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Farmers' climate change perceptions and adaptation intensions in the Seewinkel region: a qualitative analysis

A Master's thesis

by

Tina Achs, BSc

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University of Natural Resources and Life Sciences, Vienna (BOKU)

supervised by:

Univ.Prof. Dipl.-Ing. Dr. Erwin Schmid

DDipl.-Ing. Dr. Hermine Mitter

Dipl.-Ing. Bernadette Kropf, BSc

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Declaration

I, TINA ACHS, born on July 10th 1993, hereby declare that I am the sole author of the present Master’s Thesis, “Farmers´ climate change perceptions and adaptation intensions in the Seewinkel region: a qualitative analysis” pages 145, and that I have not used any sources or tools other than those referenced or any other illicit aid or tool, and that I have not prior to this date submitted this Master’s Thesis as an examination paper in any form in Austria or abroad.

Vienna, June 2021.

Tina Achs

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Abstract

Anthropogenic climate change is a global challenge and characterized by an increase in average temperatures, changes in precipitation patterns, and a likely increase in frequency and intensity of extreme events. Agriculture is directly affected by climate change, which can result in both, opportunities and risks. Farmers can implement adaptation measures to minimize adverse climate change impacts and to utilize emerging opportunities. Therefore, the aim of this master's thesis is to investigate farmers' perceptions of regional climate change and related impacts on their farms, and farmers' adaptation intentions in the Seewinkel region. The Seewinkel region is located in the Pannonian climate zone in eastern Austria. The Pannonian climate is characterized by long sunshine hours and average annual precipitation sums below 600 mm. In the 2019/2020 winter season, 21 semi structured interviews were conducted with 24 farmers working and living in the Seewinkel region. The interviews were transcribed and analyzed by means of a qualitative content analysis. The results show that all interviewed farmers perceive regional climate change such as an increase in average temperature. Furthermore, they report related impacts on agricultural production. They mention opportunities, such as an increase in product quality and risks, such as yield reduction or losses. Most interviewed farmers already adapt to the perceived regional climate change and intend to implement additional adaptation measures in the future. For instance, they intend to change crop management and wine production and some of them intend to invest in efficient irrigation systems.

Kurzfassung

Der anthropogene Klimawandel gilt als globale Herausforderung und ist durch einen Anstieg der Durchschnittstemperatur, durch Änderungen in den Niederschlagsmengen und durch eine voraussichtliche Zunahme der Häufigkeit und Intensität von Extremwetterereignissen gekennzeichnet. Die Landwirtschaft ist vom Klimawandel direkt betroffen, wodurch sowohl neue Chancen als auch Risiken entstehen können. LandwirtInnen können Anpassungsmaßnahmen umsetzen, um ungünstige Auswirkungen des Klimawandels zu minimieren und neue Möglichkeiten zu nutzen. Das Ziel dieser Masterarbeit ist die Erhebung und Auswertung der Wahrnehmungen- und der Anpassungsabsichten von LandwirtInnen zum Klimawandel und dessen Auswirkungen in der Region Seewinkel. Die Region Seewinkel liegt in der pannonischen Klimazone im Osten Österreichs. Mit den längsten Sonnenstunden im Jahresdurchschnitt und durchschnittlichen jährlichen Niederschlagssummen unter 600 mm zählt der Seewinkel zu den wärmsten und trockensten Regionen Österreichs. Im Winter 2019/2020 wurden 21 leitfadengeschützte Interviews mit 24 LandwirtInnen in der Region Seewinkel geführt. Die Interviews wurden transkribiert und mittels qualitativer Inhaltsanalyse ausgewertet. Die Ergebnisse zeigen, dass die meisten befragten LandwirtInnen den Klimawandel z.B. durch den Anstieg der regionalen Durchschnittstemperatur wahrnehmen. Des Weiteren berichten die LandwirtInnen von damit verbundenen Auswirkungen auf die landwirtschaftliche Produktion. Sie erwähnen Chancen wie eine bessere Qualität der Produkte und Risiken wie Ernte- und Ertragseinbußen. Die meisten LandwirtInnen passen sich bereits jetzt an den Klimawandel an und beabsichtigen auch in Zukunft Anpassungsmaßnahmen auf ihren Betrieben umzusetzen. Zum Beispiel beabsichtigen LandwirtInnen, Veränderungen in der Bewirtschaftung von Ackerland und von Weingärten vorzunehmen und einige planen auch, in effiziente Bewässerungstechnologien zu investieren.

1 Introduction

Subchapter 1.1 (background and problem description) gives an overview of climate change impacts from global to national scale. In addition, literature on farmers' perceptions of climate change impacts and possible adaptation measures are described. Moreover, the research questions of the thesis are presented. Subchapter 1.2 gives an overview of the structure of the thesis.

1.1 Background and problem description

Changes in climate can be observed worldwide. The global average surface temperature has risen by almost 1 °C since 1880, mainly due to anthropogenic greenhouse gas (GHG) emissions and other human activities that impact the earth's radiation balance (APCC, 2014, 28). Without comprehensive measures to reduce or avoid GHG emissions, a global temperature increases of 3 – 5 °C is expected by the year 2100, with self-reinforcing processes such as the additional release of GHG playing an important role (APCC, 2014, 28).

There is no standardized definition of the earth´s climate system. However, in this thesis, the term refers to the entire planet and atmosphere that affects the climate. It includes those parts of the planet and atmosphere that can change significantly over the course of centuries to millennia. The earth´s climate system strives for a constant equilibrium between incoming solar radiation and emitted terrestrial radiation. The sun is not seen as direct part of the earth´s climate system, though the earth´s climate system largely depends on the sun as an energy source. In addition to the atmosphere, the earth's climate system also includes the hydro-, cryo-, bio- and lithosphere and is characterized by unpredictable fluctuations (APCC, 2014, 138ff).

The Kyoto Protocol was adopted in 1997 with the aim to decrease anthropogenic GHG emissions. According to the Kyoto Protocol, the following emissions were explicitly considered. In addition to carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O), there is also the group of fluorinated compounds (F-gases). In order to be able to make the climate impact of these gases comparable, the use of a parameter has established which allows to calculate CO_2 equivalents (APCC, 2014, 175f). A global warming potential (GWP[1]) of 1 is defined for CO_2. For CH_4 the global warming potential is 21, which means that 1 kg of CH_4 is as strong as 21 kg of CO_2 in the atmosphere. 1 kg of N_2O is as strong as 310 kg CO_2, i.e. GWP of 310. The group of fluorine-chlorine-hydrocarbon compounds (CFCs) is also regarded as GHG. However, their emissions have declined significantly in recent decades, especially in industrialized countries. Its contribution to climate change is comparably small, but due to the low rate of degradation in the atmosphere it will persist for decades, even if there are no more emissions (APCC, 2014, 176f). An average global increase in the atmospheric CO_2 concentration by 39% above pre-industrial levels was measured by the end of 2010 (IPCC, 2011, 168). Highly accurate measurements of CO_2 concentrations in the atmosphere were first initiated by Charles Davis Keeling in 1958, documenting the changing composition of the atmosphere (IPCC, 2007a, 100). These data are used in science to prove the impact of human activity on the chemical composition of the global atmosphere (IPCC, 2007 a, 100). However, to compare the extend of anthropogenic GHG emissions to natural cycles in the past, it requires a long-term records of CO_2 emissions and other natural greenhouse gases (IPCC, 2007a, 100).

In addition to the warming trend, increasing winter and decreasing summer precipitation are expected for Europe, whereby a stronger decrease in annual precipitation is expected in the Mediterranean region and in South-East Europe (Eitzinger, et al., 2010, 1). In the past few decades, the European alpine climate has been subject to variability. From the late 19th century to the end of the 20th century, alpine temperatures rose about twice as fast as the northern hemisphere average. This corresponds to an annual temperature increase of around 2 °C (Gobiet et al., 2014, 1140).

