed research of individual processes and adaptation options, this have been omitted due to the scope of the study. The geographical boundary of the study is Rogaland county, with a focus on agricultural areas. Nevertheless, decisions and work with climate change adaptation occurs at multiple scales and levels of governance and across territorial levels. Government initiatives will therefore also be mentioned where appropriate. Economics and psychological aspects will not be a big part of the study.

1.2 The structure of the study

In order to be able to say something about the perceptions and decision-making of Norwegian farmers, it is necessary to say something about the context in which the farmers are in. Farmers decision-making of agricultural adaptation is influenced by various factors and processes, involving different actors. Depending on the context can influencing factors of external and internal forces be either drivers or constraints of adaptation.

The thesis is structured in seven chapters. The first chapter introduces the topic and presents the problem statement and research questions. In chapter 2, relevant literature regarding farmers and their situation are reviewed. This includes expected changes in climate and effects on agriculture. The current framework for climate change adaptation is also presented in this chapter to view the role of public policy in agricultural adaptation. In chapter 3, perspectives on climate change adaptation, vulnerability and adaptation options is presented, and I consider the conceptual and analytical framework of this analysis. Chapter 4 describes the methodological choices that are taken, on what ground and how the data were collected, and the analysis has been conducted. Chapter 5 presents the findings in this thesis. In chapter 6 the findings are interpreted and discussed in comparison to the conceptual and analytical framework. In chapter 7 a conclusion is reached of the study.

2. Research context

This chapter will briefly address expected climate changes in Norway, Rogaland and predicted impacts on agriculture. Then essential documents of climate change adaptation are presented to display the connection between policies and plans on different governance levels. These documents are reviewed to get a perspective on how the responsibility of climate change adaptation is distributed and how adaptation in agriculture is considered in national and regional plans.

2.1 Expected changes in climate

Climate change is understood as changes in average conditions over longer periods of time, in global or regional climate which can be difficult to discover without long-term records, such as temperature increase, sea level rise and ocean acidification (CSIRO, n.d). Climate variability and weather are changes which occur more rapidly, but which can be affected by climate change.

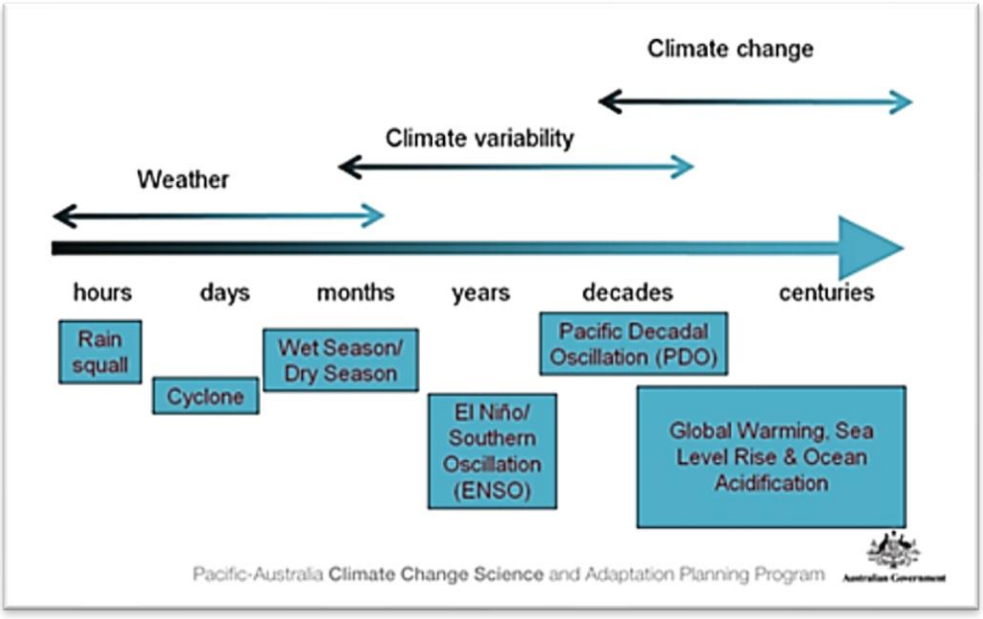

Figure 1: The timescales applicable to weather, climate variability and climate change (Pacific-Australia Climate Change Science and Adaptation Planning Program (PACCSAP) & Australian Government, n.d).

Although Norway, compared to other countries, is both less vulnerable and better equipped to deal with climate change, the climate is expected to change considerably during this century.

Main changes in Norwegian climate is expected to include increased temperatures and annual precipitation as well as increased frequency of some types of extreme weather events (NOU, 2010; Uleberg & Dalmannsdottir, 2018). Changes in climate will also vary greatly from region to region, reflecting the different climatic zones and the variety of the Norwegian landscape. Main climatic zones in Norway consist of temperate climate, polar climate and arctic climate (Uleberg & Dalmannsdottir, 2018).

Rogaland county covers all three climate zones in Norway, and changes in climate can vary between municipalities as well as internally in the municipalities (County Governor of Rogaland, 2011). In Rogaland episodes with heavy rainfall are expected to increase substantially in both intensity and frequency which will lead to larger and more cases of floods and landslides (Norwegian Centre for Climate Services [NCCS], 2017). Heavy storms, strong wind, increased precipitation and storm surge at the coast is also predicted to occur more frequently. Recent events, like the drought during summer 2018, have also shown lack of water to be a problem. Climate changes in Rogaland will therefore require agricultural planning and adaptation to both too much water and too little (Aamaas & Berg, 2019).

Increased probability		Possible increased probability	
Heavy rainfall	Episodes of heavy rainfall are expected to increase substantially in both intensity and frequency. This will also lead to more surface runoff.	Drought	Small changes in summer precipitation are expected, and higher temperatures and increased evaporation may therefore increase the risk of drought.
Rain floods	More and larger rain floods are expected.	Ice formation	Shorter icing season, more frequent winter ice floes and ice floes higher up in the waterways. Almost ice-free rivers near the coast.
Landslides, mud- and slush flows	Increased danger as a result of increased rainfall.	Avalanches	With a warmer and wetter climate, it will more often rain on snow covered ground. This can reduce the risk of dry avalanches and increase the risk of wet avalanches in landslide exposed areas.
Storm surges	As a result of sea level rise, storm surge levels are expected to increase.	Quick clay landslides	Increased erosion due to heavy rainfall and increased floods in rivers and streams can trigger more quick clay landslides.

Figure 2: Expected climate changes in Rogaland (adapted from NCCS, 2017).

2.2 Climate change effects on agriculture

Agriculture is a primary industry and is highly dependent on climate to produce commodities. Depending on the agricultural production, it could also be especially sensitive to interannual climate variability. In Norway, climate change could be both positive and negative for agricultural production. On the one hand, climate change could cause longer growing season and larger growing areas as a result of average temperature increase (Aaheim et al., 2009). On the other hand, could climate change cause increased precipitation which again could decrease growing season. Several factors influence growing season and agricultural production (such as rainfall, radiation, exposure, snow cover etc.) which reflects the complexity of the issue of handling climate change impacts. In addition to increased frequency of heavy rainfall, the evaporation rate could also escalate during the summer season. This could implicate agricultural production by reduced waterflow in rivers, longer periods with low groundwater levels and drought. Increased average temperature could also affect the survivability of pest populations during winter which could implicate spring crops and introduce new and unknown diseases (Schmidhuber & Tubiello, 2007).

Figure 3: A overview of the core area of agriculture in Rogaland (Rogaland County Municipality, 2013).

Rogaland is a large agricultural county in Norway given the good climatic conditions. Direct effects of climate change, such as increased temperature and longer growing season could provide flexibility and the potential for new species. However, heavy rainfall, strong winds, and increased precipitation could affect agriculture by increased runoff, and cause major damage to the soil and increased drainage requirements to use the soil (Aamaas & Berg, 2019). Increased runoff of pesticides, due to heavy rainfall, could increase the need in agriculture to use more pesticides.

Climate change also increases the risk of plant pests and livestock diseases which reduce productivity. In addition, are agricultural businesses and industries indirectly affected by climate change (e.g. input factors, such as

animal feed could become more expensive after weather events abroad) (Aamaas & Berg, 2019). In Rogaland, most of the agricultural land is concentrated in Jæren (figure 3). About 60% of the total production in Rogaland is located at Jæren (County Governor of Rogaland, 2018a). During 2018, in Rogaland, there was produced 8200 tons of grain, and delivered 5145 tons of sheep, 14648 tons of cattle, 30584 tons of poultry and 38528 tons of pig to slaughter for food (Statistics Norway [SSB], 2019). There are about 4000 farmers in Rogaland and agriculture makes it so that there are around 17000 jobs in the food industry in Rogaland (Rogaland County Municipality, nd.). At a national level, about 14% of all value creation in Norwegian agriculture takes place in Rogaland. Livestock production is the dominant mode of operation in the region, and the animal density is very high. Rogaland is the largest meat producing county in Norway with mainly livestock of poultry, pigs, cattle and sheep (SSB, 2019). Jæren is a major contributor to the national food production and has a high value creation from agriculture (Fadnes, Frydenlund & Mathiesen, 2019). Plant pests and livestock diseases could therefore be a big risk to the agriculture in Rogaland in the future.

Figure 4 and 5 display the development of precipitation over the last 119 years, and measurements in precipitation during different months the last four years at Jæren.

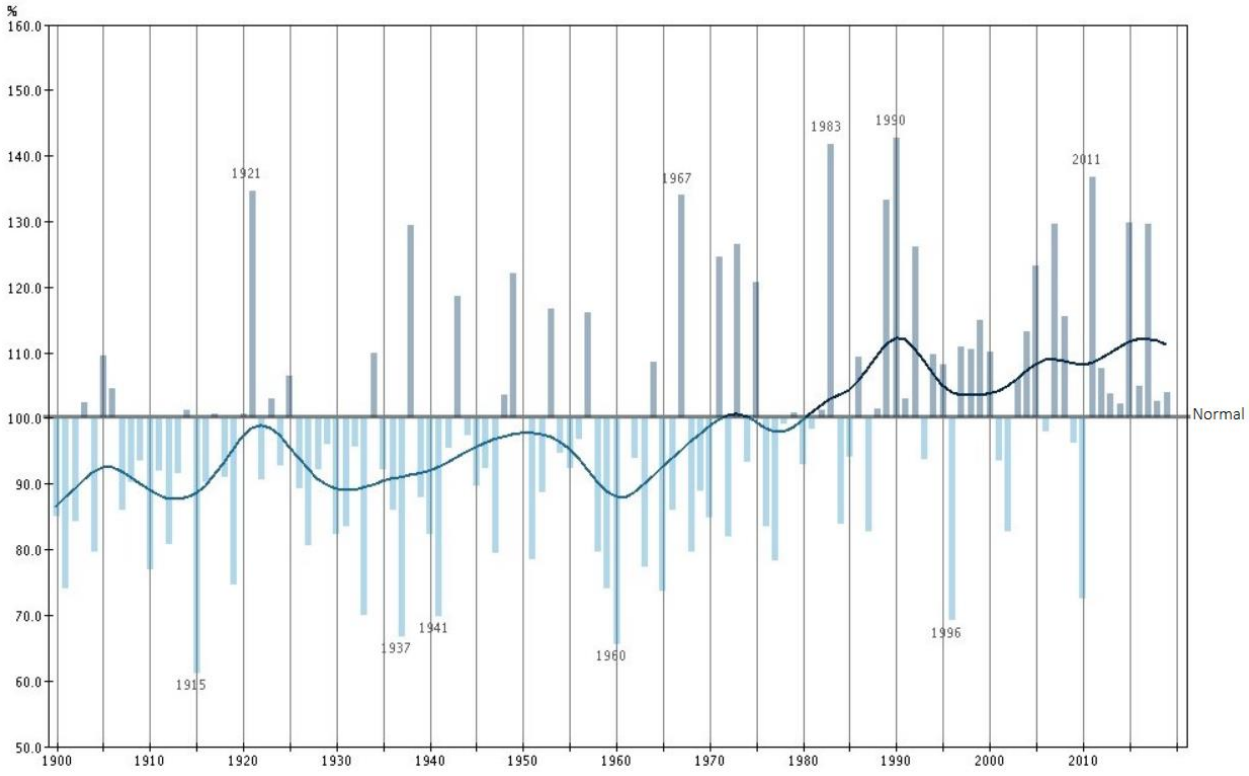

Figure 4: The development of precipitation in Western Norway over the last 100 years (The Norwegian Meteorological Institute, 2019)

Figure 5: Measurements in precipitation from Obrestad lighthouse at Jæren (adapted from NRK and the Norwegian Meteorological Institute, 2020)

2.3 The current framework for climate change adaptation

As climate change affects agriculture, it poses a threat to the global food production. This has led agencies, such as the Food and Agriculture Organization of the United Nations (FAO), to make international efforts to defeat hunger and achieve food security through strategies like adaptation (FAO, 2017). International agreements have also been developed to help countries speed up the process and achieve these goals. Partially binding objectives in these agreements put pressure on nations to make progress and changes in politics on climate change and adaptation. Reports from IPCC and the scientific understanding of climate changes in those reports are important elements to enable this progress in Norway's climate policy. In Norway, the Ministry of Climate and Environment has the overall national responsibility for environmental policy, including climate change adaptation (NOU 2010:10). Through the

national Climate Act of 2017, the government is committed to provide annual reports to the parliament on the status regarding how Norway is preparing for and adapting to climate change (Norwegian Ministry of Climate and Environment, 2018). Although the ministry of Climate and Environment has the overall responsibility, there is a basic principle in Norway's adaptation policy that the person or organization in charge of a sector, on a daily basis, is also responsible for adapting the business to current and future climate. This involves assessing the impacts of climate change and undertake action within their field (Norwegian Ministry of Climate and Environment, 2018). With individual or farm-level responsibility of adaptation to climate change, it could be difficult to oversee and report the national progress on adaptation in agriculture.

2.3.1 International agreements

The impacts of climate change on agriculture have been identified as possibly the most serious in regard to the number of people affected and the seriousness of effects on those least able to cope. It has been recognized that agriculture is especially vulnerable and that maintaining agricultural production is important in international climate change action (Wreford et al., 2010). In accordance to this concern, the ultimate objective of the UNFCCC is to stabilize greenhouse gas concentrations in the atmosphere to avoid dangerous anthropogenic interference with the climate system (UNFCCC, 1992). In the Convention, agriculture is recognized as especially vulnerable in terms of global impacts and article 2 of the UNFCCC (1992) state that action "should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" (p. 2).

The Paris Agreement (UNFCCC, 2015) from the Conference of Parties 21 meeting (COP21) of the United Nations Framework Convention on Climate Change (UNFCCC) was established to limit global warming and strengthen countries' ability to deal with the impacts of climate change. It encourages member parties to engage in adaptation planning processes and enhance national plans to include adaptation action (Article 7, UNFCCC, 2015). Norway has submitted several national communications related to climate change under the UNFCCC, with a growing recognition of the importance of adaptation (Norwegian Ministry of Climate and Environment, 2018).