For Austria, an increase in days with a maximum temperature of over 30 °C and a simultaneous nocturnal minimum of over 18 °C in Upper Austria, the Waldviertel (Lower Austria), Vienna and Northern Burgenland in summer was researched comparing two 25 - year periods, i.e., 1961 – 1985 and 1986 – 2010 (Chimani et al., 2016, 24 ff).

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[1] In order to make the climate impact of the various GHG comparable, a parameter – the GWP - is used. It reflects the global climate impact of the respective substance over 100 years in relation to CO_2 (cf. APCC, 2014, 176).

Anthropogenic GHG emissions are a major cause of climate change. According to the IPCC (2011): "*Most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic greenhouse gas concentrations"* (IPCC, 2011, 168).

Examples of anthropogenic influences are

- Burning fossil fuels, especially coal, oil and gas
- Land use changes (e.g., deforestation) and agricultural production (nitrogen fertilization, methane emissions through livestock production)
- Process related industrial emissions (e.g., CO2 release in cement and lime production) (APPC, 2014, 150).

In numerous regions of the world, changing precipitation patterns or the melting of snow and ice are changing the hydrological systems, affecting water resources in terms of quality and quantity. Climate change also causes glaciers to shrink worldwide and causes warming and thawing of permafrost in some parts of the world. *Natural* global climate change has led to significant changes in ecosystems and to species extinctions over the last million years but was much slower than the current *anthropogenic* climate change (IPPC, 2014a, 4).

The anthropogenic influence on the earth´s climate system - the so called, anthropogenic climate change - is very complex. However, some activities explain most of the observed consequences (APCC, 2014, 150).

According to the UNFCCC, *anthropogenic* climate change is defined as a change in climate, attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability. These changes can take place a long time, usually decades or longer (UNFCCC, 2011, 1f). Even if anthropogenic emissions were stopped immediately, the climate system would continue to change until these forces were balanced, due to the slow response time of some components of the climate system. Due to the slow processes, the equilibrium conditions cannot be reached for many centuries (IPCC, 2013, 129).

Climatic fluctuations manifest itself in altered average climatic conditions on different time scales. Short-term events such as weather extremes with their high potential for damage to agriculture are also expressed through short-term climatic fluctuations. *Anthropogenic* climate change is superimposed by the still acting natural climatic fluctuations, which are difficult to estimate because the mechanisms of action are still too little known (Eitzinger, et al., 2010,1).

In agriculture, direct and indirect impacts of climate change are manifold. Impacts on crop yields vary across regions. In some regions, crop yields will likely increase due to favorable conditions, in other regions, they will likely decrease, whereby adaptation through irrigation will increase in importance on global average (Kang et al., 2009, 1667 f). Climate change primarily impact plant and animal production, mostly through changes in the hydrological balance and other components of agricultural systems. Crop and livestock yields are directly impacted by changes in temperature and precipitation as well as by extreme weather events such as drought, floods and wind storms. The types, frequencies and intensities of various crop and livestock pests may also change due to climate change (Adams et al., 2017, 19). Adams et al. (2017) consider agricultural systems as managed ecosystems. The human response, thus, is critical to understanding and assessing the impacts of climate change on production and, moreover, on food supply (Adams et al., 2017,19).

Multiple studies show a strong relationship between observed climate variables and crop yields, suggesting that future climate change may have serious impacts on crop production. Studies show that between 1981 and 2010, climate change reduced global average yields of corn by 4.1%, of wheat by 1.8% and of soybeans by 4.5% compared to pre-industrial climates, even when CO_2 fertilization and agronomic factors as adaptation measures have been taken into account (IPCC, 2019, 451).

If current trends in population growth and food consumption continue, crop production will need to be increased by 60% by 2050 to meet global food demand. Crop growth models are used to simulate the growth and development of plants on a global to local level, to make impact assessments of climate change and to evaluate agricultural adaptation options. Possible impacts of changes in plant management, for example sowing the plant earlier or later in the season, can be investigated (Asseng et al., 2019). Asseng et al. (2019) examined as part of the Agricultural Model Intercomparison and Improvement Project (AgMIP) the combined impacts of CO_2, water, nitrogen and temperature on the protein concentration of wheat grains in a changing climate for the world's major wheat production regions. They found negative yield impacts of climate change on total wheat grain and protein yields for mid- and low-latitude locations and positive yield impacts for high-latitude locations (Asseng et al., 2019). Wood et al. (2014) examined household level characteristics of smallholder farmer cropping decisions related to climate variability. They found, that farmers with easy access to weather and climate information are more likely to adapt whereas, less wealthy farmers are less likely to adapt (Wood et al., 2014, 2).

According to Fischer et al. (2002) a high concentration of CO2 in the atmosphere may lead to improved crop growth conditions in selected areas and, increase crop production in these areas. This is expected to increase the productivity of crops by increasing photosynthetic activity and improving the efficiency of water use. On the other hand, however, increased crop failures can occur as the higher temperatures may intensify the pest and disease problems (Fischer et al., 2002, 39ff). In some countries, crop yields may also be impacted by dry conditions and increased water stress. Changes in precipitation patterns influence local seasonal and annual water balances, and therefore impact crop growth as well (Fischer et al., 2002, 39ff).

Crop pests and pathogens move to new habitats as global warming progresses. Observational reports show that many plant pests, including insect and bacterial pests, move toward the North and South Poles at an average speed of 2.7 km per year. 10-16% of crops are lost to pests today, further losses occur after the harvest (Bebber, 2013, s.p.). More than half of the plant diseases that occur are said to be transmitted through the introduction of humans (e.g., through traffic and tourism). However, once introduced, for many pests and pathogens changing weather conditions will be the main component in whether, they establish or not. Plant diseases and pests could have drastic impacts on food security worldwide, in particular in combination with climate change (Bebber, 2013 s.p.).

Climate change was examined for Austria by comparing climate data from two 25-year periods, i.e., 1961-1985 and 1986-2010. The analyses were carried out selectively at flagship stations in Austria. An increase in duration of heat periods by 2.8 days (on average) was found. In locations below 1000 meters (altitude), such as in the Seewinkel region the duration of heat periods increased by 13 days between the periods 1961-1985 and 1986-2010. The authors also found an increase in the vegetation period by 13.5 days to 212 days on Austrian average. The strongest increase is recorded in the lowlands of northern and eastern Austria with up to 20 days, as well as in mountain and valley regions. The annual start of the growing season in Austria in the lowlands and valleys was 20 to 5 days earlier in the period 1986-2010, compared to the period 1961-1985. A decrease in frost days by 8 days to 48 days was recorded throughout Austria. There was a slight increase in the annual precipitation amount of 11%, with the exception of the southern side of the Alps. There has been a sharp decrease in the amount, intensity and days of precipitation in winter on the south side of the Alps and an increase in spring on the north side of the Alps in the last 25 years (Chimani et al., 2016, 24ff).

Schönhart et al. (2014) points to a high variation in the impacts of climate change between Austrian regions. Their analysis shows a variability in the relative changes in average dry matter crop yields between a historical (1991-2010) and a future period (2031-2050). Significantly higher average temperatures and lower precipitation sums are noted, which impacts crop yields (Schönhart et al., 2014, 161).

Sustainable development supports and enables social transformations that would be necessary to limit global warming to 1.5 °C above the pre-industrial level, as agreed on in Paris (European Union website, s.a.). The UN SDGs (Sustainable development goals) build on efforts to reduce poverty, hunger and other disadvantages (United Nations, s.a.). The governments of Colombia and Guatemala originally proposed the idea of global goals, accompanied by indicators, and officially presented it at the RIO +20 conference. SDGs are a universal set of goals, objectives and indicators that the UN member states agreed to use to define their action strategies for the next few years (Hák, 2016, 566). Future Earth's Scientific Committee identified seven environmental priorities that are crucial for inclusion in the SDGs: climate, ecosystem services, biodiversity, nitrogen and phosphorus cycles, fresh water supply, pollution and the use of novel materials (Gaffney, 2014, 22). Action strategies and specific measures must also consider efforts to integrate disaster risks, sustainable management of natural resources and human security. With strong political will, increased investments and existing technologies, it should be possible to limit the rise in the global average temperature to 2 °C above the pre-industrial level. This requires urgent and ambitious action, as stated in SDG 13 - climate action (UNDP, 2021).

The EU has adopted measures to reduce GHG emissions and support energy from clean sources while participating in international climate negotiations. However, the EU has not succeeded in reducing GHG emissions in some sectors (Claeys et al., 2019, 2). Climate policy has become one of the most controversial EU issues. However, the European Commission, promised to expand and strengthen EU climate policy, by proposing a European climate law. According to that, the EU must become climate neutral by 2050, which would make Europe the first continent to do so (Claey et al., 2019, 2). In order to achieve this goal, a comprehensive policy framework is required that includes climate, energy, environmental, industrial, economic and social aspects. That is what the European Green Deal is all about (Claeys et al., 2019, 2). The European Commission has presented a comprehensive concept of the European Green Deal, including, an increase in the EU's GHG emissions reduction target for 2030 from 40 to 55 percent and the introduction of a carbon tax (Claeys et al., 2019, 2).

Crucial in the impact of climate change on agricultural crop production is the resource water. Water resources play a vital role in plant productivity and prosperity. However, water availability in surface and groundwater reservoirs may be affected by climate change (Kang et al., 2009, 1667 ff). If water availability is reduced in the future, drought tolerant crops may be more suitable to maintain or increase crop yield levels. Agriculture is one of the sectors most impacted by climate change. There are diverse options to adapt to climate change (Schönhart et al., 2013, 34).

Accordingly, there are numerous possible adaptation measures which should be carefully examined before their implementation and adaptation to the respective circumstances. In the agriculture sector, adaptation measures can basically be decided or accomplished at the farm level (APCC, 2014, 788).

The Seewinkel is a semi-arid region in eastern Austria with an average annual temperature of around 10 °C and an average annual rainfall of 550 - 600 mm (Blaschke and Gschöpf, 2011, 3). Precipitation falls mainly in summer, but periods of drought are increasing (Steingruber, 2013, 11). As a result, the likely increase in frequency of dry periods and droughts due to climate change can hinder the renewal of the groundwater body (Reisner, 2014, 7). However, changes in the annual precipitation volume and shifts in the seasonal pattern due to climate change are highly uncertain in the Seewinkel region (Chimani et al., 2016).

The present thesis should gain an understanding of farmers’ perception of climate change in the Seewinkel region and related beneficial and adverse impacts on their farms. Furthermore, farmers’ intentions to adapt to climate change are explored.

In this context, the research questions are as follows:

RQ1: „Which climatic changes do farmers perceive in the Seewinkel region and which impacts of the climatic changes do they perceive on their farms?”

RQ2: „Which adaptation measures are already implemented by the farmers in the Seewinkel region and which adaptation measures are planned for the future?”

RQ3: „Which risks and opportunities do farmers perceive in relation to agricultural water management in the Seewinkel region?”

1.2 Outline of the thesis

This thesis deals with empirical data collection and also includes a scientific literature review. Chapter 2 summarizes the literature of potential beneficial and adverse climate change impacts and potential agricultural adaptation measures, with a focus on Austria. Chapter 3 describes material and methods that were used for the master's thesis. In the chapter, the theoretical framework guiding the research, the design of the interview guide and details on data collection and data analysis are presented. The study region Seewinkel is characterized and an overview of qualitative social research and semi structured interviews is given. Furthermore, the selection of farmers for the interviews and the transcription of the interviews are described. Results are presented in Chapter 4. In this chapter the research questions are answered by presenting farmers’ perceptions of climatic changes and related impacts on their farms. Furthermore, the adaptation intentions of the interviewed farmers and future developments and challenges are presented as well. The results are discussed in Chapter 5. In Chapter 6 conclusion are drawn and an outlook for further research is given.

2 Literature review

Subchapter 2.1 provides an overview of potential beneficial and adverse climate change impacts on agriculture. Subchapter 2.2 discusses on-farm adaptation measures to climate change, whereby measures to adapt to dry climatic conditions are in the foreground because of their particular relevance for the empirical research.

2.1 Potential impacts of climate change on agriculture in Austria

Climate change impacts on agriculture may differ between agricultural production regions in Austria. In areas with high rainfall, such as the northern foothills of the Alps, for example, warmer climates increase the yield potential of crops. In regions with lower precipitation, such as in the east of Austria, the likely increases in droughts and heat waves may reduce the yield potential, especially of rainfed summer crops, and increase the risk of crop failure. Livestock also suffer from increasing heat spells. This can reduce growth rates and increase the risk of disease (APCC, 2014, 35).

Hot days are more common now in Austria than they used to be in the past, which is a development that is projected to continue in the future (Hochrainer – Stiegler and Hanger – Kopp, 2017, 600). Drought events will likely increase in Austria, especially in already dry regions. As has recently been shown in Austria, the damage caused by drought events in agricultural can be large. In eastern Austria the agricultural damage caused by droughts amounted to around 120 million € in the year 2012 (Hochrainer – Stiegler and Hanger – Kopp, 2017, 600).

In addition to agriculture, climate change could also improve or worsen the availability of water resources. With their study, Schönhart et al. (2018) came to the conclusion that the eastern parts of Austria in particular are sensitive to changing rainfall patterns. The rather uncertain changes in precipitation patterns will be decisive for future fresh water availability and water quality (Schönhart et al., 2018, 501ff).

Cultivation areas with an unfavorable climatic water balance and / or high summer temperatures will be particularly impacted. This is especially true for already dry agricultural production areas, such as the Seewinkel region (Lebensministerium, 2012, 28).

Temperature and precipitation conditions and their possible changes are always to be seen in conjunction with a specific system of production, since different, critical, climatic limits apply. Eitzinger (2007) came to the conclusion that with a temperature increase of up to approx. 2 °C, average impacts on the potential yield in agriculture could be positive (Eitzinger, 2007, 3ff). However increasingly negative impacts would occur in specific regions and for specific production systems. In the following, possible positive and negative impacts of climate change are outlined for crop and livestock production (Eitzinger, 2007, 3ff).

2.1.1 Field crop and permanent crop production

Average crop yields can increase in the next decades because of an increase in average annual temperature, an extended vegetation period and the CO2 fertilization effect. However, such positive developments are counteracted by a variety of impairments, for example through extreme weather events and weather periods, as well as damage to ecosystem functions, i.e., the occurrence of pests (Steininger, 2015, 2).

Examples of potential opportunities (i.e., positive climate change impacts) and risks (i.e., negative climate change impacts) are shown schematically in Figure 1.