As agriculture has gained more attention, measures such as the Koronivia Joint Work on Agriculture (KJWA) has been established. The KJWA under the UNFCCC, is a decision (decision 4/CP.23) that was reached at the UN climate conference (COP23) in 2017 to acknowledge the importance of agriculture and food security in relation to the discussion of climate change (UNFCCC, 2017). The KJWA invites Parties to submit views on elements to be included on methods and approaches for assessing adaptation, adaptation co-benefits and resilience. Norway's submission to the KJWA consider financial support, public incentives and support schemes for agriculture, sharing experiences and lesson learned, and cost-efficiency technology development and access to be some of the ways to advance the implementation of the outcomes from the KJWA (Chiriacò et al., 2019).

2.3.2 National policies

The report Adapting to a changing climate (NOU 2010: 10) and Storting White Paper No. 33 (2012-2013), *Climate change adaptation in Norway*, are two main documents on climate change adaptation on a national level. The report Adapting to a changing climate (NOU 2010: 10) is a national assessment of the impacts of climate change on Norway and recommendations from the committee for future action. In order to improve adaptation in agricultural industries, the committee states that plant varieties and technology has to be better adapted, management regimes needs to take into account the climatic impacts on ecosystems, and awareness and expertise of the consequences of climate change has to be improved (NOU 2010: 10). The White Paper presents similar recommendations and includes a range of multiple challenges agriculture might face in a changing climate (Norwegian Ministry of Climate and Environment, 2013).

Climate change adaptation in the agricultural sector has been discussed in more detail in the Storting White Paper No. 39 (2008-2009), *The climate challenges – agriculture a part of the solution.* The white paper lists specific targets for climate change adaptation in agriculture, including strengthening monitoring and reporting routines to monitor developments, facilitate plant breeding and variety development, strengthen monitoring and preparedness in relation to plant and animal diseases, and facilitate targeted research to gain knowledge on effective and environmentally friendly pest control measures for plant pests (Norwegian Ministry of Agriculture and Food, 2009). It also suggests measures to achieve these targets and other challenges in agricultural adaptation. Another white paper dealing agricultural policy, more in

general, is the Storting White Paper No. 9 (2011-2012), *Landbruks- og matpolitikken. Velkommen til bords* (in Norwegian only).

2.3.3 Regional plans

Regional plans and strategies are important to pursue national goals and to maintain good communication between different levels of governance. A main plan for climate change adaptation in Rogaland is the attachment to the regional risk- and vulnerability analysis (ROS), *Klimatilpassing i Rogaland* (County Governor of Rogaland, 2011). The analysis describes, in detail, indirect and direct climate change impacts relevant to Rogaland and agriculture, challenges that needs to be dealt with and potential adaptation measures. Suggested measures consist of approaches handled on various levels, from farm-level adjustments to policy change on a county level. It is the County Governors' task to pursue national environmental goals through guidance and coordination, and make sure that climate change considerations are followed-up in municipal plans (NOU 2010: 10).

At present, a regional plan for climate change adaptation in Rogaland is being developed which consists of three parts; a main document, an action program and a knowledge section (Rogaland County Municipality, 2020). It is a comprehensive project which deals with the multiple steps from planning to implementation, with the main goal of ensuring a sustainable society that is well prepared for, and adapted to, climate change. The plans vision is "together for a climate-robust and sustainable Rogaland" with sub-goals of knowledge and competence, well-functioning ecosystems and a climate-robust and adaptable society (Rogaland County Municipality, 2020, p. 5). According to the progress plan it will be adopted by the Rogaland County Council in October 2020.

3. Conceptual and analytical framework

This chapter will examine literature on climate change adaptation, drivers and constraints influencing farmers decision-making in agricultural adaptation and concepts which are significant for the problem statement and research questions to be answered.

3.1 Climate change adaptation

Several definitions of adaptation are found in literature on climate change. A widely used definition by the IPCC defines adaptation in human systems as adjustments to actual or expected climate to avoid damage or take advantage of beneficial opportunities (IPCC, 2014a). Another commonly used description of adaptation, in the context of climate change, is by Smit et al. (2000, p. 225) which refer to adaptation as "adjustments in ecological-social-economic systems in response to actual or expected climate stimuli, their effects or impacts". Adaptation to climate change is a broad concept which deals with a range of events with different forms and time horizons. It is often referred to as a process, but it could also be an action or outcome in a system in order to manage changing conditions (Smit & Wandel, 2006). Adaptation could therefore involve both building the adaptive capacity of a system and implementing adaptation decisions, in other words transforming that capacity into action.

Maani (2013) argues that climate change adaptation is understood as a 'wicked' problem since it is a relative 'new' challenge which requires collective learning and new models of decision making. Wicked problems are complex, difficult to solve, and involves several people and opinions. They are also interconnected with other problems and occurring at multiple levels in society. Similarly, could climate change adaptation in agriculture be looked at as a wicked problem as it is dependent on multiple actors, difficult to solve and interconnected with other problems.

International agreements and decisions, such as the Paris Agreement decided at COP21 in 2015, contain global goals which encourages international cooperation and puts pressure on countries to take responsibility at national, regional and local levels. Decisions made at such COP meetings and findings in the IPCC main reports provides guidance for national climate policy. National climate policy further passes on goals and expectations to regional and local levels of governance through for example national strategies and guidelines. Decisions made at local levels are thereby influenced by policies created by international and national circumstances,

and are not made in isolation (Shaw, Pulhin & Pereira, 2010). This influences how information is interpreted and translated into decisions, which in turn are affected by social context, individual characteristics, and direct experiences (Shaw et al., 2010). Adaptation, in other words, occurs at different but related levels, and is a multi-scalar process of multi-level governance concerned with the interaction of individual and collective behaviors. These behaviors in turn, act from the bottom-up and top-down in response to changing circumstances (Adger, Lorenzoni et al., 2009). It is thereby important to see climate politics and adaptive decisions in a larger context to understand the motivation behind decisions.

Regarding Norway's climate policy, it is the IPCC's definition of CCA that is commonly referred to in White papers and Norwegian Official Reports. It is also the one generally used in climate research, e.g. by CICERO, which, in addition to national policies, is what regional planning and decision-making often is based on. The IPCC divides climate change adaptation into three categories consisting of anticipatory, autonomous and planned adaptations (IPCC, referred to in Aall et al., 2018). The three categories vary by the timing relative to impacts. Anticipatory adaptations occur before climate change impacts are observed, while autonomous adaptations are triggered by change and climatic stimuli, and happen automatically. Planned adaptations are outcomes of deliberate policy decisions and adjustments based on a recognition that conditions have changed or are about to change (IPCC, referred to in Aall et al., 2018).

In unmanaged natural systems, species and ecosystems adjust in response to changing conditions, and adaptations happen autonomous. In human systems, adaptations will vary according to who's involved (either undertaken by private actors or public agencies or governments), the climate changes that bring about them, and their timing, functions, forms and effects (Smit & Pilifosova, 2001). Adaptations will also depend on the adaptive capacity of an affected system to manage the impacts of climate change. Adaptation is often viewed in comparison to mitigation, which deal with reducing the human causes of climate change. In practice, mitigation and adaptation are complementary actions in which both will be essential to address climate change challenges (Wreford et al., 2010).

3.1.1 Adaptive capacity

Adaptive capacity refers to "the capacity of a system to adapt to climate change, take advantage of the opportunities, and to cope with the consequences" (NOU 2010: 10, p. 62). The adaptive capacity of a system depends on several elements which could be influential or constraining.

These elements or ‘drivers’ or ‘determinants’ of adaptive capacity could be local, or they could reflect wider socio-economic and political systems (Smit & Wandel, 2006). These elements are also flexible and could, over time, lead to a decrease or increase in the adaptive capacity because of changes in economic, social, political and institutional conditions. The elements of adaptive capacity represent the systems base from which adaptation actions and investments can be made.

The adaptive capacity of a system could be influenced by factors such as for example political influence, kinship networks or household characteristics, managerial ability, and economic, institutional, social and technological conditions (Smit & Pilifosova, 2001; Smit & Wandel, 2006). These influential factors could affect each other, and access to one could lead to the acquisition of another. Such as economic resources could facilitate the implementation of a new technology (Smit & Wandel, 2006). Some might also play more important roles in some systems than others. For example, could a strong kinship network play an important role in a subsistence-based society, while play an absolutely different role in a developed world agribusiness context where institutional and financial structures affect the adaptability (Smit & Wandel, 2006). Smit and Pilifosova (2001) argue that economic resources certainly is a determinant of adaptive capacity and that economic benefits and costs are important parts of adaptation options.

The adaptive capacity of a system could be hidden and appear only when the system is exposed to the actual or expected changes in climate. A systems capacity to adapt is one of several components of its vulnerability, in addition to exposure to impacts and sensitivity. The concepts of adaptive capacity, vulnerability, resilience, adaptation, exposure and sensitivity are closely associated to each other and are widely used in global change science. Smit and Pilifosova (2001) state that many adaptive strategies identified to manage climate change effects involve technology (e.g. warning systems, irrigation, crop breeding). The lack of technology therefore has the potential to reduce the adaptive capacity by limiting the range of possible responses.

3.1.2 Vulnerability and resilience

How vulnerable a system is, is defined in terms of how sensitive and receptive the system is to harm from exposure of hazardous conditions and the system’s ability to handle, adapt or recover from the effects of those conditions (Smit & Wandel, 2006). The more exposed and sensitive a system is to changing conditions, the more vulnerable it likely is, compared to less exposed and

sensitive systems. Elements of exposure, sensitivity and adaptive capacity could vary based on place, system, timing, and form, and are all dynamic and vary over time.

Vulnerability research could identify the climatic attributes, sensitivities and elements of exposure, relevant to specific agricultural systems (Smit & Skinner, 2002). For example, could cultivated plants be more vulnerable to drought and heavy rainfall than livestock, which in turn might be more vulnerable to other attributes such pests and disease subsequent to temperature increase. This could influence farmers decision-making by revealing which features different agricultural systems are receptive to, and thereby what adaptations that are suitable. The purpose of adaptation is often seen as to reduce a systems vulnerability and enhance its adaptive capacity to expected or actual climate changes (Smit & Pilifosova, 2001), but adaptation can also be viewed in relation to sustainable development by providing broader benefits (Adger, Dessai, et al., 2009).

The adaptive capacity of a system depends on the resilience of these systems. Resilience is understood as the capacity or ability of social, economic and environmental systems to handle a damaging event by responding by preserving their basic function, identity, and structure while also maintaining the capacity for adaptation, learning and transformation (IPCC, 2014a). Resilient systems return to a predisturbed state without acquiring any long continuing fundamental change. Resilience in agriculture in the face of climate change and variability, therefore, depends on the scale, intensity and rate of change of the climate system, as well as the essential ability of ecosystems or communities to adjust to new circumstances (Lal, Harasawa & Murdiyarso, 2001).

3.2. Agricultural adaptation

Climate change adaptation is a broad concept which occur at a variety of scales, over different time horizons, and by various actors with different responsibilities. In agriculture, adaptation to climate change could differentiate in spatial scale (such as adaptation at plant, field, farm, regional and national level) and among the actors involved (individual producers, agri-business, and governments) (Smit & Skinner, 2002). Research on agricultural systems have contributed to developing a better understanding of the dynamics of agricultural production systems and their responses to climatic and non-climatic stimuli (Smit & Skinner, 2002). Agriculture is seen as a complex system, within which combined effects of economic, environmental, political and social forces drive change.

There is a lot of uncertainty surrounding climate change and the potential effects on agriculture. Uncertainties influence agricultural decision-making and the process of evaluating and implementing adaptation measures. Uncertainties regarding the assessment of climate change effects on agriculture, have been divided into three main categories (Wreford et al., 2010). The three categories consist of uncertainties around the rate and magnitude of climate change itself, uncertainties with the biological response of agricultural outputs and uncertainties concerning how society responds to expected impacts (Wreford et al., 2010). Uncertainties influence decision-making and could affect how and when adaptation measures are implemented. At a policy level, uncertainties are often perceived as a limiting factor for effective adaptation and an argument for continuing and improving predictions of future climate instead of making decisions and acting (Wreford et al., 2010). Another uncertainty in agriculture is the potential capacity of farm-level processes and farmers to adapt to climate risks. Unlike societal adaptation, where the assumption is that the level of economic development is the basis for adaptive capacity, experience, knowledge and dependency on weather sensitive resources could be more essential factors in agricultural adaptive capacity (Wreford et al., 2010). Despite continuing uncertainties, Wreford, Moran & Adger (2010) argue that society must take adaptation decisions, and that uncertainties are a reason for decision, not for delaying them.

While some research on impacts of climate change on agricultural productivity have tried to evaluate the combined response of agricultural systems to changes in water availability, temperature and elevated ambient CO2, with results indicating positive benefits, such as improved water-use efficiency and higher rates of photosynthesis, the overall picture is often disregarded in terms of other climate changes, like extreme events (Wreford et al., 2010). Although the third IPCC assessment (TAR) showed that extreme events and weather variability probably will have a larger impact on animal productivity than effects connected to average changes in climate, understanding the effects of both climate variability (including increased frequency in extreme events) and climate change together could be important.

3.2.1 The role of public policy in adaptation

Although agricultural production is the owner or farmers' private responsibility, thereby usually a bottom up initiative, agricultural outcomes are public goods which are necessary for the society. This creates a link to public policy roles and policy intervention in agricultural production and adaptation. Public policy roles can influence adaptive behavior and farm production practices through programs, laws, support initiatives etc. with a top down approach.

(Smit & Skinner, 2002). These influential elements are regarded as some of the external forces affecting farmers decision-making. The role for public policy, regarding adaptation, is argued to involve seven objectives (Aaheim et al., 2008). These consists of information, knowledge and learning, early-warning and disaster relief, facilitating adaptation in the market, mainstreaming climate policy, infrastructure planning and development, regulating adaptations spillovers, and compensating for the unequal distribution of climate impacts (Aaheim et al., 2008, p. 5).

Looking at adaptation options available, and existing adaptation processes and mechanisms is also dependent on the relationship between farm production practices and financial management, and public sector decision-making process (Smit & Skinner, 2002). For example, could the implementation of irrigation on a farm be constrained by existing water management regulations such as the legislation of water use rights (Loë et al. referred to in Smit & Skinner, 2002). In this sense, government decisions could be a limiting factor in agricultural adaptation.

Disaster risk management

Disaster risk management (DRM) is the process of adoption of policies, strategies and practices directed to avoid new conditions of risk, reduce current risks or to the preparation and response to disasters (Clements et al., 2011). Similarly, to climate change adaptation is DRM oriented at reducing the risk level or minimizing its effects. In agriculture, DRM initiatives have been put into action to limit impacts on food production. Initiatives include early warning systems, risk awareness and assessment, information provision, education and training, environmental management etc. (Clements et al., 2011). Climate change adaptation shares much in common with DRM in avoiding harmful impact from extreme events. One of the key differences is that DRM approaches are for the most part based on past experiences, while CCA focuses more on the future projections. Combining CCA and DRM initiatives as a holistic set of complementary actions with collaborations and coordination cross sectors could be significant when dealing with complex issues such as climate change (Shaw et al., 2010).