Opportunities	*Risks*
Increase in atmospheric CO2 concentration associated with plant growth due to CO2 fertilization (Kang et al., 2009, 1669).	For many species living in the agricultural landscape (e.g., spiders and ground beetles) long periods of drought can lead to a collapse of the species (Zulka and Götzl 2015, 172).
It can be assumed that warmth-loving summer crops such as maize, soybeans or sunflowers benefit from increasing average temperatures (APCC, 497).	Rising average annual temperatures are particularly disadvantageous for plant growth and plant fertility of water-intensive plants. In addition, rising temperatures increase energy and water consumption of the plant (Tigchelaar et al., 2018, 1).
Viticulture would benefit from a further rise in average annual temperature over the next few decades. An increase in average annual temperature would have a particularly favorable effect on red wine types and on the red wine quality in relation to more mature, extract-rich and alcohol-rich wines. (APCC, 2014, 501f).	Premature vine phenology due to a longer vegetation period, in combination with higher sugar and lower acid contents of the berries, would lead to an increased infestation pressure by putrefactive agents such as fungal attack by botrytis or other harmful agents such as acetic acid bacteria. (APCC, 2014, 502).
The production potential of crops would be improved, especially in hitherto limited production regions, by a prolonged vegetation period (for example, forage harvesting in rainy grassland regions). (Eitzinger, 2007, 3).	The risk of frost damage could increase due to the prolonged growing season (fruit crops) (Eitzinger, 2007, 3) and due to changes in the onset of flowering (Unterberger et al., 2018, s.p.).
An increase in field working days due to drier conditions would allow certain machine capacities to be reduced as a cost factor (Eitzinger, 2007, 3).	Schultz et al. (2005) stated that higher average annual temperatures during grape harvest prevent optimal fermentation of grapes. In order to ensure optimal fermentation, grapes would have to be harvested in cooler evening and night hours or cooled before further processing (Schultz et al., 2005, s.p.).

Figure 1: Potential positive (opportunities) and negative (risks) impacts of climate change in field crop and permanent crop production. Source: own illustration.

2.1.2 Livestock production

Several studies indicate that animal behavioral, immunological and physiological functions are potentially impaired due to thermal challenges. When animals are exposed to thermal stress, metabolic and digestive functions can be impaired (Mader et al., 2009, 530).

However, livestock production is differently impacted by climate change due to different husbandry systems. Rising temperatures under climate change increase the risk of animal mortality. If ruminants are kept outdoors milk yield losses of between 0 - 3% have been modelled due to heat stress, until 2100 (Schönhart et al., 2018, 119). Changes in climate impact milk production in many ways, whereby direct impacts can lead, for example, to heat stress in dairy cows, indirect impacts may occur if milk or feed production is impacted, thereby creating supply and price impacts. Animal diseases caused by climate change are largely unexplored (Martinsohn and Hansen, 2013, 1ff). For newly occurring diseases and pests in livestock farming, the knowledge is generally not sufficient to estimate a potential extent of damage (BMLFUW, 2017b, 33).

The analysis of heat exposure in pig and poultry production regarding climate change impacts is rather rare in literature. One reason for the lack of analysis could be that climate in closed stables can be controlled by using technical means (Schönhart et al., 2018, 119).

Examples of potential opportunities (i.e., positive climate change impacts) and risks (i.e., negative climate change impacts) are shown schematically in Figure 2.

Opportunities	*Risks*
In the case of swine production, swine should reach market weight as early as June and July as their development cycles are positively impacted by the average annual rise in temperature (Mader et al., 2009, 536).	Direct impacts of climate change can lead to heat stress in dairy cows, leading to a decline in milk yield, reduced fertility and impairment of the immune system. The climate change scenarios used in an analysis between the years 2021 to 2050 show that heat stress in the first days and weeks after calving and during the peak of lactation can have a clearly negative impact on milk yield. In addition, sensitive animals can quickly suffer from circulatory diseases. Results show, that in case of heat stress both feed intake and milk yield decrease (Martinsohn et al., 2013, 1ff).
Average rising temperatures in the winter months can reduce the need for heating in stables, this has been investigated in particular for piglets (Hörtenhuber et al., 2020, 11).	Longer heat periods can reduce livestock performance, which can for example result in a decrease in egg size in laying hens. (APCC, 2014, 471 ff).
It is expected that the CO2 concentration in the atmosphere will have a positive impact on crop production, which compensates for growth problems in grassland and thus feed production (Martinsohn et al., 2013, 13).	The stable climate reacts to changes in the meteorological conditions with greater sensitivity than is the case for livestock housing conditions outdoors. This leads to a significant increase in heat stress in animals in the stable (ACRP, 2019, 29).
Indirect impacts can occur if milk or feed production in other regions are affected, thereby creating supply and pricing opportunities. For instance, costs of purchased feed may decrease if climatic conditions in key growing regions improve (Martinsohn et al., 2013, 1).	Indirect impacts can occur if milk or feed production is negatively influenced in large agricultural production regions, resulting in supply and price changes (Martinsohn et al., 2013, 1).

Figure 2: Potential positive (opportunities) and negative (risks) impacts of climate change in livestock production. Source: own illustration.

2.2 Climate change adaptation measures in agriculture

According to Dolan et al. (2001) *"adaptation refers to responses by individuals, groups and governments, to climatic stimuli or effects to reduce vulnerability of, or susceptibility to, adverse impacts or damage potential".* Adaptation can reduce negative consequences or increase benefits from opportunities associated with climate change (Dolan et al., 2001, 1ff). Adapting to climate change is a continuous task that will range over longer time horizons. The aim is to integrate aspects relevant to adaptation in all decision-making processes (BMLFUW, 2017a, 16ff).

Ekstrom et al., (2011) describes a rational adaptation process to consist of three major elements – *understanding*, *planning* and *managing*. The adaptation process shown in Figure 3 describes first the phase of understanding which involves, problem detection, information gathering and problem definition (characterizing the problem according to pre-existing knowledge). Secondly the phase of planning, which involves development of adaption options, assessment of adaption options (for notification of the selection progress), and selection of adaptation options, third the phase of managing, which involves, implementation, monitoring and evaluation (Ekstrom et al., 2011, 9ff).

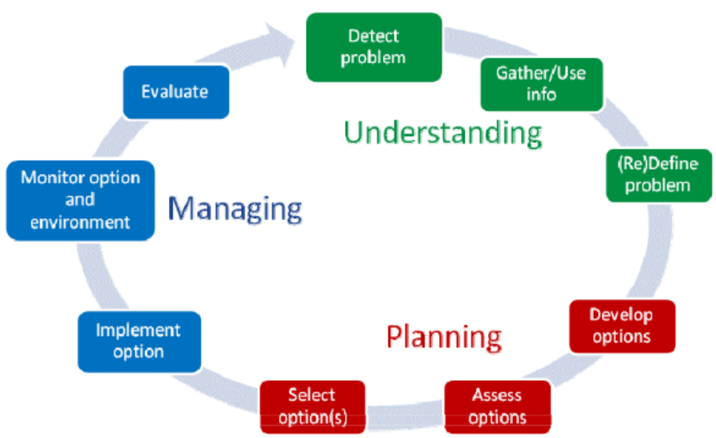

Figure 3: The adaptation process with usual phases and sub-processes (Ekstrom et al., 2011).

There are many adaptation options in agriculture, which are measures or practices that can be taken. Adaptions in agriculture differ in terms of climate stimuli between the different farm types and locations, as well as the economic, political and institutional circumstances under which management decisions are made (Smit and Skinner, 2002, 86).

Mitter et al. (2017a) distinguish between *private*, *public* and *natural* adaptation, depending on the actor implementing the respective adaptation measure. Private adaptation is mainly for private benefit and relates to farm management and investment decisions. Infrastructure supply is primarily a public responsibility that seeks to maintain agricultural land use and aims to support practices to mitigate climate change. Natural adaption refers to natural selection that allows for sovereign adaptation of natural systems. Humans can intervene to facilitate natural processes and focus on the adaptability of nature (Mitter et al., 2017a, 16f).

Adaptation measures also include short term coping and longer term, transformations, aim to achieve more than climate change goals alone, and may or may not succeed in moderating harm or exploiting beneficial opportunities (Ekstrom et al., 2011, 9ff). These include different forms, in technical, financial and management areas, as well as scales at the global, regional and local level and participants such as governments, industries and farmers (Smit and Skinner, 2002, 86).

Adaptation decisions by farmers are based on socio-cognitive processes that relate to selection, organization and interpretation of sensory information. Socio-cognitive processes take into account that human knowledge depends on a broader socio-ecological context. This socio-ecological context differs according to culture and geographical region, which can change over time (Mitter et al., 2019, 804). The relevance of socio-economic processes for adaptation to climate change in agriculture is illustrated by the fact that adaptation decisions by farmers take place at the local level and react to socio-ecological contexts. This includes social and institutional support, cultural values and norms, regional values and climate-related triggers (Mitter et al., 2019, 804). In addition to socio-cognitive processes, farmers' perceptions are also influenced by biophysical, political and socio-demographic factors. For example, groundwater decline, level of education, farm size, access to information and agricultural subsidies have been included on the list of contextual factors underlying the adaptation strategies (Luu et al., 2019, 2).

Mitter et al. (2017a) divided the adaptation measures in three categories, which serves as a basis for the master thesis:

- *Incremental adaptation measures* describe agronomic measures in crop (e.g., cultivation of drought-resistant varieties) and in livestock production (e.g., changes in feeding), in-house financial management (e.g., buying an insurance product) and the organization of work on the farm.
- *Systemic adaptation measures* describe long-term investment and production decisions at farm level (e.g., investments in water storage and irrigation systems).
- *Transformative adaptation measures* describe the strategic orientation of a farm, such as fundamental changes in farm type or the inclusion of non-agricultural secondary activities (e.g., activities in tourism) (Mitter et al., 2017a, 61f).

Adaptation measures in agriculture include, for example, improved drainage systems, changes in land use, plants and new varieties, improved irrigation technology, orderly use of surface and ground water, reduced tillage, as well as educational programs and information on adaptation to the climate (Karner et al., 2019, 1f). Artificial irrigation systems will therefore become very important in the future, with emphasis on efficient and sustainable water use. In addition, irrigation systems should be energy efficient and soil friendly. Water abstraction is subject to authorization regulated in the Water Law and listed in the register of the respective municipalities (Lebensministerium, 2012, 28). Other options for adaptation consist of changes in management measures by farmers, such as changes in operating times, tillage practices, and investments by public authorities in the development or improvement of irrigation systems (Dolan et al., 2001, 1ff). According to BAB (2020) effective adaptation measures consider adapted sowing and harvesting dates, changing use of fertilizers and the choice of alternative crops. Insurance is a typical adaptation measure against crop losses. Uncertainties in adaption exist in changes and impacts in plant and livestock diseases as well as agricultural pests (BAB, 2020,14).

3 Material and methods

The master thesis is based on qualitative semi structured face to face interviews with farmers from the Seewinkel region. The Model of Private Proactive Adaptation to Climate Change (MPPACC) guided data collection and the empirical analysis. It is introduced in subchapter 3.1(Theoretical model for the empirical analysis). In subchapter 3.2 the Seewinkel region is described. In subchapter 3.3 the principles of qualitative social research and in 3.4 semi structured interviews, the design of the interview guide and the selection of interview partners as well as the conducting and the transcription of the interviews are described. The qualitative content analysis is described in subchapter 3.5.

3.1 Theoretical model for the empirical analysis

The Model of Private Proactive Adaptation to Climate Change (MPPACC, Grothmann and Patt, 2005) was used as a core element for creating the interview guide. Furthermore, it guided the empirical analysis.

In order to explain why some people show adaptation behavior while others do not, Grothmann and Patt (2005) developed a theoretical model, which is mainly based on the Protection Motivation Theory (PMT). PMT has its roots in psychology and has been widely applied in health research (Rogers, 1983; Rogers and Prentice – Dunn, 1997). Duinen et al., (2014) also take the PMT as basis for their study and state that the motivation of farmers in the Netherlands to adapt to drought can be explained by cognitive factors. Perceived and expected climate change impacts, climate change appraisal and climate change adaptation appraisal are the major components of the theoretical model of the thesis (Figure 4). McClaran et al. (2015) used PMT in their analysis to structure a study of ranchers in the US state of Arizona. The results show, that the perceived effectiveness of selected adaptation measures to drought is positively related to implementation (McClaran et al., 2015).

The focus of the empirical analysis is to investigate how farmers already adapt and how they intend to adapt their farm to climate change. Figure 4 represents the theoretical model schematically.

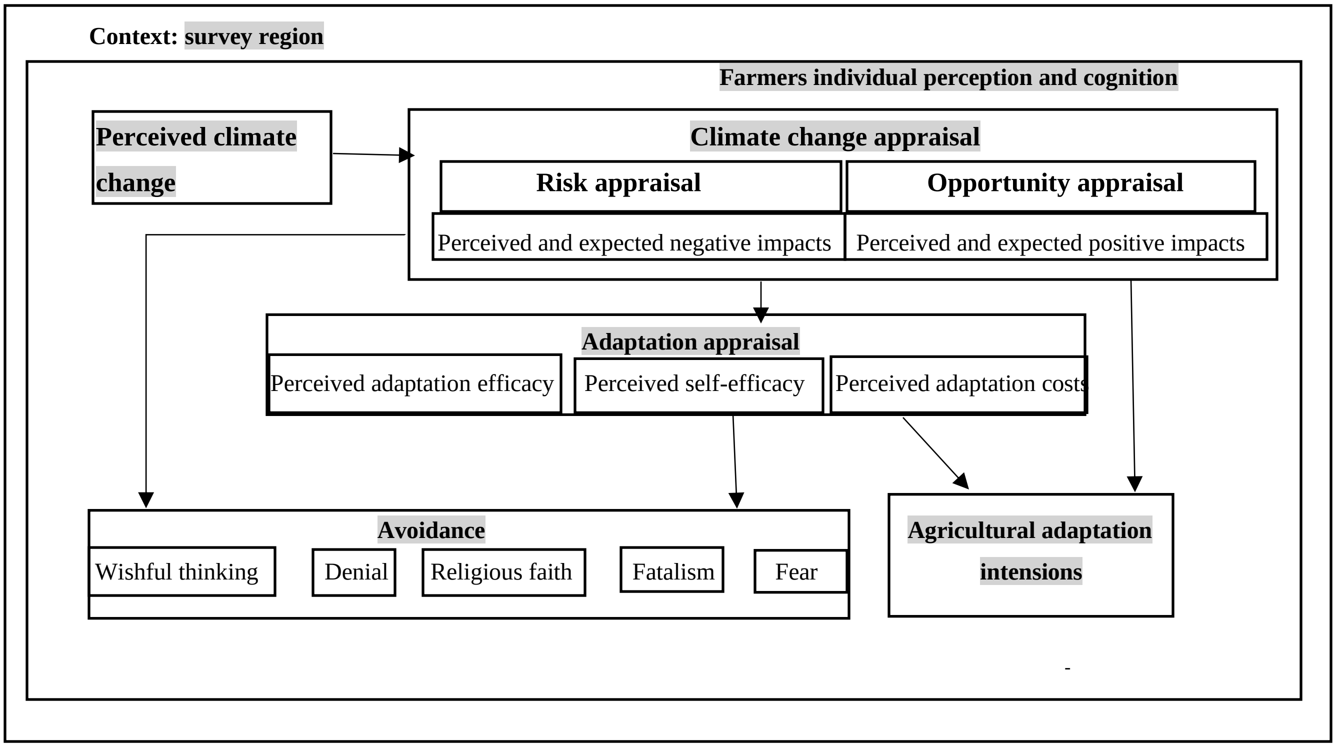

Figure 4: Theoretical model for analyzing farmers´ individual perceptions and cognition. Own illustration, based on Grothmann and Patt, 2005.