3.2.2 Decision-making

Decision-making is often viewed as a linear activity which starts with a problem, added with information which leads to a decision and implementation (Maani, 2013). In regard to adaptation as an action this could be relevant, but with adaptation as a process the steps might occur in a more cyclical fashion. Maani (2013) divides drivers and motivations for adaptive

decision-making into personal, organizational/institutional and political drivers. These represent a categorization of drivers divided by actors involved combined with intentions. The personal drivers consist of personal beliefs and worldviews on climate change, organizational or institutional drivers represent an influential group made up of the potential resistance and barriers to adaptation. Political drivers are the governmental and political agendas that drive national and global policies and politics (Maani, 2013). Agricultural adaptation is the result of farmers individual decisions influenced by climatic stimuli and non-climatic forces internal and external to the farmer (Smit & Skinner, 2002). Decisions are rarely driven by one force alone, but rather by combined influences of several forces made in the context of current economic conditions, public and institutional strategies, and of existing technology and social norms (Bryant et al., 2000).

Barth (1966) argues that it makes methodological sense to focus on choice. Choices are actions that make a difference (they have a consequence), and in a way they are the concentration (or point) where all the forces that affect a person are expressed simultaneously. He explains how social forms are created in and by opportunities for interaction and transaction. This is defined as the individual's opportunity situation, which is described as the circumstances of choice. Social forms can be understood as the results or outcome of social processes acting on a limited number of determinants (Barth, 1966). Social forms are constituted by a series of regularities in a large body of individual elements of behavior. These individual elements act as constraints and incentives on choice to which actions are evaluated and could e.g. be values in culture.

There is limited research on the process of adaptation in agriculture itself. Most research tend to focus on adaptation options available to farmers and governments, instead of looking at the likelihood of adaptation measures being adopted or the conditions under which such adaptations might occur (Smit & Skinner, 2002). Smit & Skinner (2002) argues that in actual adaptation decision making there are different roles and that decisions to adopt measures are rarely made relative to one risk alone, but in consideration to the mix of conditions and risks that affect decision-making. Decisions are also usually made in a dynamic way by trying and failing, an on-going process, and not made in a 'once-off' manner. Uncertainties regarding climate risks also tend to be an important influence depending on the farmers perception of those risks.

3.2.3 Worldviews and perceptions

Adaptive behavior and actions are partially formed by deeply embedded cultural and societal norms and values which at the individual level include beliefs, preferences, perceptions, worldviews etc. (Adger, Dessai, et al., 2009). Climate change poses several risks to agricultural productivity. The perception of what risk is, differs from person to person, between societies, and changes over time (Aaheim et al., 2009). O'Brien et al. (2012) state that there is a tendency to rather act on measures which are directed towards the short-term horizon, rather than those which lies some distance into the future and are perceived as uncertain. In other words that what is perceived as urgent is often prioritized. Peoples responses to climate change and variability will be based on the perception of the severity of the threat and the likelihood that it will affect them. Research from Norway has shown that in situations where individuals perceive no risk, little or no action is undertaken, described as complacency, meaning a lack of awareness of potential dangers and an accompanying self-satisfaction that no action is needed (O'Brien, Eriksen, Sygna & Naess, 2006). In another study from 2011 on how climate change will affect agriculture in Northern Norway it is found that changes in policy are at that time a greater challenge to farmers than changes in climatic conditions (Kvalvik et al., 2011). Due to direct negative effects of climate change on society in general, political action are taken to reduce greenhouse gas emissions, which turn into indirect effects of climate change which farmers also must adapt to. Farmers aren't necessary skeptical to direct climate change effects, but rather to the indirect effects such as political regulations and requirements (Kvalvik et al., 2011).

Research on adaptive behavior suggest that farmers' perception of climate change and variability are important factors in farm-level decision-making. Farmers pay a great deal of attention to climate variations, but not necessarily to long term changes in climate. Uncertain climate variations from year to year are risks which bring about adaptive behavior among farmers (Bryant et al., 2000). Yet, Granjon (referred to in Bryant, 2000) found that a common attitude among farmers were a skepticism about the reality of climate change and surrounding the rate of change in conditions. Perceptions of their own adaptive capacity could also be an influential factor of adaptive behavior among farmers. Bryant et al. (referred to in Bryant et al. 2000) found that farmers in Quebec had a high level of confidence in their ability to handle climate variability, except that from their point of view this also therefore applied to climatic change.

Similar to adaptation options, are innovations created to solve problems in a new or better way. Innovations are defined as ideas, practices or objects which is understood as new by people (Rogers, 1995). Rogers (1995) argue that people tend to surround themselves with innovations that fit their interest and attitudes, and that they will engage with new innovations only if they feel the need for it. In other words, the compatibility of the innovation to the individual's values, past experiences and needs. This could apply to adaptation options as well, as adoption of them could depend on farmers interest, needs and attitudes. If a farmer doesn't feel the need to implement an adaptation options, then it is not likely it will be adopted.

A study of U.S crop farmers showed that farmers' perceptions of risks to their own farm, attitudes toward innovation and adaptation attitudes were the most important determinants of adaptation (Mase, Gramig & Prokopy, 2017). Farmers, who believed in human contribution to climate change, tended to be more concerned about impacts to their farms than farmers who believe it was a natural phenomenon. The research also found that farmers' level of concern with on-farm risks, such as drought, extreme rainfall, insects and disease, was the most important factor in adaptation behavior (Mase et al., 2017).

Risk perception is one of various components, with different characteristic, which agricultural adaptation is dependent on and influenced by. Agricultural adaptation is also affected by components such as stresses on the systems, characteristics and scales of the system, and responses. These components of these frameworks are outlined in Figure 6.

Components of Agricultural Adaptation

Component	Elements or Examples
Stresses and their Characteristics	Climatic change and variability Government policies Consumer pressure Economic conditions Other environmental factors
Agricultural System Characteristics or Filters	Cultural Economic Institutional Political Social Technological
Scales of System Vulnerabilities and Responses	International National Agricultural sector Region Community, locality Farm, field, plant
Responses	Autonomous: crop choice, diversification, irrigation, crop insurance … Public and Institutional Policy: infrastructure, information, research and development, taxes and subsidies

Figure 6. Key components of agricultural adaptation (Bryant et al., 2000).

3.3 Adaptation options and strategies

Norwegian agriculture faces the challenge of climate change in coming decades. The impacts of higher average temperature, increased precipitation and increased frequency of extreme events all have implications for the Norwegian agricultural sector. Adaptation in agriculture transpire either individually by farmers, collectively by farmers and local institutions, or through national policy decisions. Policy decisions and government initiatives include providing research and development, finance, property rights or legal frameworks to enable action, individual or collective (Wreford et al., 2010).

Agricultural adaptation to climate changes is a process affected by several different agents, and formed and motivated by larger economic, political and social forces. Adaptation, in other words, does not take place independently at the farm level (Smit & Skinner, 2002). Kurukulasuriya and Rosenthal (2003) argue that argue that adaptation measures either are ex-post or ex-ante, depending on the timing of implementation of the measure in relation to changes in climate. Ex-post adaptations consist of adjustments made after an event has happened, to manage and cope with the impacts that has taken place, while ex-ante adaptations are implemented in advance of what is predicted to come (Kurukulasuriya & Rosenthal, 2003). These categories are similar to anticipatory, autonomous and planned adaptations by the timing of implementation, but require the decision maker to possess different kinds of information to function, either it being knowing what is coming for ex-ante adaptation measures or knowing what have occurred for ex-post adaptation measures.

As adaptation options have different characteristics they could be sorted in different ways. They could be classified and arranged based on the spatial scale in which they occur (macro and micro level), by the intent of the adaptation in temporal scale (short-term, long-term or neither), by the actors involved and or by several of dem simultaneously (Kurukulasuriya & Rosenthal 2003; Smit & Skinner, 2002). Smit & Skinner (2002) presents types and examples of adaptation options in Canadian agriculture divided into four groups based on the scale at which they are undertaken and at which the stakeholders are involved. These categories consists of (1) technological developments, (2) government programs and insurance, (3) farm production practices and (4) farm financial management (Smit & Skinner, 2002, p. 96). These categories differentiate according to actors involved, scale, form, intent and purposefulness, and timing and duration. Technological developments in agriculture could be crop development, weather and climate information systems, and resource management innovations. These developments

are most likely undertaken by research institutes, governments or private sector industries (Smit & Skinner, 2002). Government programs and insurance are institutional responses to the economic risks and could for example be subsidy and support, private insurance and resource management programs. Changes in farm production practices are most likely changes done by the farmer, but which could be stimulated or informed by government programs or industry initiatives. For example, changes in farm production (diversify livestock types and varieties etc.), land use (e.g. change the location of livestock production), land topography, irrigation and timing of operations (Smit & Skinner, 2002). Farm financial adaptation options are changes made to reduce income loss by using farm income strategies (both government supported and private). This could be done through crop insurance, crop shares and futures, income stabilization programs and household income. Smit and Skinner (2002) argue that these categories of adaptation options are often interdependent and that for example an adaptation technology developed by the government sector might be adopted to modify farm production practices.

These adaptation options have different characteristics which could relate differently to farmers and thereby influence their decision-making. With all the several aspects and attributes of adaptation it is important to have holistic approach when looking into the current status of adaptation strategies and what influences farmers decision-making in agricultural adaptation to climate change.

3.3.1 Barriers to climate change adaptation

Factors influencing farm-level decision making can act as barriers or limitations to climate change adaptation. Barriers are obstacles that can be overcome with coordinated effort, creative management, prioritization and change of thinking (Moser & Ekstrom, 2010). Unlike barriers, are limitations often looked at as obstacles that tend to be absolute in a real sense. Limits are traditionally analyzed as a set of unchangeable thresholds in biological, economic or technological parameters, but can also come from society. Many seeming limits, could also in fact be shapeable barriers (Adger, Dessai et al., 2009). Adger, Dessai et al. (2009) argue that adaptation efforts are not likely, in effect, limited by the lack of accurate and precise predictions about future climate conditions. This is because climate is only one of many uncertain processes that influence society and its activities, and climate predictions should therefore not be the central tool to guide adaptation to climate change (Adger, Dessai et al., 2009). In adaptation, the limits could also be the points at which the adaptation actions fail to protect things that

stakeholder value (Barnett et al., 2015). Barriers could occur in all stages of the decision-making, from the starting point of understanding the problem, looking into adaptation options and implementing one. Barriers could be personal to the decision-maker and or occur at a larger external level. In practice barriers and limits to adaptation could involve a lack of water, inadequate community engagement, lack of trusted relationships between communities, governments, and scientists, and lack of management structures with long-term perspectives, to mention some (Barnett et al., 2015).

Some systematic barriers to effective adaptation in Australia are identified as market barriers and regulatory barriers (Productivity Commission, 2012). Market barriers to adaptation could be limited availability or access to information about climate change and adaptation options, cognitive barriers preventing the decision-maker to take action, disincentives for self-preparedness, investment barriers hindering investment in adaptation, transaction cost and externalities (Productivity Commission, 2012). Regulatory barriers occur where regulations don't take climate change into account. Understanding the nature of barriers to adaptation is important in order to find ways of dealing with them.

Kurukulasuriya and Rosenthal (2003) claim that there can be conflicts between public and private objectives. National objectives could be to grow crops that are less water-dependent, but this does not mean that the crops necessarily are profitable to the farmer. This could create conflict between the public or national objective to save water and the private producer's objective.

3.4 Analytical framework of agricultural adaptation and its determinants

To use the conceptual and theoretical perspective described above, I have constructed an analytical framework to better categorize factors which drive or constrain farmers decision-making in agricultural adaptation. Farmers adaptive decisions are influenced by factors which can be categorized into two groups. These two groups represent the overall influential forces and the internal farm-level forces. These are drivers and constraints are not mutually exclusive and could have overlaps.

3.4.1 External forces

External forces represent factors which affect the agricultural system at large. This includes climatic stimuli, socio-economic and political influences, technology and socio-cultural factors.

Climate change and climate variability are climatic stimuli which pose risks to agricultural systems. Socio-economic and political influences include market access and government initiatives. Government initiatives could stimulate adaptive decisions through information provision, policies and financial resources such as insurance and support programs. Technology represent technological developments and innovations which can influence depending on the technology available and feasible and how they interact with political, social and economic processes. Socio-cultural factors are the larger cultural associations and forces which influence decision-making, such as social norms.

3.4.2 Internal forces

Internal forces represent farm-level characteristics and personal traits. Farm-level characteristics consists of local biophysical factors and farmers personal perceptions of risk and climate change, worldviews, values, attitudes and motivations. Local biophysical factors are features of the farm such as soils and topography, hydrology and type of agricultural production. The internal forces are factors which are more distinctive to the individual farmer.

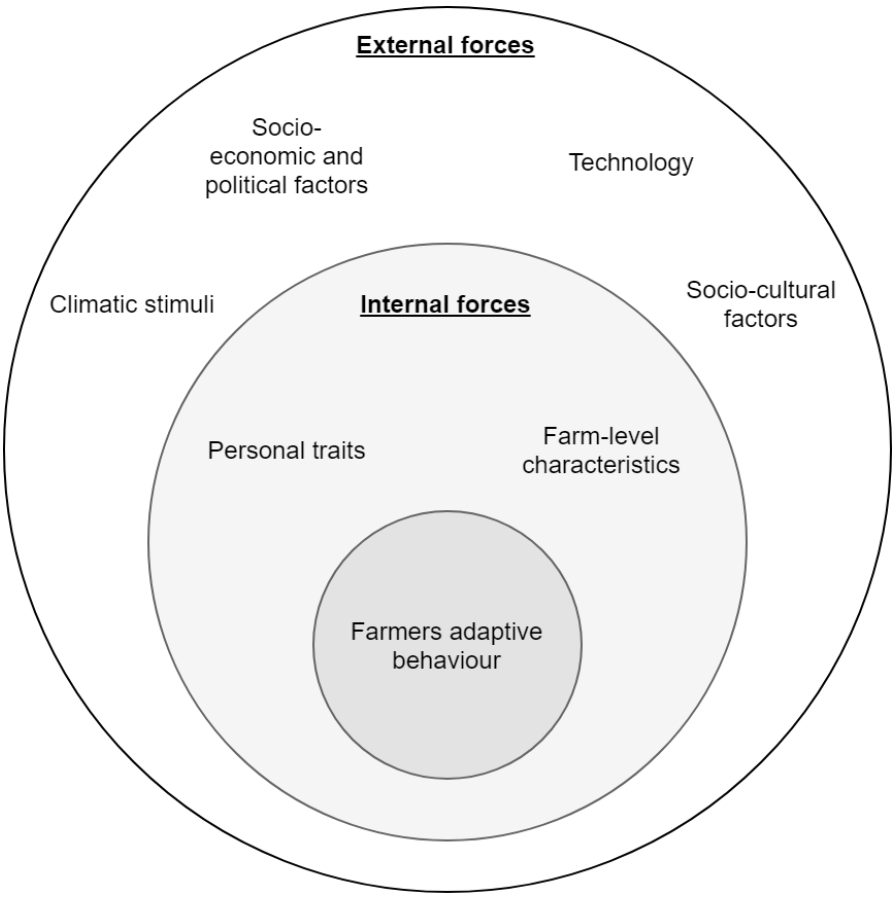

Figure 7: Drivers and constraints influencing farmers decision-making (author)

4. Methods and research design

In this chapter the chosen research design and method will be explained. Methods are techniques of data collection and analysis (Blaikie & Priest, 2019). I will focus on which techniques and choices I have made during this study.