Building on MPPACC, the study empirically explores farmers' individual perceptions of climate change and their actual and intended adaptation. According to the theoretical model, farmers assess a certain risk or opportunity that they perceive due to climatic changes in a first step (*climate change appraisal*). In a second step their subjective capacity is to deal with this risk or opportunity (*adaptation appraisal*) (Mitter et al., 2019, 807f). Adaptation appraisal consists of the three sub-components *perceived adaptation efficacy*, *perceived self - efficacy* and *perceived adaptation costs*. Depending on the outcome of the first two steps, two socio-cognitive paths are considered which the farmer can follow: *intention* or *avoidance* of adaptation in agriculture. Adapting to climatic changes offers measures that prevent physical or financial damage or opens up new possibilities, while avoidance relates to reactions such as *wishful thinking*, *denial*, *religious faith*, *fatalism* and *fear* which create negative emotional consequences of perceived risks (Grothmann and Patt, 2005). Adaptation intentions to future climatic changes can be made easier or more difficult by contextual factors. While the original formulation of MPPACC is limited to risk appraisal (Grothmann and Patt, 2005) in this study risks and opportunity appraisal are considered (Mitter et al., 2019, 808) as a range of opportunities exist for farmers in different regions that ease adaptation planning and implementation.

The MPACC is chosen as the basis for the empirical research, as it is well suited to structure the narratives of farmers and to research the appraisal of climate change and adaptation of farmers as well as their adaptation intention and avoidance including contextual factors (Mitter et al., 2019, 807).

Other studies also build their analysis on the MPACC. For example, Burnham et al. (2017) found that perceived self - efficacy, including financial capital, institutions, and information and technology, increases the adaptive intent of smallholder farmers in China (Burnham et al., 2017). Woods et al. (2017) found a positive association between farmers' concerns about climate change and the intended adaptation to negative impacts in Denmark (Woods et al., 2017). Relevant adaptation measures, agricultural systems, geographical regions, and socio – cognitive processes should thus be taken into account for the analysis and the design of research questions (Mitter et al., 2019, 807).

In addition, policymakers can more effectively influence farmers' actions if they focus on the adaptability of farms and the perceptions and cognition of farmers (Grothmann et al., 2005, 14). Compared to other behavioral theories such as the Theory of Planned Behavior (Ajzen, 1985) and the Value - Belief - Norm Theory (Stern, 2000), the MPPACC explicitly considers context factors that are of particular importance for adaptation to climate change (Mitter et al., 2019, 806).

3.2 Geographical characteristics of the Seewinkel region

The semi - arid Seewinkel is an agricultural production region in the East of Austria of about 45,100 ha (Karner et al., 2019, 2). The region is located geographically in the northern part of the province of Burgenland at the Austrian – Hungarian border. The region was selected because it is one of the driest and warmest regions in Austria with an average annual rainfall of less than 600 mm and an average annual temperature between 8 – 10 °C. Typical of the climate are the dry and hot summers, followed by cold winters, causing daily maximum temperatures to fluctuate between 40 °C in the summer and daily minimum temperatures of - 20 °C in the winter, referred to as the continental or Pannonian climate (Steingruber, 2013, 9ff).

The Seewinkel region has been identified as an individual groundwater body, whereby climate change induced dry spells and droughts might impede the renewable of this groundwater body (Karner et al., 2019, 2). Of particular importance are the many saltine lakes of the Seewinkel region, which are fed by capillary rise. Of the approximately 140 saltine lakes in 1900, which covered an area of 3.600 hectares, today there are around 63 saltine lakes left, with a total area of 800 hectares and a tendency to fall dry. Due to drainage and a falling groundwater table, the saltine lakes have suffered dramatic losses (Steingruber, 2013, 10). Due to their salt content, the saltine lakes have a unique flora and fauna and are dependent on a saline supply from the saline soil layers via a capillary rise of the groundwater.

However, the actual drainage ditches repeatedly lead to low groundwater levels, which negatively influences this mechanism (Blaschke and Gschöpf, 2011, 3). The National Park Neusiedler See - Seewinkel is located in the west of the region where the largest steppe lake in Central Europe is located (Karner et al., 2019, 3).

Statistical land use data from 2012 - 2014 show that about 25,000 ha are used for cropland, 3,500 ha for grassland and 3,000 ha for vineyards in the Seewinkel region (ACRP, 2013, 21). Figure 5 shows the modelling results for average annual land use for the period 1975 - 2005. For the period, an average annual irrigation volume of 26.5 million m^3 was modelled (cf. ACRP, 2013, 21 ff).

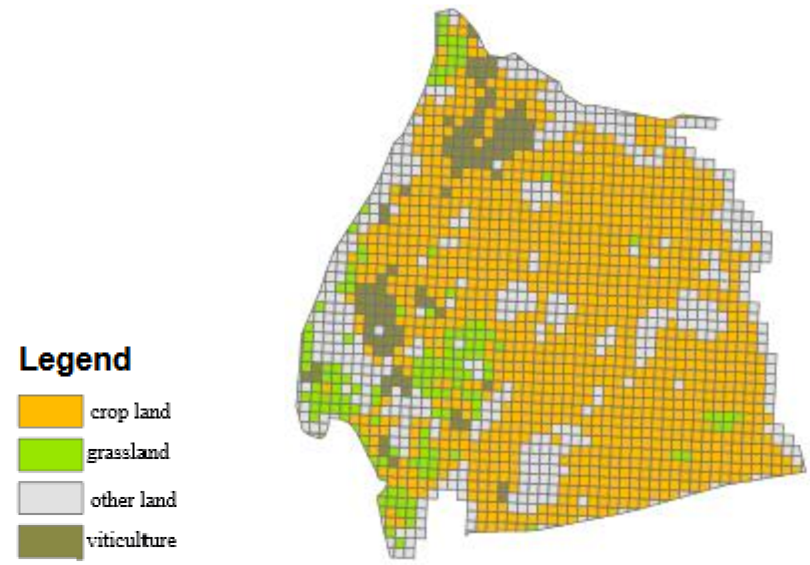

Figure 5: Average annual land use in the Seewinkel region. Model results for the period 1975-2005 (ACRP, 2013, 21).

Favorable climatic conditions led to a cultivation and agricultural use in the Seewinkel region, which leads to interventions in the water balance through drainage ditches and a large number of extraction wells for irrigation purposes (Blaschke and Gschöpf, 2011, 3). The agricultural sector is the main user of groundwater in the region, whereby cropland and vineyards are mostly irrigated (Karner et al., 2019, 2).

Figure 6 shows modeled average annual irrigation water use in the Seewinkel region. The model results show that the average irrigated area covers about 16,000 ha (ACRP, 2013, 21f).

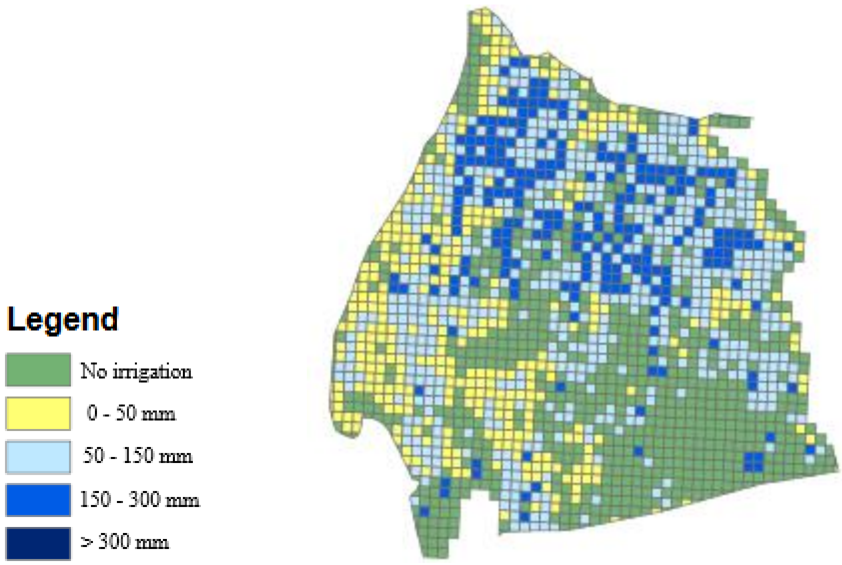

Figure 6: Average annual irrigation volumes in the Seewinkel region. Model results for the period 1975 –2005 (ACRP, 2013, 22).