4.1 Research design and strategy

The focus of this study is to understand the impacts of climate change on agriculture, how farmers adapt and what factors affect farmers decision-making in agricultural adaptation. The study has a qualitative approach. With a qualitative approach one can engage in and carry out thorough analyses of social phenomena, and achieve an understanding of it, which is an important goal with qualitative approaches (Thagaard, 2013). A research design is a document developed by the researcher, and used by the researcher as a guide or plan for how one should answer the questions raised in the study (Blaikie & Priest, 2019). The purpose of this study is to gain insight into and an understanding of how farmers in Rogaland view climate change and adjust to changing conditions.

This study will have a descriptive and explanatory design. It will be descriptive in the sense that I try to get an overview of how CCA is handled in Rogaland, which is necessary to answer the research questions. It will also be explanatory because I try to explain and understand the findings that I discover through my research.

A research strategy is the logic applied to be able to answer the research questions asked in a study (Blaikie & Priest, 2019). This study uses an approach which largely coincides with an abductive research strategy, in which a frame of interpretation is the foundation for the study (Danermark et al., 2002). I try to explain the social regularities which have been discovered but which have not been understood. The starting point of abductive logic is the lifeworld of the social actors being investigated. This consists of their construction of reality and way of giving meaning to their social world, which can only be discovered for the accounts they give (Blaikie & Priest, 2019). In this study I will attempt to discover the motivations and meanings that lie behind the actors' activities and actions.

With abductive logic the conclusion can provide new insights as the outcomes are the researchers interpretation or explanation combined with the help of theory (Danermark et al.,

2002). The conclusion could therefore be one of many possible conclusions as we relate ideas and knowledge differently to each other. In other words, abduction shows something that might be.

4.2 Scientific point of view

The concepts of ontology and epistemology refer to ideas about the nature of the world and social reality, and how knowledge of it can be accessed (Blaikie & Priest, 2019). My ontological assumptions are that I believe reality exist independently of social scientists. I believe climate change is occurring separately of peoples' perceptions, but that the climate threat is transformed into risk through our perceptions, values and knowledge of the world which constitutes the social reality. Social reality is 'relative' according to how individuals experience it at any given time and space.

My epistemological assumptions are that knowledge on drivers and constraints of agricultural adaptation must be seen in relation to the participants motives and meanings. Meaning arises in and out of our engagement with the realities of our world. What factors influence farmers decision-making in Rogaland must be discovered through engagement with their social reality and context.

4.3 Data collection

To answer my problem statement, primary and secondary sources of data are used. Primary data is data collected by the researcher while secondary data has been collected by someone else, and you use it in their raw form (Blaikie & Priest, 2019). Data have been collected through documents and interviews.

4.3.1 Documents

This study is particularly concerned with how policies and agreements on an international and national level affect farm-level decision making, and to which degree it plays a role in local agricultural adaptation. International agreements and public policies, with relevance to agricultural adaptation, have therefore been thoroughly reviewed to get an overview of what options farmers have and are available, and how these are presented. Documents as a source of data can be used to recognize phenomena among which connections are established (Blaikie & Priest, 2019). The content analysis is based on international agreements, national and regional

plans which are available to the public. In addition, have I looked into these documents' references and referrals to other relevant plans and documents. Some of the documents were referred to me by my informants, while some I found on my own.

International level	Paris agreement
	Koronivia Joint Work on Agriculture (KJWA)
National level	Meld. St. 33 (2012-2013) Climate Change Adaptation in Norway
	NOU 2010: 10 Adapting to a changing climate
	Meld. St. 39 (2008-2009) Agriculture part of the Solution
	St. Meld. Nr. 11 (2016-2017) Change and development - A future-oriented agricultural production
	Landbruk og klimaendringer [Agriculture and climate change] (2016)
Regional level	Regional plan for agriculture in Rogaland (2011)
	Regional plan for climate change adaptation in Rogaland (2020-2050)
	Climate change adaptation in Rogaland (2011) FylkesROS

Figure 8: The most important government documents used

4.3.2 Interview

In this study interviews were conducted to gain a deeper knowledge of local views and beliefs on climate change and adaptation. The purpose of an interview is to get comprehensive information about how other people experience their life situation, and what views and perspectives they have on topics addressed in the interview (Thagaard, 2013). Interviews provide a particularly good bases for gaining insight into people's experiences, thoughts and feelings.

The interview data has been collected through semi-structured interviews, which can be considered as conversations between the researcher and interviewee where the main topics are decided in advance, but the order of the topics is determined along the way (Thagaard, 2013). A benefit with semi-structured interviews is that the researcher can elaborate on topics that the interviewee bring up, but which the researcher had not thought of in advance, while still ensuring that the topics that are important in relation to the issue are discussed during the

interview (Thagaard, 2013). Semi-structured interviews are flexible and provide the researcher with the ability to elaborate on new topics that the interview bring up, but which were not planned in advance.

The interviewees were selected through strategic selection based on their qualifications which are important in relation to the problem statement and the theoretical perspectives of the research (Thagaard, 2013). I have interviewed two farmers from Rogaland based on their profession and background in the agricultural sector. Both are members of the Norwegian Agrarian association and a part of the Rogaland County Board. The Norwegian Agrarian Association works to improve the conditions for agriculture and make the importance of agriculture visible to society. I have also interviewed two informants from the County Governor of Rogaland, which can be describes as "information-rich individuals". One informant is employed in the department of agriculture, and the other informant is employed in the department of environmental protection. These individuals were interviewed because they work in departments which are relevant to what I am researching, which includes agriculture, climate change and adaptation. By interviewing both farmers and policymakers I could gain insight on both the public and private perspectives on agricultural adaptation to climate change. Below is an overview of the informants and what their position is.

Informants from the agricultural sector	
Farmer 1	Female. Runs a dairy farm and operates a machine station, rental driving, with tractors.
Farmer 2	Male. Runs a dairy farm, a little forestry and grassland.
Informants from the County Governor of Rogaland	
Informant 1	Male. Employed in the department of agriculture.
Informant 2	Female. Employed in the department of environmental protection.

Figure 9: Overview of the informants interviewed

During my research the Covid-19 virus was discovered, and it rapidly spread across borders. This led nations, including Norway, to close borders and limit contact between people to reduce the risk of infection. Due to this the interviews were conducted by videocalls through internet, and regular calls when videocalls were not possible. All informants preferred calls with video,

but in two cases the technology did not allow so. The interviews lasted from 30 to 60 minutes. The interviews were sound recorded with the approval of the interviewees, received in advance of the conduction of the interviews. The advantage of sound recordings is that the researcher can concentrate on the interviewee and their reactions, and that everything that is said is preserved (Thagaard, 2013). After each interview the sound recordings were transcribed, anonymized and then deleted. Notes were also taken during the interview to have some key points which could help arrange the analysis.

4.4 Data analysis

Through a content analysis of documents, data have been coded into categories to identify phenomena among which connections are established. The data has been analyzed by coding and categorizing the material in order to describe my findings. My approach is both theme-centered and person-centered, as attention is focused on both topics and situations in the material (Thagaard, 2013). In the process of coding and categorizing, the collected data have been given designations of sections of data with terms that express the meaning of the text. The interviews were transcribed and then divided into different topics, while data from the secondary sources were sorted by different topics by using the software NVivo. This was done to find recurring themes, to be able to go in depth on individual topics and to analyze topics across the material. I have gone through the data material several times to find topics regarding adaptation options and influential factors on farm-level decision-making.

4.5 Research quality

Validity and reliability are usually viewed as methods to evaluate the quality and credibility of scientific research. Validity is measures by the degree instruments measure what they claim to measure, while reliability is concerned to which degree measurements could be replicated (Blaikie & Priest, 2019). However, the concepts of validity and reliability have been criticized and deemed not suitable as universal markers of quality in qualitative research. The reliability and validity of research studies is particularly important in qualitative work, where the researcher's subjectivity can overshadow the interpretation of the data. Thagaard (2013) argue that the researcher must argue for reliability by explaining how the data has been developed during the research process, and validity by asking questions about whether the interpretations one arrive at are valid in relation to the reality we have studied.

Validity in qualitative data is related to the interpretation of data and the genuineness of the interpretations the researcher arrives at (Thagaard, 2013). Miles & Huberman (1994) explains this as internal and external validity in which internal validity may be defined as the degree to which findings are presented in a study recognizable to those from which the findings come from. External validity refers to the transferability or fittingness of the research which can be checked by looking at whether the conclusions can be generalized and if they are transferable to other contexts (Miles & Huberman, 1994).

In my thesis the findings and the subsequent discussion of the material have been presented separately to display the informants' own information independent of the researcher's interpretations of the participants accounts. My role, during the data collection, was not completely unbiased as I had a theoretical framework prepared in advance of the interviews and which partially determined which questions were asked. The aim of this study has not been to generalize the findings, but rather to gain insight and understanding of the phenomenon I explore. My informants were also not randomly sampled, they all had a connection to the phenomenon being studied. I considered these informants relevant to the stated research problem the thesis has sought to address.

Reliability, in qualitative research, can be described as whether a critical assessment of the project gives the impression that the research has been carried out in a reliable and trustworthy manner (Thagaard, 2013; Miles & Huberman 1994). In other words, the credibility of the research. This can be achieved through transparency of the research process. In this thesis I have described the methodological bases that has guided my research throughout, and the sources have been made explicit. Concerning the reliability of my informants and their social accounts, my purposes for my interviews could have affected the replies given to the questions asked.

4.6 Research ethics

In social research, human participation is common to advance the understanding of social life. Nevertheless, intervening in people's lives has the potential to also cause them harm (Blaikie & Priest, 2019). Conducting a research ethically correct involves, among other things, being transparent and honest, not falsifying information and accept responsibility of one's own work.

In this study the thesis proposal, interview guides and consent forms were reviewed and approved by the Norwegian Centre for Research Data (NSD). The NSD is a national archive which provides data protection services for all Norwegian universities and university colleges. All research projects carried out at universities in Norway, which require the processing of personal data, are subject to notification. Before conducting my interviews, I gained informed consent from my informants through a consent form which explained the purpose of the project and information about the informants right to withdraw from participating at any time, and that their identities would be kept anonymous.

The informants are relevant to me because of their profession and job position. Their jobs are directly linked to climate change adaptation and adjusting to changing conditions are a big part of their daily practices. They are also relevant to me because of their experiences and knowledge of the agricultural sector. In the interview situation, the ethical problems are particularly related to the researcher's considerations about how personal and approachable the questions being asked are (Thagaard, 2013). Initially, my problem statement was not sensitive or private, but during the interview some of the questions became personal as it was talk about the future.

5. Findings

In this section findings from the data collection will be presented. This chapter is partially arranged according to the analytical framework and the headlines are implicitly structured around the research questions. National and regional policies are reviewed to understand the public role in agricultural adaptation and what adaptation options are available for farmers in Rogaland. In addition will the data received from the informants be presented here to see which factors influence adaptive decisions and how climate change is perceived. This chapter will only present the findings, while in the next chapter, chapter 6, the findings will be discussed against the analytical perspective.

5.1 Organization and responsibility

Norwegian environmental and climate policy is characterized by a sector principle which means that various administrative sectors must contribute to and ensure that national environmental and climate goals are met, and that the goals are reflected in the day-to-day operations (Brobakk, 2017). At a national level, the informant from the department of environmental protection mentioned that the responsibility for coordinating climate change adaptation topics has been moved from the Norwegian Directorate for Civil Protection (DBS) to the Norwegian Environment Agency. In general, at a County Governor level, the responsibility for climate change adaptation issues lies with the department of civil protection. At the same time, does the County Governor follow the principle of responsibility. The department of agriculture is therefore responsible for climate change adaptation issues in their branch, with some cooperation with the department of civil protection. The County Governor also has a good coordination with the County Municipality. The informant from the department of agriculture in the County Governor of Rogaland mentioned that there had been an increase in assignments related to climate change adaptation the last couple of years, and that they were currently organizing a climate coordinator in office, with an internal appointment to a person dedicated to climate challenges, including climate adaptation.

The County Governor of Rogaland and the Rogaland County Municipality provides information about climate change and adaptation options in agriculture in Rogaland through for example risk and vulnerability analyzes. They also provide guidance through policies and plans. One of the most important regional policy management documents for the development of agriculture in Rogaland is the regional plan for agriculture (Rogaland County Municipality,

2011). The regional plan for agriculture in Rogaland represents regional agricultural policy and displays goals, strategies and measures to strengthen agriculture in all regions of Rogaland. Goals related to agriculture and climate change adaptation include improving soil structure and getting plant cultures adapted to climate challenges (goal 48) and enable society in general and agriculture in particular to deal with various crisis situations (goal 50) (Rogaland County Municipality, 2011). The strategy of goal 48 is to build competence on cultivation methods and crops adapted to changing climatic conditions. For goal 50, the strategies include strengthen the municipalities' preparedness for outbreaks and management of animal and plant diseases, increase social preparedness and preparedness among farmers to be able to handle disease outbreaks. Different areas of responsibility within these goals are passed on to municipalities and administrative bodies such as the Norwegian Food Safety Authority or given to the County Governor of Rogaland.

The informant from the agricultural department in the County Governor of Rogaland mentioned that there was good cooperation between the county and the agricultural industry. In addition, is there a collaboration between the County Governor, County Municipality, Norwegian Agrarian Association, Norwegian Farmers and Smallholders Union, Rogaland forestry industry forum and Innovation Norway. All the actors who work with and for agriculture have a network that meets several times a year, in relation to discussing common challenges. In June 2019, the Norwegian Agrarian Association and the Norwegian Farmers' and Smallholders' Association entered into a climate agreement with the government. This agreement focuses on greenhouse gas reduction with goals of increasing carbon uptake in agriculture over the next ten years. The informant from the department of agriculture also mentioned that there were in general more attention aimed towards mitigation, but that focus on adaptation has increased in the last couple of years.

A desire within the County Governor of Rogaland is to rather work with climate change adaptation measures which are aimed at being ahead of events. As the informant from the agricultural department in the County Governor of Rogaland told:

> We do not want, as in 2018, to use 4 people to work with climate compensation for reduced yields. It is much better to work with climate change adaptation on measures that is in advance. And get the compensation schemes halved and rather work with climate adaptation. (Informant 1 from the agricultural sector).

Agricultural policy in Norway has four overarching goals which consists of food security, agriculture across the country, increased value creation and sustainable agriculture with lower greenhouse gas emissions (Norwegian Ministry of Agriculture and Food, 2016). These goals are connected to climate change adaptation, and good adaptation is a key prerequisite for achieving environmentally sustainable agriculture.

5.1.1 International agreements

International agreements and goals are mostly mentioned in white papers, policies and plans on a national level. Such as with the Paris Agreement, are Norway's goals listed as our contribution to the agreement (Norwegian Ministry of Agriculture and Food, 2016). In terms of this agreement are goals of greenhouse gas reduction mentioned more often than goals of climate change adaptation. Norway's undertakings in adaptation planning are submitted through the Seventh National Communication which describes Norway's status on vulnerability assessments, climate change impacts and adaptation measures (Norwegian Ministry of Climate and Environment, 2018a). The report describes roles of responsibility but does not go very much in depth on specific measures and adjustments that can be made in different sectors. In regard to agriculture, it does aim attention at the importance of providing knowledge, financial support, systems and services to improve agricultural practices. Genetic diversity and plant breeding are also mentioned as some important measures.