In the Seewinkel region, water abstraction for agricultural irrigation is organized by water cooperatives. In the years 1989 - 1991, a technical concept for irrigation was created in the Seewinkel region, since the area was used intensively from an agricultural point of view. Water cooperatives were sought in the Water Law, where the future use for agricultural irrigation should be regulated. Thus, a water cooperative was established for each municipality in the Seewinkel region (Maracek, 2019, personal communication).

A decision of the water cooperative and Seewinkel district XXX serves as an anonymous example:

- In the KG XXX a number of ### plots of land can be irrigated for agriculture.
- The plots can be irrigated from ### field wells.
- The water withdrawal from these wells is regulated at an average annual withdrawal rate of ### and a maximum extraction per well of ### in the months of March - November for the purpose of agricultural irrigation per year.

These figures are similarly regulated in all water cooperatives in the region (Bescheid, BH, Neusiedl).

3.3 Principles of qualitative social research

Based on qualitative interviews with farmers from the Seewinkel region, the research questions and the objectives are to be answered. The communicative process becomes the center of attention, so that in qualitative research the communication processes are crucial (Lamnek et al., 2010, 16ff).

Qualitative studies can reveal empirical phenomena that are barely discovered by quantitative methods. Its particular strength lies in the fact that with its help it is possible to discover the senses and orientations of the actors over which the researcher had no previous assumption and which therefore cannot be taken into account in the construction of survey instruments (Kelle, 1999, 8). Today, the term qualitative research is used to summarize a very wide range of procedures, each of which provides very different theoretical and methodological approaches to social reality. Qualitative approaches range from highly descriptive to strictly analytical approaches, whereby the descriptive approaches are usually related to transcribed interviews (Mruck and Mey, 2005, 6). Mruck and Mey (2005) emphasize three principles of qualitative research: the strangeness principle and the principles of openness and communication. According to the strangeness principle, researchers should not have underlying preliminary assumptions in qualitative research work. The principle of openness stipulates that, researchers approach the respective research field of interest with methods that are as open as possible and that have little pre-structuring. The openness principle states that the new depends on the way in which the researcher designs the search for the new and does not depend on the researcher's awareness of what is already known at the content level. For qualitative social research, the communication between the researcher and the one to be researched is considered as an underlying element of the process of understanding (Mruck and Mey, 2005, 8ff).

3.4 Semi structured interviews

The semi structured interview is a type of partly standardized interviews in which the interviewer prepares an interview guide with guiding questions that serves as a basis for structuring the interview. Guiding questions support the interviewer to elicit the information relevant to answer the research questions. The researcher can use the guiding questions to determine which topics are important for the research process and which questions need to be asked during the interview and thus guide the interview (Gläser and Laudel 2010, 90ff).

According to Gläser and Laudel (2010) the use of semi structured interviews is recommended when several different topics have to be addressed in an interview. The interview should be similar to a “natural conversation”, whereby the interviewer should steer the conversation with guiding questions to ensure that the interviewee provides relevant information. Conducting a semi structured interview therefore means planning a communication process that is adapted to the interviewee's context and providing all the information needed for the investigation (Gläser and Laudel, 2010, 90ff.).

The design of the interview guide and the choice of respondents is of particular importance for the quality and validity of results (Lamnek, 2010, 351).

3.4.1 Design of the interview guide

The interview guide was designed based on the research questions and along the components of the MPPAAC. It also builds on the interview guide of Stöttinger (2016). The interview guide is structured as follows (see Appendix II):

1. *Information about the master thesis itself, the interview guide and data protection before starting the interview.*
2. *Perceived climate change, perceived farm and personal impacts*

   2.1 From a regional perspective

   2.2 From a farm perspective

   2.2.1 Positive impacts

   2.2.2 Negative impacts

   2.3 From a personal perspective

   2.3.1 Positive impacts

   2.3.2 Negative impacts
3. *Adaptation to climate change*

   3.1 Personal adaptation

   3.2 Farm adaptation

   3.3 Irrigation

4. *Future: expected climate change and impacts*
    4.1 From a regional perspective
    4.2 From a farm perspective
    4.3 Adaptation intention
    4.4 Context factors
    4.5 Expected challenges until 2050
    4.5.1 From a regional perspective
    4.5.2 From a farm perspective
5. *Final open questions*

The interview guide was pretested with a farmer of the survey region. Based on a reflection with the interviewed farmer and on experienced challenges during the interview, the interview guide was slightly adapted.

After the fourth interview (including the pretest), the interview guide was again slightly adapted. In particular, sub - questions to “Personal adaptation to climate change” were included, because it was mentioned by all four interviewed farmers. As the interview guide was only slightly adopted, all interviews were considered for analysis.

Interviewed farmers should be encouraged to answer the questions of the interview guide in a free narrative. The interview guide is intended to help the interviewer conduct the interview flexibly, but the chronology of the guiding questions can be adapted to the interview setting and does not have to be carried out in the order presented above. Sequence and wording should be adapted to the situation whereby spontaneous, impulsive questions that might arise during the interview process can also be asked if they appear to be helpful in answering the research questions (Lamnek, 2010).

3.4.2 Selection of interviewees

In total, 24 farmers of 21 farms from the Seewinkel region were interviewed face to face. In some of the interviews, two farmers were present, resulting in a total of 24 interviewees. All 24 farmers live and work in the Seewinkel region (see Appendix IV). When selecting the interviewees, attention was paid to maximal variation with regard to the structure of the farms (e.g., farm type, location of the farm, main production activity, farm size, irrigation system, cultivation system) and the demographic characteristics of the farmers (e.g., age, gender). Figure 7 summarizes the interviews and the interview partners.

Interviews	Interviewees	Farms
21 Interviews	17 men	21 farms
28 minutes – 02 hours 5 minutes	7 women	2 – 2100 ha
Maximal variation of interview partners	24 – 71 years (at the time of the interview)	12 municipalities in the Seewinkel region

Figure 7: Structural data on the interviews conducted.

The interviewees were contacted by the researcher either by email or by phone. The researcher paid attention to maximal variation of the interviewees beforehand. To do this, the researcher first obtained information on the internet. With a few exceptions, most of the interviewees agreed for the conversation. Some interviewees were contacted through third parties. This contact was made via so-called gatekeepers. Prior to this, the gatekeepers were informed about the guiding questions and the course of the interviews, after which the interviewee was first contacted by the gatekeepers and then, if they agreed, by the researcher.

According to Flick (2009) the procedure for purposive sampling by selecting farmers can be as follows:

- Aim for the maximum variation in the sample. Select only a few cases, but those that are as diverse as possible.
- Select cases according to intensity. Interesting features, processes, experiences, etc. should be given or accepted in them.
- Selection of critical cases aims to make the relationships to be examined particularly clear, for example the opinion of experts in the field.
- It may also be appropriate to select a politically important or sensitive case in order to show positive results in the assessment (Flick, 2009, 122).

The criteria for the selection of the farmers are:

i. The interviewed farmers should be experts in different farm types, which are directly or indirectly affected by climate change.

ii. There should be maximal variation in terms of age, gender, cultivation system, production type, farm size and regional location of the farm within the Seewinkel region.

iii. Some of the farmers are supposed to irrigate their crops.

Figure 8 illustrates the distribution of the production activities, where the interviewed farmers are engaged. Some farmers have mixed farms. This results in a higher number of production activities compared to the number of interviewed farmers.