The Climate Change Act (2017) shall promote the implementation of Norway's climate goals as part of the transition to a low-emission society in Norway in 2050. In relation to climate change adaptation, the act states that the government shall account for how Norway prepares for and adapts to the climate changes (Climate Change Act, 2017, § 6 b). This was done for the first time in 2018 in the form of a statement entered as part of the Norwegian Ministry of Climate and Environment's budget proposition (Norwegian Ministry of Climate and Environment, 2018b). Yet, in the budget proposal it is stated that in the climate work, climate measures shall be given higher priority than climate adaptation in order to contribute to the follow-up of the Paris Agreement in the recipient countries (Norwegian Ministry of Climate and Environment, 2018b). The act relating to food production and food safety (Food Act, 2003) also indirectly addresses climate change adaptation through requirements of notification and implementation of measures related to plant and animal safety. The act states that everyone must exercise the necessary care so that there is no danger of the development or spread of plant

pests and no danger of developing or spreading infectious animal disease (Food Act, 2003, § 18-19).

Specific international agreements are rarely literally mentioned in plans and documents on a regional level. The goals and ambitions in international agreements are instead passed on to a regional level through national guidelines (e.g. through national expectations regarding regional and municipal planning). In the ongoing regional plan for climate change adaptation in Rogaland the UN's sustainable development goals (SDGs) are highlighted, and it is described how they are implemented in the regional plan (Rogaland County Municipality, 2020). The UN's 17 SDGs are leading for Norwegian development policy towards 2030. The SDGs put ecological, economic and social development in context, and adaptation to climate change must be seen in connection with the other goals. In regards to adaptation, the ongoing regional plan emphasizes sub goal 13.1 and 13.2 which is about strengthening the ability to resist and adapt to climate-related dangers and natural disasters, and strengthen institutions and individuals ability to counteract, adapt and reduce the consequences of climate change by strengthening knowledge and raising awareness (Rogaland County Municipality, 2020). The informant from the department of environmental protection in the County Governor of Rogaland, told that the SDGs and agreements like the Paris Agreement, although not always literally mentioned in regional plans and policies, were continually in the mind of the policymakers at the county level. The SDGs, especially, were a focus in the process of decision-making and development planning. In the regional plan for agriculture in Rogaland, sustainable agriculture and the sustainable use of resources are important elements.

The informants from the County Governor of Rogaland were familiar with the Paris agreement and the sustainable development goals, but as adapting to climate changes in agriculture is the farmers decision alone the County Governor of Rogaland cannot demand farmers to implement certain strategies or uphold international agreements. The integration of international agreements in regional plans and policies were more evident through topics regarding mitigation. For example, was the Paris agreement and its main target to keep global warming well below two degrees compared to pre-industrial times, mentioned specifically in the climate agreement between the government, the Norwegian Agrarian Association and the Norwegian Farmers' and Smallholders Association.

The informant from the department of environmental protection mentioned that taking care of bodies of water, such as swamps could be a better adaptive measure than implementing new waterways through drainage and trenching.

5.2 Farmers perspective of climate change and threats

The informants from the agricultural sector mentioned that they viewed the decrease in red meat consumption, or in other words trends in the consumer market, as a challenge for the future. This was recognized as a threat to agriculture in Rogaland, and a climate related challenge as less and less people might want to eat red meat because of its high carbon footprint. This is well illustrated in the following interview excerpt:

> We have two climate challenges in agriculture. Cause we have the big climate challenge that many people do not want to eat red meat anymore, and the one which is about CO2 accounting. (Informant 1 from the agricultural sector).

CO2 accounting was regarded as a challenge in relation to requirements from the government to cut emissions in agriculture, such as stated in the climate agreement from 2019. Both informants expressed a concern regarding climate change and said that it is necessary to not only focus on greenhouse gas reduction, but that it is important to also acknowledge that climate variabilities are getting more extreme and adapt to those. One of the informants from the agricultural sector mentioned: "*What one encounters most in one's own everyday life on an ongoing basis, is that with trenching and adapting to drought and rain in a way". (Informant 2 from the agricultural sector).* This was especially important with regard to heavy rainfall and increased precipitation as this was seen as the greatest threat to agriculture in Rogaland in terms of direct climate change effects. Long periods of excessive rain and increased precipitation were particularly challenging as this could create small time frames to do jobs such as fertilizing or harvesting. The use of heavy machinery in such periods also created a dilemma as they could do the job faster, but the risk of soil compaction was increased. Knowing what to do and how to act in situations such as the wet conditions in 2017 and the drought in 2018, and in general being a good agronomist was viewed as an advantage on several areas. As one of the informants from the agricultural sector said, *"To be professionally good at what one does, you get it back, even in an extreme situation."* (*Informant 2 from the agricultural sector).*

There were some ambiguities around climate change adaptation such as when asked about short-term climate measures done in agriculture one of the informants from the agricultural sector mentioned that farmers usually have a long-term perspective but said that:

> It is clear that more and more people are looking at the e.g. solar cell, and you evaluate your fuel consumption regularly. Basically, we could have gone over to and use only biodiesel on the tractors, but it is a huge investment because it is twice as expensive as regular diesel. (Informant 1 from the agricultural sector).

According to the informants from the agricultural sector, there is some skepticism in the agricultural community surrounding the reality of human induced climate changes. It was stated that this was a minority and that most farmers acknowledged climate change as a reality. One of the informants also added that *"Those who choose to 'close their eyes' to climate change will eventually have problems maintaining operations at the level they have been". (Informant 2 from the agricultural sector).*

In terms of direct climate change effects, it was mentioned by the informants from the agricultural sector that wet weather and increased precipitation was viewed to be the biggest farm-level challenge on agriculture in the future. Wet conditions prevent the farmer from operating in the field, whether it is fertilizing or harvesting. It also makes it unfavorable to use heavy machinery as this could lead to soil compaction. Soil compaction further damages the living conditions for earthworms which one wants to keep in the soil as they increase nutrient availability, drainage and stabilize the soil structure. However, climate change (or changes in climate variability) was also perceived as an opportunity as it was mentioned that changes in climate also could benefit agricultural productivity. Climate change can lead to a longer growing season. This can increase the potential for yield, if one manages to utilize it, the informants from the agricultural sector stated. An example of this that was given, was this year's growing season. The farmer said:

> My neighbor has kept rainfall statistics for many years. He recorded a rainfall record in July this year. But we have had good weather periods both at the 1st haymaking and now at the 2nd haymaking. In other words, one has received a lot of water when one wasn't going out to work in the meadow, but when the

> time for harvest came, the conditions for driving on the fields were good. (Informant 2 from the agricultural sector).

Climate change was not perceived as only negative, but that it depended on the timing of the weather events in relation to timing of operations. But if such as in 2017, when the wet weather lasted for so long it was impossible to harvest. The farmer added *"If you do not get long enough periods with good conditions for harvesting, and at the right time during the growing season, then it does not help that the crop grows well." (Informant 2 from the agricultural sector).*

In relation to the collaboration between government initiatives and the agricultural sectors, it was mentioned that there exist some support schemes and compensation, but these weren't perceived as 100% good enough. The climate agreement between the government, the Norwegian Agrarian Association and the Norwegian Farmers' and Smallholders Association also provides some funding and support for research and for the implementation of environmentally friendly measures, but it sets certain requirements and goals for the agricultural sector in terms of reducing greenhouse gas emissions. Most of the climate measures mentioned dealt with greenhouse gas reduction. In general, despite climate challenge with CO2 accounting, the informants experienced it as if both the County Municipality and the County Governor were supporting and cheering on the farmers. Adaptation in agriculture was regarded by the informants from the agricultural sector as the individual farmers own decision, influenced by ideology, beliefs and economy rather than something imposed by the government.

It was said, by one of the informants from the agricultural sector, that the direct effects of climate change and variability were the absolute strongest factor influencing their decision-making. In addition, were a mix between governmental subsidies and support schemes, personal preferences and direct climate change effects also perceived as influential factors in the farmers decision to adapt to climate change. One of the informants told:

> It is a motivation in itself to find good solutions for the operation, which are suitable for how the climate develops. Taking advantage of the benefits of a changing climate, and at the same time find solutions to the problems or challenges. (Informant 2 from the agricultural sector).

5.2.1 Previous weather-related events

All four informants mentioned the summer of 2017 and the summer of 2018 as especially difficult summers for the agricultural sector. The summer of 2017 was exceptionally wet with extremely high tide on agriculture, and several farmers were not able to harvest their crops. Following the summer of 2016 which also was pretty wet, 2017 became particularly difficult for farmers. According to a report by Bunger & Hillestad (2019), a total of 67 million Norwegian kroner was paid in crop failure compensation in 2017, with 4.8 million of this going to grain production. With 2017 being a difficult crop year on Jæren, many farmers had problems getting the roughage crop harvested. This probably also had effects on milk production as 2017 showed poor results for milk production at Jæren, with an agricultural income reduction in milk production of 19% from 2016 to 2017, as reported by Berger et al. (2020). The summer of 2018 on the contrary, was unusually dry and very demanding for many actors in the Norwegian agricultural sector. It was stated by one of the informants from the agricultural sector that:

> There are very many who bought irrigation systems after 2018, so it is clear that when one has had it so bad and looked at dry soils, one has thought that this is not something I want to experience again, and then taken preventative measures so that it does not happen again. (Informant 2 from the agricultural sector).

The informant from the department of agriculture in the County Governor of Rogaland said that there were large challenges with of not getting enough water and stated that: *"It was perfectly fine to drive and perform tasks, but the grass did not grow. Extreme feed shortage." (Informant from the County Governor of Rogaland).* 2018 was also affected by the lack of harvest from the previous year because of the wet weather. According to the Norwegian agriculture agency (2019), grain production was halved compared to the previous year, while grass crops on a national basis were 74% of normal. Less roughage led to an increased need for concentrates for cattle which resulted in a huge increased import. Import of other agricultural products such as hay and straw were also record high, showing an increase of 4,5% in import of agricultural products to Norway in 2018, reported by the Norwegian agriculture agency (2019). According to Norwegian Ministry of Agriculture and Food (2019), the Norwegian agriculture agency paid out 1.6 billion kroners in crop damage compensation, during 2018, to farmers affected by the drought. Still some Norwegian farmers are struggling with the aftermath of the drought of the summer 2018.

Although the summer on 2018 was very damaging for farmers across the country, a discovery was mentioned by one of the informants from the agricultural sector. During the winter when there is frost on the ground, the agricultural land usually cracks. This provides better air circulation and is necessary to make things grow. With climate change and warmer temperatures, this happens less often. This was mentioned as a concern by the farmers for future soil quality. Yet, with the uncertainties regarding biological responses to climate change, it could be difficult to know how the soil will react to warmer temperatures. One of the informants from the agricultural sector in Rogaland said: *"It was seen that during the 2018 summer drought, something happened to the earth so that it cracked up in a different way than what one is used to around here. That is very positive." (Informant 1 from the agricultural sector).*

5.2.2 Adaptive capacity and barriers

The informants from the agricultural sector in Rogaland viewed farmers as adaptable but said that those who choose to ignore the changes would struggle in the future. In a research by Skarbø and Vinge (2012) on agriculture in western Norway and perspectives from the industry on indirect and direct effects of climate change, farmers adaptive capacity is discussed. It is stated that farms which have a more diverse production could be better equipped to adapt than those that have a one-sided production. In addition, are farmers who only work part time on their farm looked at as more adaptable since they can increase their focus on other sources of income. According to the report, the lack of education is also seen as a barrier of adaptation among the farmers on the west coast, since the farmer possess less basic knowledge of biological processes, and in terms of thinking innovatively and creatively in regards to changing conditions (Skarbø & Vinge, 2012). Education was also mentioned by the informant from the department of environmental protection in the County Governor of Rogaland and it was stated that in comparison to other counties, few farmers in Rogaland have a higher degree. It was mentioned that this was as something that affects perceptions of climate change, but that there also is a big difference in where farmers live within the county and this affects perceptions too. By the informants from the agricultural sector, it was mentioned that knowledge and being a good agronomist was an important factor which increased the adaptive capacity. Technological innovations were also mentioned by the informants as an element which could make agriculture more adaptive, if the price was right.

The adaptive capacity is based on several traits which similarly could be barriers if they reduce the adaptive capacity. According to the report on perspectives in western Norway, economic

resources were found to be one of the main barriers of climate change adaptation (Skarbø & Vinge, 2012). In addition, were the investment that had been made, been put into machines and equipment which would make it easier to run the farm. Technological developments, such as trenching or drainage of agricultural land, requires large investments, which can make them less sought after. This was stated by the informants from the agricultural sector in Rogaland as well and one of them elaborated *"Finance will always be an element in adaptations. New machines cost money. Drainage costs money, irrigation costs money." (Informant 2 from the agricultural sector).* Several climate measures, for both greenhouse gas reduction and CCA, were said to be expensive and could be demanding economically for farmers as they are self-employed and controls their own accounts and profits. In terms of their own opinions or experiences on barriers to climate change adaptation, one of the farmers mentioned that financial resources, along with efficiency requirements, is what often made it difficult to find adaptation solutions suitable to the changing climate. Economy and efficiency requirements were two topics that were understood by the informant as interconnected.

One of the informants from the agricultural sector mentioned that basically, farmers are a part of social security, i.e. critical task, and must be at home and continue to produce and continue as normal in for example cases of crisis such as the corona pandemic. One challenge in relation to this crisis that was brought up, was that quite a few uses foreign labor in demanding productions, typically vegetable production, which require a lot of hands. The informant said:

> So, then it is much more demanding to get enough labor or possibly train Norwegians in those things there. In general, Norwegian agriculture is based on family farming, farms where the family runs it, so then it is quite robust in the first place. (Informant 1 from the agricultural sector).

The fact that farms in Rogaland often are driven by a family and a family business was also mentioned as something that made them robust and increased the adaptive capacity.

5.3 Adaptation options in agriculture in Rogaland

Adaptation measures are developed based on expected impacts presented in climate projections. Various adaptation options suit different impacts and can be put into action through a range of adjustments. In Rogaland the average temperature is expected to increase, along with increased annual precipitation and the risk of drought. Adaptation to individual factors can be analyzed

and to a certain extent planned for, but when several such events occur in critical periods, it becomes more unpredictable and more difficult to plan for.

5.3.1 Technological measures

One of the farmers from the agricultural sector mentioned that they believed new technological innovations would be important in the future in order to be able to run the agricultural land or farm efficient. Specifically, it was mentioned robotization in agriculture and how light machines could take into account the challenges posed by climate change while also operate efficiently. The informant stated that *"A machine basically does not need breaks to rest, this provides other opportunities for efficiency, even if productivity per working hours are not very high." (Informant 2 from the agricultural sector).*

Crop and plant development

A warmer climate could provide better conditions for harmful organisms, which could involve pests and diseases reproducing at a higher rate and the introduction of new and unknown diseases. An adaptation suggested in relation to the risk is the development and breeding of crops. Plant breeding and processing has in several publications and parliamentary proceedings been suggested as an important measure to increase agricultural resilience towards future climate changes (St. Meld. Nr. 39 (2008-2009); Norwegian Ministry of Agriculture and Food, 2016; Seehusen et al. 2016). Plant breeding could increase plant varieties resilience towards threats like pests and make them thrive in warmer and wetter conditions. According to the County Governor of Rogaland, is plant breeding and processing necessary for the plants to be able to be grown under different climatic conditions (County Governor of Rogaland, 2011). The development of plants could also make them more suitable and robust to other threats such as changing conditions. Graminor AS (graminor.no) is a leading actor in the development of plant varieties to the Norwegian climate and contribute to ensuring that the Norwegian agriculture have access to plant varieties fitted for a changed climate (Norwegian Ministry of Agriculture and Food, 2016). The informants from the agricultural sector mentioned plant breeding as an important measure but said that it took some time to breed and develop plants. It was therefore also looked at as a long-term measure, and one which was generally carried out by research institutes and not something farmers themselves usually participated in. Except for testing different sorts out. Farmers choose which plants they purchase, and the informants said that if new crop types look promising it can be something they try out.

Weather and climate information systems

In Meld. St. 21 (2011-2012) Norwegian climate policy, the government pointed out that it will strengthen the knowledge base in the climate area and increase climate research. Multiple weather and climate information systems have been developed to provide daily weather predictions and seasonal forecasts. The Norwegian Meteorological Institute has the national responsibility for monitoring the atmospheric climate in Norway and informing the public with future changes (Norwegian Ministry of Climate and Environment, 2013). It is a Norwegian governmental agency subject to the Ministry of Climate and Environment. The Norwegian Meteorological Institute provides daily weather forecasts through the website yr.no, which is a collaboration with the Norwegian Broadcasting Corporation (NRK). Yr.no shows detailed weather forecasts hour by hour, and several days ahead. The Norwegian Meteorological Institute also offers services on landslide and flood warning through the website varsom.no, weather history, information on questions people might have in relation to climate and weather, and information on how the climate probably will be in the future. Information on future and expected climate is provided through the Norwegian Centre for Climate Services (NCCS), a collaboration between the Norwegian Meteorological Institute, The Norwegian Water Resource and Energy Directorate (NVE), the Norwegian Research Centre (NORCE) and the Bjerknes Centre for Climate Research. The NCCS was established to present data on climate and hydrology in a way that would make it easier for government levels to conduct necessary analyzes of consequences and possible adaptation measures, and thereby provide a decision basis for climate change adaptation in Norway (Norwegian Ministry of Climate and Environment, 2013). At a regional level, the NCCS has prepared separate climate profiles for each county to display more local impacts of climate change, and what each county might expect.

Farmers pay close attention to the weather and the informants mentioned yr.no, storm.no and pent.no to be the most used services for daily weather updates. These systems were used regularly and was clearly an important aspect of day-to-day operations on the farms. The websites storm.no and pent.no are similar to yr.no, and likewise provides daily weather forecasts, hour by hour and several days ahead. In terms of the development stage of e.g. how far the grass has come, one of the informants from the agricultural sector mentioned the Norwegian agricultural extension service as a crucial source of information for soil treatment and when to mow the grass.

According to the report "Landbruk og klimaendringer" (agriculture and climate change) by Hohle et al. (2016) another important system for agricultural production is the online warning and information service VIPS (www.vips-landbruk.no), which was developed for integrated pest and disease control in agricultural and horticultural crops. The service is especially aimed at farmers and advisers in Norwegian agriculture (VIPS, 2020). VIPS was developed by NIBIO and the Norwegian Agricultural Extension Service and has provided warnings since 2001. Similar to VIPS, is Terranimo (www.terranimo.dk) a model for prediction of the risk of soil compaction due to agricultural field traffic, and a helping tool to reduce this risk (Hohle et al., 2016).

5.3.2 Government programs and insurance

In the regional plan for agriculture in Rogaland it is stated that *"Information and knowledge are two important factors when it comes to dealing with climate change."* (Regional County Municipality, 2011). One such information source is the report "Landbruk og Klimaendringer" (Agriculture and Climate change) which was developed and submitted in 2016 by Hohle et al. (2016), a climate committee appointed by the Norwegian Ministry of Agriculture and Food. The report contains recommendations for emission reductions and climate adaptations in agriculture and is a collection of existing and new knowledge about possible measures for emission reductions and climate change adaptation in agriculture. Based on the IPCC's findings in AR5, the report provides a broad knowledge of the challenges and opportunities agriculture will face in a changing climate (Hohle et al., 2016). Main adaptation measures recommended consists of plant processing or breeding, measures for wetter conditions, adaptation of fertilization and tillage, technical measures to shield fruit and berry production, plant health, adaptation of environmental measures and adaptations in livestock production (Hohle et al., 2016).

At the regional level, an information source which can be useful for farmers is risk and vulnerability analyses (fylkesROS) prepared by the County Governor of Rogaland. ROS analyzes shall form the basis for spatial planning, crisis preparedness, supervision and exercises. A more detailed analysis attached to the risk and vulnerability analysis from 2011 focuses on climate change adaptation and gives an overview of possible challenges different sectors may face in the future and how they can prepare for it. The analysis claims that effects of climate changes, especially temperature increase, could increase the risk of pests and diseases on plants and animals in the future. It also describes the main physical damages on agriculture

to be changes in growing season and crop, soil compaction and erosion due to heavy rainfall, drought and temperature increase (County Governor of Rogaland, 2011). The analysis suggests several measures that should be implemented in order to handle these challenges.

In relation to climate change and impacts, farmers can apply for compensation or subsidy for their agricultural business from the Norwegian Agriculture Agency. Farmers can get compensation in the event of crop failure and in the event of a failure in honey production (Norwegian Agriculture Agency, 2020a). This only applies to damage that is caused by climatic conditions and for which it is not possible to take out private insurance. The informant from the agricultural department in the County Governor of Rogaland pointed out that after the drought in 2018 there had been unusually many applications for compensation for crop failure and many billions of kroners had been paid out. According to the informant from the agricultural department, there is a 30% deductible on the compensation, and in 2018 farmers therefore had quite a large loss despite the support scheme. One of the informants from the agricultural sector expressed their view and said: "*It is based on some average numbers in what the crop should be so therefore, if you operate better than average, you do not get full for it." (Informant 1 from the agricultural sector).*

Farmers can also get subsidy to drainage of agricultural land (Norwegian Agriculture Agency, 2020a). This is an important step in adapting agriculture to a changed climate with more heavy rainfall and precipitation. Good drainage reduces the risk of erosion from agricultural land and thereby contributes to good water quality and a good water environment. Well-drained soil also emits less nitrous oxide than water-saturated soil. Subsidy to drainage is given to farmers who own or rent agricultural land that has previously been trenched, and to measures such as systematic trenching, profiling and unsystematic trenching.

At a national level, The Climate and Environmental Program (KMP) provides project grants for knowledge development, studies and information measures within climate change adaptation, greenhouse gas emission, soil aquatic environment, biodiversity and cultural monuments (Norwegian Agricultural Agency, 2020b). Anyone who works with knowledge development or knowledge dissemination can apply for grants from the KMP. At a regional level, each county has its own environmental program with a selection of environmental measures one can receive grants to carry out. The measures are decided based on what the County Governor sees as the biggest environmental challenges in his county. In Rogaland, the

Regional Environmental Program (RMP) for 2019-2022 is based on the environmental challenges discussed in the Regional Rural Development Program. Some of the main environmental challenges presented are loss of biological diversity, pollution and greenhouse gas emissions. Climate change adaptation is not literally mentioned, but within certain sections there are requirements equivalent to climate change adaptation. Such as within the operation of grazing, there is requirements that farmers shall organize effective and proper supervision and collection of their own animals, adapted to local conditions (County Governor of Rogaland, 2019).

Similar to the RMP, are grants also given for special environmental measures in agriculture (SMIL). SMIL are about implementing environmental measures beyond what is expected of normal agricultural operations. The purpose of SMIL is to promote the natural and cultural heritage values in the agricultural landscape and reduce pollution from agriculture. Grants from the SMIL scheme mainly apply to one-off measures, while in the RMP scheme, annual grants can be given. The RMP and SMIL were mentioned by all four informants as support schemes for farmers.

The informant from the agricultural department also mentioned that Innovation Norway provides support and services to the agricultural sector, such as investments and business development in agriculture. Innovation Norway contribute to innovation in the business community and the development of competitive Norwegian companies.

At a national level, the government is working to modernize the regulations to prevent and combat animal disease. With about 25% of livestock production in the country, Rogaland must pay extra attention to challenges related to animal health. In Rogaland, a measure suggested to prevent or limit the spread of animal disease is to improve notification routines and communication between the Norwegian Food Safety Authority and relevant regional agencies (County Governor of Rogaland, 2018a). Everyone is responsible for avoiding the spread of animal diseases, and for notifying the Norwegian Food Safety Authority in the event of suspicion of a contagious animal disease that could have significant social consequences. Early detection and effective measures to deal with an outbreak can reduce the costs of spreading disease and the possible use of antibiotics. Good systems for finding the source of infection and who is infected are also essential for good management of a crisis, and the Norwegian Food Safety Authority has worked hard to get this in place (County Governor of Rogaland, 2018a).

5.3.3 Farm production practices

Adjustments in farm production practices involve changes in practices on a farm-level, but which could be stimulated or informed by government or industry initiatives. Depending on production type and location, changes in farm production practices could be changes in land use, land topography, implantation of irrigation, changes in timing of operations and changes in farm production (Smit & Skinner, 2002). Rogaland is a county with generally a lot precipitation, which is expected to increase in the future, but it is a county which can also expect increased risk of drought (NCCS, 2017). Adjustments in operation to wetter, but also drier conditions are therefore important.

Farm production

The informants from the agricultural sector mentioned that thinking about what type of machines are used and one's own machine use is an important adaptive measure. One of the informants said that "*to think through the use of machines and how one can get things done with perhaps lighter machines, is also a measure each individual must see the opportunities of on their farm." (Informant 2 from the agricultural sector).* This was mentioned as especially important when conditions were wet. The use of heavy machines increases the effectiveness, but it also increases the risk of soil compaction. Both informants from the agricultural sector mentioned that they managed one or more type of production besides running a dairy farm. According to the report on agriculture and climate change by Hohle et al. (2016), are the switch in growth choices that better withstand wetter conditions, an important adaptive measure towards increased precipitation. This adaptation is based on development and refining of plants. The report also states the use of different planning tools to be an important measure, such as using VIPS and Terranimo to easier make quick decisions.

At an Agricultural Policy Conference held in Stavanger in 2017, called "Klimasmart landbruk – Parisavtalen ned på jorda" (Climate smart agriculture – Paris agreement down to earth), several ideas and suggestions were presented in relation to issues surrounding climate change and agriculture (County Governor of Rogaland, 2017). According to some of the presentations at the conference, were precision agriculture displayed as possible solution for production in Norway. Precision agriculture is a type of smart farming which uses advanced technology to observe, measure and respond to inter and intra-field variability in crops. This has been put

forward as an important measure to realize the potential for increased production under a changing climate (Hohle et al., 2016).

One of the informants from the agricultural sector said: "*One must cultivate the earth in a good way and bring out the potential in the earth" (Informant 2 from the agricultural sector).* According to the report on agriculture and climate change, tillage is among the most important cultivation technical measures necessary in agriculture and changing the method and timing of tillage can affect the soil structure and development of pests, which further affects the need to use pesticides (Hohle et al., 2016).

Drainage and trenching

According to the analysis on climate change adaptation in Rogaland, one of the main problems in agriculture is insufficient trenching. Most drainage measures in agriculture in Norway are dimensioned for the climate as it was before 1980 (County Governor of Rogaland, 2011). Drainage includes many measures to remove water both on the surface and below the soil, while trenching is generally perceived as digging or laying drainage pipes. One of the informants from the agricultural sector said that an important adaptive measure is increased focus on waterways in the terrain, and increased focus on drainage and trenches. The informant further stated that: *"In daily operations, I would say that it is more important than ever to 'be on the cutting edge'. In other words, be ready to perform a planned work task when weather and conditions allow this." (Informant 2 from the agricultural sector).* The informant also mentioned that they were currently trenching on their own farm to make sure the water flows away.

According to the report on agriculture and climate change, has drainage of agricultural land a direct effect on production opportunities and it is a prerequisite for safer food production (Hohle et al., 2016). Other advantages of a well-drained fully cultivated soil are good utilization of added nutrients, better plant growth, reduced soil compaction and runoff, reduced greenhouse gas emissions and better utilization of the growing season. The informants from the agricultural sector mentioned that trenching helps in the long run and one of them added that *"In the short term it has at least no financial gain because it costs quite a lot to trench, and it takes quite a few years before you can say that you have recovered that cost." (Informant 1 from the agricultural sector)*. According to the informants from the agricultural sector and the informant from the department of agriculture in the County Governor of Rogaland, farmers in Rogaland

can get subsidies for trenching and drainage of agricultural land. Support for trenching and drainage is both about spreading knowledge among the farmer and using financial means. After the wet summer in 2017, applications for drainage subsidies have increased and the County Governor of Rogaland had to apply, for the first time, to the Norwegian Directorate of Agriculture for an additional allocation of drainage funds (County Governor of Rogaland, 2018b). Trenching was mentioned by the informants as a common adaptive measure in the agricultural sector, and an important measure mostly in the long term.

Irrigation

According to a report by Molteberg and Vågen (2016) on agriculture and affects by climate changes, it is stated that after major development in the 1970s, there has been little activity in relation to new irrigation systems in Norway. With a change in climate towards longer periods of drought, the development of new irrigation systems may become more relevant in some production areas (Molteberg & Vågen, 2016). The informants from the agricultural sector mentioned that, after the dry summer in 2018 several farmers had installed irrigation systems. Another measure against dry seasons was to ensure that the plants, in the dry years, had become accustomed to having long roots that got hold of the water that was far down.

5.3.4 Farm financial management

To reduce the risks of climate-related income loss, farmers can have private insurance which is suited to the type of agricultural production. The informants did not mention any specific insurance programs, but as mentioned could they get compensation for some types of climate change impacts on agriculture.

Household income

Of the two informants from the agricultural sector, one was a farmer fulltime and the other one had a part-time position elsewhere. This was not mentioned by the informants from the agricultural sector as a conscious adaptive measure to be more prepared for future climate changes.

6. Discussion

In this chapter findings will be linked and compared to the perspectives in the conceptual and analytical framework. This chapter is structured by the research questions presented in the introduction.

6.1 How is the threat of climate change interpreted by farmers and policymakers within the agricultural sector in Rogaland?

Both informants from the agricultural sector expressed a concern for climate change, although in general the biggest climate challenge towards the agricultural sector was mentioned as changing consumer trends and the risk of reduced red meat consumption. Consumer trends are not something farmers necessarily can control or do something with, which might be reason for why it is perceived as a bigger challenge than other climate change effects. Of direct climate change effects, the farmers expressed that wet weather and increased precipitation was their main concern. It was mentioned as a concern because of its potential to prevent them from doing their job and working out in the fields. It was not expressed as a big risk in terms of direct impacts on the agricultural land, although it was said by one of the informants from the agricultural sector that they were currently trenching on their farm which suggest that direct climate change effects is a problem impacting agricultural systems as well. This also supports the view the informants from the agricultural sector in Rogaland had of the agricultural sector as adaptable. The weather and climate, and changes in this is a big part of the day-to-day work of farmers and something they are used to adjust to. Nevertheless, how it changes also has a great impact on their everyday lives. Changes in climate can create varied weather patterns and increase the frequency of extreme events, which could be a bigger challenge in the future. There was more focus on short-term changes in climate variability and weather as this was mentioned as a challenge in several occasions, while long term changes in climate, such as temperature increase, was not mentioned. As O'Brien et al. (2012) argues, is there a tendency to rather act on measures which are directed towards the short-term horizon, and delay those that lies some distance into the future.

Past experiences of the drought in 2018 and the wet summer in 2017 also indicated that more extreme climate variations was a concern among farmers for the future. Long term changes in climate such as temperature increase, appeared to be recognized as less critical than short-term or seasonal changes. Although there was an acknowledgement of the differences between long-

term (climate change), short-term (climate variability) and weather, these categories seemed to a bit merged. Changes in climate variability were mostly brought up. Despite some farmers being skeptical about the reality of climate change, it was expressed that most farmers believed it.

At the County Governor of Rogaland and in regional plans the focus is on both long-term changes in climate, especially temperature increase, and changes in climate variability, particularly expected changes in Rogaland such as increased precipitation and increased frequency of extreme events. This reflects the County Governors desire to rather work with preventive measures in advance of incidents, instead of working with coping measures after an event, as the informant from the department of agriculture mentioned. Within the County Governor of Rogaland, the two informants acknowledged the threat of climate change and viewed it as an important subject within policymaking. They also expressed commitment to CCA in agriculture, although this in the end is the farmers decision and responsibility. From regional policies and plans, it seems like more attention is given to mitigation action than adaptation initiatives. Nevertheless, was CCA in general a growing field. Farmers are faced with complex choices. Climate change adaptation in agriculture certainly fits into the category of a wicked problem. It is a relative new challenge there is some lack of knowledge about. There is also a lot of uncertainty surrounding the effects of climate change and how different systems might respond. This correlates with Maani (2013) description of a 'wicked problem'. In Rogaland, of the available climate change adaptation initiatives, a lot of effort on a policy level is focused on improving predictions of future climate. This could be because of the uncertainties of climate change, as Wreford et al. (2010) claims. Nevertheless, the regional plan for CCA in Rogaland is based on a precautionary principle to reduce the uncertainties in extrapolations or information about the future (Rogaland County Municipality, 2020).

In a way, political support schemes could be viewed as sort of a barrier since the informants from the agricultural sector mentioned they did not perceive them as 100% good enough. CO2 accounting was also mentioned as a climate challenge, which indicates some feeling of restriction by policies. On the other hand, did they also say that they felt the government were cheering them on and not limiting or restricting them through political regulations and goals such as those in the climate agreement. This contrasts with what Kvalvik et al. (2011) found about political regulations being a great challenge to farmers, and that farmers therefore were skeptical towards it.

6.2 How are international agreements, such as the KJWA decision, implemented in regional governance?

International agreements are more often mentioned in national policies and white papers than in regional plans and policies. Although the Koronivia decision is relatively new, it is not mentioned anywhere on the government or County Governor of Rogaland webpages or in any plans. The SDGs and the Paris agreement on the other hand, was mentioned by the informant from the department of environmental protection, and the regional plan was also directly linked to two of the sub-goals of the UN SDG goal no. 13. The informant also mentioned that decisions at a regional level were often taken with these international targets and decisions in mind, which consists with Shaw et al. (2010) statement that decisions at local levels are influenced by policies created by international and national circumstances, and not made in isolation. International agreements are followed up on a national level and recontextualized to national circumstances which are further passed on to regional and local governments. In Rogaland, climate change adaptation is a topic that is gaining more attention by policymakers and by individuals. Regional initiatives and plans play an important role in agricultural adaptation in Rogaland. The role of public policy in the county, involve certain objectives of providing information and risk and vulnerability analyses, warning-systems and compensation and grants. This partially correlates with Aaheim et al. (2008) statement that the role of public policy, regarding adaptation, involves seven objectives, consisting of information, early-warning, facilitating adaptation in the market, mainstreaming climate policy, infrastructure planning, regulating adaptation spillovers and compensation.

6.3 What are the drivers and constraints shaping farmers decision-making in agricultural adaptation to climate change?

To answer this question, the figure of influential factors presented in chapter 3.4 will be used, which looks at decision-making in connection to external and internal forces.

6.3.1 External forces

By the informants from the agricultural sector, direct climate effects were perceived as the most influential factor on their decisions to implement adaptation options. Climatic stimuli, especially wet weather and increased precipitation were perceived as likely changes that would happen in the future. It was also a very influential factor in farmers decision-making of agricultural adaptation. New technological innovations were also perceived as an influential

factor and one which could make agriculture more adaptable, if the price was right. Several of the adaptation options developed by the government are connected to technological adjustments adopted to modify farm production practices, such as subsidies for trenching or drainage. This supports Smit and Skinner (2002) argument that categories of adaptation often are interdependent. Government subsidies for measures such as trenching and drainage, were very influential and large drivers for those measures being implemented.

6.3.2 Internal forces

Personal traits such as past experiences were a highly influencing factor in implementing adaptation options. Past experiences with severe damages on agricultural land, such as the drought in 2018, was such difficult times and something farmers did not want to experience again. Perceptions and attitudes of climate change were also an influencing factor on farmers decision-making, as skepticism of climate change were viewed as a barrier to adaptation.

Knowledge and education were another internal force in farm-level decision-making, based on the farmers personal attributes. The level of knowledge farmers had of biological processes, changes in climate and impact, influenced their concern and view of adjusting, and their decision of agricultural adaptation to climate change. Having little knowledge were seen as a constraining factor as it limited farmers from knowing what to do when incidents occurred and or knowing what one could do in advance in terms of preventive efforts. The farmers interviewed said they would try new innovations such as new crop types if they looked promising. Not necessarily because they needed it, but because they wanted to help the scientists who developed it. This is not consistent with the findings of Rogers (1995) who claims that people only will engage with new innovations if they feel the need for it. New innovations influenced decision-making and could be a driver of adaptation if it looked promising.

Adaptation in agriculture in Rogaland are driven by multiple external and internal forces, particularly climatic stimuli, climate change perceptions, past experiences and government initiatives. This corresponds with Bryant et al. (2000) which argues that decisions rarely are driven by one force alone, but rather by combined influences of several forces.

6.3.3 Barriers to agricultural adaptation

In Rogaland, the main barriers to adaptation seem to be a mix of the lack of economic resources, climate change perceptions, education, and lack of agronomic knowledge. In addition to climatic conditions, is agricultural adaptation in Rogaland influenced by various economic, technological and social processes. These processes are formed by different actors and constitute uncertainties in agricultural adaptation. This supports Adger, Dessai et al (2009) argument that adaptation is affected by many uncertain processes and is therefore not limited by the lack of information of one of them.

Another issue which could be barrier to agricultural adaptation, is conflicting interest between individual farmers and goals or target set by the government. A warmer and wetter climate could for example increase the need to pesticides in agriculture. This can be conflicting with the government's goal of reducing the use of pesticides in agriculture to get a more environmentally friendly food production, which corresponds with Kurukulasuriya and Rosenthal (2003) statement that there can be conflicts between public and private objectives in agricultural adaptation, which could be a barrier to adaptation.

6.4 How is the agricultural sector in Rogaland adapting to climate change?

In Rogaland, farmers are adjusting to changing conditions by both continually using tools such as weather information systems or warning systems and implementing technologies in a once-off manner such as irrigation systems. This corresponds with Smit and Wandel's (2006) definition of adaptation as a process, action or outcome in a system in order to manage changing conditions. Farmers adapt based on their own assessments of risk and vulnerability. These assessments can be affected by adaptation strategies at a regional level, but will also take place independently of such strategies, in other words autonomously. The perceptions by the informants of expected direct climate effects in Rogaland corresponds with the descriptions in regional plans. This could indicate that the available information on e.g. the County Governor's webpage is also used by farmers and an influencing factor on their perception of climate change.

At a farm-level, adaptation measures are often implemented in an ex-ante or autonomous way, in response to impacts that have occurred or are occurring. Farmers seemed to be more reactive than proactive despite good access to information, knowledge and predictions of future changes. This seemed to be because of the uncertainties surrounding future climate change effects, as

experienced in the past with great differences and contrasts from year to year, such as with 2017 and 2018. Such as after the drought in 2018, many irrigation systems were implemented in an ex-post way, in which the farmers had knowledge of what had occurred and adjusted accordingly for future events. It was also due to the sometimes-large economic investments that are necessary to implement these adaptations. Economic resources were often mentioned and a big part of farmers ability to handle changing conditions. Adaptation options was continuously evaluated against expenses, government grants, benefits and profits. This correlate with Smit and Pilifosova (2001) statement about economic resources being an important factor in adaptive capacity and an essential part of adaptation options. A combination of climatic stimuli, economic considerations and past experiences are all considerable influential factors affecting farmers decision-making in Rogaland. Decisions are, such as Smit and Skinner (2002) argues, taken in consideration to several risks, including climate risks and the risk of income loss.

Every farmer's or public employee's opportunity situation is different, as Barth (1966) states. Each choice the farmer has to make is also a reflection of what they want to achieve, what values they have, what resources they have available (money, technology, education, insight, information, network, personality, etc.). Choices of climate change adaptation are actions that make a difference and have a consequence. They are the point where all the forces that affect the farmer are expressed simultaneously. This correlates with Barth (1966) argument of social forms which are outcomes of social processes, or the result of climate change adaptation, acting on a limited number of determinants.

Adaptations at a government level in Rogaland, on the other hand, are generally planned and implemented in an ex-ante way, in advance of what is predicted to come. Adaptations from research institutes, such as plant breeding, were more likely to be anticipatory or planned.

6.4.1 Proposed vs measures taken

In regional reports and research documents, several adaptation options, suitable to the expected changes in Rogaland, are suggested for farmers in Rogaland to implement on their farm. By the informants, technological innovations, governmental initiatives and changes in farm production practices were mostly mentioned as adaptation measures adopted by farmers. Few farm financial management changes were mentioned as adaptation options, although one of the informants did have another source of income besides being a farmer. Farm finances seemed to rely on government subsidies and grants, and not something that could be adjusted at a farm-

level. Several farm production practices were adjusted according to current conditions and based on data from weather and information systems. Technological innovations such as weather and climate information systems were frequently used and looked at as valuable tools. Large technological measures, such as trenching and drainage, were adaptations which required large investments and occurred in a once-off manner. Changes in farm production practices, such as adjustments in the timing of operations or land topography were not mentioned.

7. Conclusion

In this research I have tried to examine how the agricultural sector in Rogaland is adapting to climate change by looking at how the threat of climate change is interpreted by farmers and policymakers, how international agreements are passed on to the regional level and what factors influence farmers decision-making. I have also looked at what adaptive measures are suggested by the government, and which are actually implemented and used by farmers in Rogaland.

In Rogaland the main changes in climate and climate variability are expected to include increased precipitation and heavy rainfall, and temperature increase. Climate change adaptation in agriculture will therefore be crucial to reduce future impacts. The main findings in this study suggest that farmers in Rogaland look at adaptation as an ongoing process of adjustment to changing conditions by implementing certain technologies, using government initiatives or alter different farm production practices. This process is influenced by external forces of climatic stimuli in the form of heavy rainfall, socio-economic and political factors in the form of government subsidies, grants and compensation, and technology in the form of information systems and new innovations. It is also influenced by internal forces of personal traits, mainly consisting of views on climate change, past experiences and level of agronomic knowledge.
The lack of some of these factors were also seen as barriers to adaptation, such as the lack of education, economic resources and or agronomic knowledge. Perceptions of climate change could also be a barrier to adaptation. The main adjustments made in agriculture in Rogaland that were found were trenching and drainage of agricultural land, the use of weather and climate information systems and the use of compensation schemes.

At a regional level, ideas from international agreements are partially included in regional plans and documents. Some are emphasized more than others, especially the sustainable development goals and the Paris agreement. Climate change adaptation is given more and more attention at the County Governor of Rogaland, and there is a wish to rather work with preventive measures than coping measures. Although agriculture is related to national food security, adaptation in agriculture is the individual farmers choice and not something the County Governor can instruct farmers to implement. The County Governor of Rogaland takes on a supporting role through grants, programs, compensation and support schemes.

The key contribution of this research to policy is the need for integrating and linking climate change, farmers perceptions and influencing factors with efforts of provision of technological, support services to farmers in enhancing their adaptive capacity and long-term resilience to adverse impacts of climate change and variability. This research contributes to knowledge on farmers' decision-making by looking at the multiple forces influencing their choices and possible adaptation measures available. It can also contribute to the promotion of international interests in regional plans. In addition, can the research serve as a reminder for regional governments to incorporate programs and actions of adaptation into socio-economic plans and raise awareness of the multiple forces that influence a farmer's decision-making.

The findings suggest that the perceptions of climate change and its impacts could be very helpful for the researchers, political decision-makers, and other stakeholders regarding adaptation to climate change in the agricultural sector. Understanding the linkage between perception and adaptation strategies in agriculture is important for policymakers to influence and promote a wider distribution of climate change adaptation practices and the actual rate of adaptation.

While this study contributes to knowledge, it was limited in terms of participants interviewed, agricultural production types covered, and climate variables covered. This study examined the situation of two farmers in Rogaland and show by that which forces and factors could be most influential for some farmers, but not necessarily are for all farmers. This study did not go in depth on specific agricultural production types to clearly identify the extent to which changes in the local climate affect different productions and farmers, both economically and physically. The study also did not include climate change effects on other countries, and the effects of international development on Norwegian import and market prices.

7.1 Further research

There are many aspects to address when dealing with climate change adaptation in agriculture. It could be interesting to go more in depth and talk to even more farmers, who produce different products and must take different considerations into account when making choices. Looking at what factors and forces are most influential in other counties could also increase the knowledge of farmers decision-making in agricultural adaptation.

The focus on climate change adaptation is growing, both at an individual level and at a regional level. There are several uncertainties regarding how direct and indirect climate change effects will influence farmers decision to adapt in the future, and it differs between counties and nations. For future research it could be interesting to look at how the uncertainty of indirect climate effects through international development could influence Norwegian farmers. A lot of the food consumed in Norway is imported from other countries. For many countries, climate change impacts will be greater and there will be fewer resources available to handle the consequences. This could threaten the national food security and import of food could be more difficult and more uncertain. In relation to this it could also be interesting to look at what position the government should take in order to secure future food production.

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9. Attachments

Attachment 1: Declaration of consent

Vil du delta i forskningsprosjektet
"Agricultural Adaptation to Climate Change.
How is it handled in Rogaland?"?

Dette er et spørsmål til deg om å delta i et forskningsprosjekt hvor formålet er å undersøke hvordan klimatilpasning i landbruket blir håndtert i Rogaland. I dette skrivet gir vi deg informasjon om målene for prosjektet og hva deltakelse vil innebære for deg.

Formål
Formålet med masteroppgaven er å kartlegge hvordan klimatilpasning i landbruket blir arbeidet med i Rogaland, hvilke tilpasningstiltak som eksisterer, og hvilke retningslinjer eller strategier som er tilgjengelige. Dette vil baseres på synspunkt og informasjon fra jorddyrkere/bønder og ansatte i relevante avdelinger i fylket. Problemstillingen er som følger «Hvordan blir klimatilpasning i landbruk håndtert i Rogaland fylke?». Oppfølgingsspørsmål vil inkludere oppfatning av klimaendringer, syn på beslutningstakeres arbeid med klimatilpasning i landbruket, mulige tilpasningstiltak og forståelse av planer og retningslinjer for klimatilpasning.

Hvem er ansvarlig for forskningsprosjektet?
Universitetet i Stavanger er ansvarlig for prosjektet.

Hvorfor får du spørsmål om å delta?
Utvalget er basert på arbeidsstilling og relevans for problemstilling. Henvendelsen går til individer med bakgrunn/yrke innen landbruk og individer med yrker innen beslutningstaking og politikkutforming, med relevans til landbrukssektoren og klimatilpasning.

Hva innebærer det for deg å delta?
Deltagelse i studiet innebærer et intervju hvor opplysningene blir registrert med lydopptaker og notater underveis i intervjuet. Intervjuet vil vare fra 30-60 min, avhengig av hvor mye informasjon det er å innhente.

Det er frivillig å delta
Det er frivillig å delta i prosjektet. Hvis du velger å delta, kan du når som helst trekke samtykke tilbake uten å oppgi noen grunn. Alle opplysninger om deg vil da bli anonymisert. Det vil ikke ha noen negative konsekvenser for deg hvis du ikke vil delta eller senere velger å trekke deg.

Ditt personvern – hvordan vi oppbevarer og bruker dine opplysninger
Vi vil bare bruke opplysningene om deg til formålene vi har fortalt om i dette skrivet. Vi behandler opplysningene konfidensielt og i samsvar med personvernregelverket.

Bakgrunnsinformasjon med relevans for forskningen, som yrke, arbeidssted og type landbruksproduksjon vil være de eneste opplysninger som vil kunne føre til gjenkjenning i publikasjonen.

Hva skjer med opplysningene dine når vi avslutter forskningsprosjektet?
Prosjektet skal etter planen avsluttes 31.08.2020. Ved prosjektslutt vil alt datamateriale og lydklipp slettes.

Dine rettigheter
Så lenge du kan identifiseres i datamaterialet, har du rett til:

- innsyn i hvilke personopplysninger som er registrert om deg,
- å få rettet personopplysninger om deg,
- få slettet personopplysninger om deg,
- få utlevert en kopi av dine personopplysninger (dataportabilitet), og
- å sende klage til personvernombudet eller Datatilsynet om behandlingen av dine personopplysninger.

Hva gir oss rett til å behandle personopplysninger om deg?
Vi behandler opplysninger om deg basert på ditt samtykke.

På oppdrag fra Universitetet i Stavanger har NSD – Norsk senter for forskningsdata AS vurdert at behandlingen av personopplysninger i dette prosjektet er i samsvar med personvernregelverket.

Hvor kan jeg finne ut mer?
Hvis du har spørsmål til studien, eller ønsker å benytte deg av dine rettigheter, ta kontakt med:

- Student masteroppgave: Marianne Jevne Berge, 90684440, mj.berge@stud.uis.no.
- Veileder på masteroppgave: Reidar Staupe-Delgado, 51831364, reidar.staupe-delgado@uis.no
- Personvernforbud for UiS: personvernombud@uis.no

Hvis du har spørsmål knyttet til NSD sin vurdering av prosjektet, kan du ta kontakt med:

- NSD – Norsk senter for forskningsdata AS, på epost (personverntjenester@nsd.no) eller telefon: 55 58 21 17.

Med vennlig hilsen
Marianne Jevne Berge

Prosjektansvarlig (veileder)

Masterstudent

Samtykkeerklæring

Jeg har mottatt og forstått informasjon om prosjektet 'Agricultural Adaptation to Climate Change. How is it being handled in Rogaland?' og har fått anledning til å stille spørsmål. Jeg samtykker til å delta i intervju og at mine opplysninger behandles frem til prosjektet er avsluttet, ca. 31.august.2020

(Signert av prosjektdeltaker, dato)

Do you want to participate in the research project

«Agricultural Adaptation to Climate Change. How is it handled in Rogaland»?

This is an inquiry about participation in a research project where the purpose is to investigate how climate adaptation in agriculture is handled in Rogaland. In this paper, we provide you with information about the goals of the project and what participation will mean for you.

Purpose of the project
The purpose of this master's thesis is to understand how climate change adaptation in agriculture is being handled in Rogaland, which adaptation measures exist, and what guidelines or strategies are available. This will be based on the information from farmers and employees in relevant departments in the county. The problem statement is as follows "How is climate adaptation in agriculture handled in Rogaland?". Follow-up questions will include perceptions of climate change, views on policies and decision-making on climate change adaptation in agriculture, possible adaptation measures and understanding climate change plans and guidelines.

Who is responsible for the research project?
The University of Stavanger is the institution responsible for the project.

Why are you being asked to participate?
The selection is based on work position and relevance to the problem statement. The inquiry is directed to individuals with a background / occupation within agriculture and individuals with occupations in decision-making and policymaking, with relevance to the agricultural sector and climate adaptation.

What does participation involve for you?
Participation in this research involves an interview where the information is recorded with audio recorder and notes during the interview. The interview will last from 30-60 minutes, depending on how much information is available.

It is voluntary to participate
It is voluntary to participate in the project. If you choose to participate, you can withdraw your consent at any time without giving any reason. All information about you will then be anonymized. It will not have any negative consequences for you if you do not want to participate or later choose to withdraw.

Your privacy – how we store and use your information
We will only use the information about you for the purpose we have described in this document. We treat the information confidentially and in accordance with privacy regulations.

Background information relevant to the research, such as occupation, place of work and type of agricultural production will be the only information that could lead to recognition in the publication.

What happens to your information when we end the research project?
The project is scheduled to end 31.08.2020. At the end of the project, all data material and sound clips will be deleted.

Your rights
As long as you can be identified in the data material, you have the right to:

- Access to which personal information is registered about you,
- To have personal information about you corrected,
- Have personal information about you deleted,
- Receive a copy of your personal information (data portability), and
- To send a complaint to the Privacyombudet or the Norwegian Data Protection Authority regarding the processing of your personal data.

What entitles us to process personal information about you?
We process information about you based on your consent.

On behalf of the University of Stavanger, NSD – Norwegian Center for Research Data AS has assessed that the processing of personal data in this project is in accordance with the privacy regulations.

Where can I find out more?
If you have questions about the study, or want to exercise your rights, please contact:

- Student Master's thesis: Marianne Jevne Berge, 90684440, mj.berge@stud.uis.no
- Supervisor of master's thesis: Reidar Staupe-Delgado, 51831364, reidar.staupe-delgado@uis.no
- Privacy ban for UiS: personvernombud@uis.no

If you have any questions related to NSD's assessment of the project, you can contact:

- NSD – Norwegian Center for Research Data AS, by email (personverntjenester@nsd.no) or telephone: 55 58 21 17.

With best regards
Marianne Jevne Berge

Project manager (supervisor)

Master's student

Declaration of consent

I have received and understood information about the project ‘Agricultural Adaptation to Climate Change. How is it being handled in Rogaland?’ And has had the opportunity to ask questions. I agree to participate in the interview and that my information is processed until the project is completed, approx. 31. August. 2020.

(Signed by project participant, date)

Attachment 2: Interview guide - Policymakers

Demografi

- Navn
- Kort beskrivelse av jobb og arbeidsoppgaver

Organisering av arbeid knyttet til klimatilpasning og landbruk

- Hvordan er arbeidet med klimatilpasning organisert i fylket?
    - Har noen et overordnet ansvar? /Hvem opplever du har ansvar (dersom det ikke er formalisert).
    - Hvordan opplever du denne organiseringen?
- Hva oppfatter du som den overordnede planen for klimatilpasning i landbruket i Rogaland fylke?
- I hvilken grad blir internasjonale avtaler integrert i regionale planer?
    - F.eks. Avgjørelsen Koronivia Joint Work on Agriculture under FNs rammekonvensjon om klimaendringer.
- Måles fylkets arbeid med klimatilpasning (internt eller eksternt) Hvordan?
- Hva tror du er de viktigste driverne eller faktorene for å tilpasse seg klimaendringene?
- Hvordan er samarbeidet med landbruksnæringen? Har de mulighet til å påvirke avgjørelser som blir tatt på regionalt nivå? Hvordan?
- Hvilke tilpasningstiltak finnes for landbruket?
    - Blir noen tiltak gitt mer oppmerksomhet/prioritert enn andre?
- Har tidligere hendelser påvirket arbeid med klimatilpasning i landbruket?
- Hvordan opplever du at fylket «ligger an» med klimatilpasningsarbeid i landbruket?
    - Blir klimatilpasning oppfattet som en prioritet?
- Hvordan vil du evaluere egen kunnskap om klimasårbarhet og tilpasning?

Utfordringer

- Er det noe som begrenser fylkets arbeid med klimatilpasning i landbruket?
- Hvordan påvirker usikkerheten rundt virkninger av klimaendringer fylkets arbeid og prioriteringer av tiltak?
- Hvordan blir tiltak og strategier prioritert? Er fokuset på kortsiktige eller langsiktige tiltak?
    - Hvilke muligheter og utfordringer tenker du disse perspektivene (kort- og langsiktig) kan gi?

- Noe mer du vi legge til?

Attachment 3: Interview guide – Farmers

Demografi

- Navn
- Kort beskrivelse av jobb og arbeidsoppgaver
    - Hva er deres hovedområder/ hva produseres?

Klimatilpasning i landbruket

- Hvordan vil du evaluere din egen kunnskap og kompetanse om klimasårbarhet og tilpasning i landbruket?
- Hva anser du som den største klimatrusselen/risikoen mot landbruk i Rogaland?
- Hvordan har klimaendringer påvirket arbeidet deres? (negativt/ positivt) På hvilken måte?
    - Hvordan disse hendelsene påvirket dere i etterkant? Gjorde dere noen endringer eller tilpasninger?
- Har dere iverksatt tiltak for å bli bedre tilpasset forventede klimaendringer i fremtiden? I så fall hvordan? Eller hvorfor ikke?
- Hva oppfatter dere som de viktigste tiltakene en kan gjøre for å øke motstandskraften mot fremtidige klimaendringer?

Retningslinjer og offentlig politikk

- Hvordan oppfatter dere fylkets arbeid med klimatilpasning?
    - Hvordan er samarbeidet mellom Rogaland fylke og Rogaland bondelag?
- Finnes det noen retningslinjer eller regler bønder må forholde seg til i forhold til klimatilpasning? Restriksjoner, motivasjoner osv?
- Kan dere fortelle om hvilke hjelpemidler/ støtteordninger som er tilgjengelige for folk i landbrukssektoren i tilfeller av uventede hendelser av klimaendringer?
- Hvordan vil dere evaluere egen evne til å påvirke politikkutforming?
    - Er det noen tiltak som er iverksatt for å øke bøndenes innflytelse i politikk / beslutningstaking?
- Hvor oppfatter dere ansvaret for klimatilpasning ligger?
    - Ligger alt ansvaret hos bonden/eieren?

- Har dere noe mer å tilføye?

Attachment 4: NSD's evaluation

NSD NORSK SENTER FOR FORSKNINGSDATA

NSD's assessment

Project title

Climate Change Adaptation in Agriculture

Reference number

969933

Registered

23.03.2020 av Marianne Jevne Berge - mj.berge@stud.uis.no

Data controller (institution responsible for the project)

Universitetet i Stavanger / Det samfunnsvitenskapelige fakultet / Institutt for medie-, kultur- og samfunnsfag

Project leader (academic employee/supervisor or PhD candidate)

Reidar Staupe-Delgado, reidar.staupe-delgado@uis.no, tlf: 51831364

Type of project

Student project, Master's thesis

Contact information, student

Marianne Jevne Berge, mj.berge@stud.uis.no, tlf: 90684440

Project period

06.04.2020 - 31.08.2020

Status

28.05.2020 - Assessed

Assessment (2)

28.05.2020 - Assessed

NSD har vurdert endringen registrert 28.05.2020.

Vi har nå registrert 31.08.2020 som ny sluttdato for forskningsperioden.

NSD vil følge opp ved ny planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til videre med prosjektet!

Kontaktperson hos NSD: Simon Gogl
Tlf. Personverntjenester: 55 58 21 17 (tast 1)

25.03.2020 - Assessed

Det er vår vurdering at behandlingen av personopplysninger i prosjektet vil være i samsvar med personvernlovgivningen så fremt den gjennomføres i tråd med det som er dokumentert i meldeskjemaet den 25.03.2020 med vedlegg. Behandlingen kan starte.

MELD VESENTLIGE ENDRINGER
Dersom det skjer vesentlige endringer i behandlingen av personopplysninger, kan det være nødvendig å melde dette til NSD ved å oppdatere meldeskjemaet. Før du melder inn en endring, oppfordrer vi deg til å lese om hvilke type endringer det er nødvendig å melde:
https://nsd.no/personvernombud/meld_prosjekt/meld_endringer.html

Du må vente på svar fra NSD før endringen gjennomføres.

TYPE OPPLYSNINGER OG VARIGHET
Prosjektet vil behandle alminnelige kategorier av personopplysninger frem til 15.06.2020.

LOVLIG GRUNNLAG
Prosjektet vil innhente samtykke fra de registrerte til behandlingen av personopplysninger. Vår vurdering er at prosjektet legger opp til et samtykke i samsvar med kravene i art. 4 og 7, ved at det er en frivillig, spesifikk, informert og utvetydig bekreftelse som kan dokumenteres, og som den registrerte kan trekke tilbake. Lovlig grunnlag for behandlingen vil dermed være den registrertes samtykke, jf. personvernforordningen art. 6 nr. 1 bokstav a.

PERSONVERNPRINSIPPER
NSD vurderer at den planlagte behandlingen av personopplysninger vil følge prinsippene i personvernforordningen om:

- lovlighet, rettferdighet og åpenhet (art. 5.1 a), ved at de registrerte får tilfredsstillende informasjon om og samtykker til behandlingen
- formålsbegrensning (art. 5.1 b), ved at personopplysninger samles inn for spesifikke, uttrykkelig angitte og berettigede formål, og ikke viderebehandles til nye uforenlige formål
- dataminimering (art. 5.1 c), ved at det kun behandles opplysninger som er adekvate, relevante og nødvendige for formålet med prosjektet
- lagringsbegrensning (art. 5.1 e), ved at personopplysningene ikke lagres lengre enn nødvendig for å oppfylle formålet

DE REGISTRERTES RETTIGHETER
Så lenge de registrerte kan identifiseres i datamaterialet vil de ha følgende rettigheter: åpenhet (art. 12), informasjon (art. 13), innsyn (art. 15), retting (art. 16), sletting (art. 17), begrensning (art. 18), underretning (art. 19), dataportabilitet (art. 20).
NSD vurderer at informasjonen som de registrerte vil motta oppfyller lovens krav til form og innhold, jf. art. 12.1 og art. 13.

Vi minner om at hvis en registrert tar kontakt om sine rettigheter, har behandlingsansvarlig institusjon plikt til å svare innen en måned.

FØLG DIN INSTITUSJONS RETNINGSLINJER
NSD legger til grunn at behandlingen oppfyller kravene i personvernforordningen om riktighet (art. 5.1 d), integritet og konfidensialitet (art. 5.1. f) og sikkerhet (art. 32).

For å forsikre dere om at kravene oppfylles, må dere følge interne retningslinjer og eventuelt rådføre dere med behandlingsansvarlig institusjon.

OPPFØLGING AV PROSJEKTET

NSD vil følge opp ved planlagt avslutning for å avklare om behandlingen av personopplysningene er avsluttet.

Lykke til med prosjektet!

Tlf. Personverntjenester: 55 58 21 17 (tast 1)