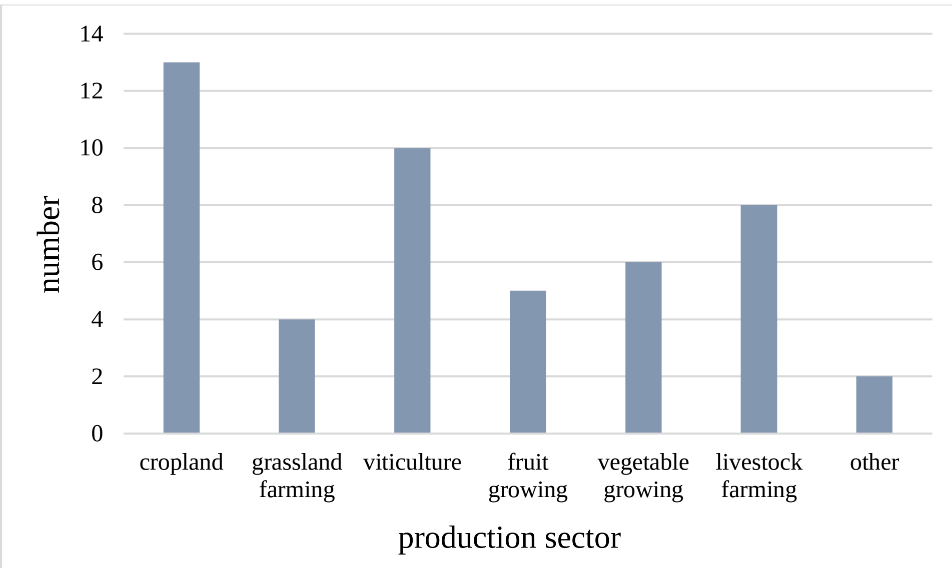

Figure 8: Number of investigated farms by production sector. Note: Some farms are engaged in more than one production activity. Source: own illustration.

3.4.3 Conducting interviews

The interviews were held between November 2019 and February 2020 in a face-to-face conversation partially at the farmers´ homes and partially at the interviewer´s home in a pleasant and familiar place for the interviewees. Before the interview, the interviewer gave some information about the research, about data protection and confidentiality of the interviews, the expected duration of the interview and the interview process itself. The farmers were asked to sign the data protection declaration and a declaration of confidentiality was given to the interviewees. In addition, when they were asked to sign the data protection declaration the interviewees received a declaration of confidentiality signed by the interviewer, in which it was assured that the data would be treated anonymously and confidentially. If personal data are collected or processed, consent of the persons concerned is required. The focus is on informing the interviewee about data recording and data use. Consent is only legally compliant if the persons participating in the study are informed about the planned implementation of the research project and the way in which data are processed (Gebel et al., 2015, 7). Before the interviews, the farmers were also asked to fill out a data sheet on socio-demographic and farm-specific information (see Appendix III). Interviewees were informed that the interviewer occasionally writes down keywords and questions which may be asked later. Furthermore, they were told that their personal experiences and opinions are important and that they are invited to answer the questions in their own words. After the interviewer answered occurring questions from the interviewees, the recording began.

In 18 of the 21 interviews one person was interviewed, i.e., the farm manager, while the other 3 interviews were held with two persons, which results in a total of 24 interviewees. In one interview, the persons joining the interview changed. In one of the 18 individual interviews, a conversation was held with a farmer couple before the interview. However, the farmer left the interview before recording and the interview was conducted only with one farmer. The previous conversation with the farmer was noted in the interview protocol (see Appendix I) and included in the analysis. Important statements from the interview protocol that were useful for answering the research question were included in the analysis. One interview was interrupted when a person entered the room and another two interviews were interrupted when the farmer´s cell phone rang. In this time the recording was ended and continued after the phone call was ended. Some of the other interviews were interrupted by family members. No action was taken during the interruptions so that the interviewees were not confused. In the case the family members´ statements were relevant for the master thesis the statements were included in the analyses. All interviews started with the introductory question “At the beginning, please tell me what is your opinion on climate change?” [2] The order of guideline questions was adapted to the interview situation and respective answers of the interviewees. It

[2] Orig: „Bitte sagen Sie mir zu Beginn, was Ihre Meinung zum Klimawandel ist.“

did not always follow the chronological order suggested in the interview guideline. For instance, if interviewees mentioned relevant topics the interviewer sometimes asked additional questions to get a better understanding of the addressed topic. Interviews were digitally recorded and lasted between 28 minutes and 2 hours 5 minutes, which resulted in a recording time of 18 hours and 33 minutes. After the interviews and the end of recording, further discussions took place. Some farmers offered to make a tour through their farm and to taste their farm products. Important content for answering the research questions was noted by the interviewer in a protocol immediately after the end of the interview, relevant topics were included in the analysis.

3.4.4 Transcription of the interviews

The conversion of the spoken language into a text form can be done in a structured process, i.e., through transcription rules. The transcription was carried out according to the system of "*clean read or smooth verbatim transcript"* (Mayring, 2014, 45). The transcription was done word - for - word. However, some expressions like *"ah", "uhm", "yeah"* were left out. A coherent text representing the original wording and grammatical structure was created, dialects were translated into the standard language, following the suggestions by Mayring (2014, 45). In addition, further rules for transcribing were applied (see Appendix V).

The interviewed farmers were coded with the abbreviation *Int_00* (consecutive numbering), indicting the chronological order of the interview conduction. If several interviewees attended the interview, a distinction was also made between *Int_00_01 / Int_00_02*.

3.5 Qualitative content analysis

Qualitative content analysis enables to process texts such as interview transcripts (Fenzl and Mayring, 2014, 38). In the qualitative content analysis, the category development can take place on the basis of previous theoretical knowledge (deductive coding) as well as from the collected data material (inductive coding).

The central idea of qualitative content analysis is to conceptualize the process of assigning *categories* to text passages as an interpretive act according to content analysis rules (Mayring, 2014, 10).

The category system is the central analysis tool with which the entire text body is coded. When developing categories, the formation of the codes and categories should be appropriate to the available data and the research questions (Bücker, 2020, 8ff.).

A major goal of the deductive approach is to apply a certain theoretically - based structure, such as the MPPACC. This structure is transferred to the empirical data material in form of a category system. All text components that address the categories are then extracted from the data material. Which text components belong to a category must be precisely determined. First, the text passages in the material in which the relevant category is located are marked (Mayring, 2014, 95). In a next step, the marked material is processed. For this work, the text analysis software Atlas.ti was used (Atlas.ti, 2017). The process is called deductive because the system of categories is set up before the text body is coded. The categories can be derived from theories or from other studies or previous research. For this work, the theoretical model presented in section 3.1 was used for deductively developing a category system. The deductively derived categories are not developed from the text material, as is the case with inductive category formation (Mayring, 2014, 95f). The formation of inductive categories is also a central process. If material is found in the text that corresponds to a category definition, a category must be created. A term that describes the material as closely as possible is typically used (Mayring, 2014, 80f).

Ruin (2019) describes the structuring procedure as the mode of category building. In most cases, mixed forms such as a deductive - inductive coding strategies are applied. This is mostly because, a purely deductive approach does not pursue the specific characteristics of the material, whereas a purely inductive approach represents the risk of not explicating existing prior knowledge that is relevant in the context of the analysis (Ruin, 2019, s.p., Schreier, 2014).

For the analysis, a category system was *deductively* created based on the MPPACC and the research questions. The first created category system was not considered to be complete and was revised and supplemented during the coding process (see step 6, Figure 9). During the process of coding interview transcripts, additional codes were identified *inductively* [3] (based

[3] Example of a code for operational adaptation to climate changes inductively: Anpassung: betr: umgesetzt_Inkrementell / Agronomisch

on the interview statements) which were then included in the category system. During and after the coding process, the memo tool in Atlas.ti was used to define and take notes, summarize analytical steps, and record queries. Important findings and connections between statements of an interviewee were also recorded in the Atlas.ti memo tool. These were used to develop the results. In the analysis, attention was paid to which interview statements match the defined codes. The results led to answer the research questions. The steps of the analysis presented in Figure 9.

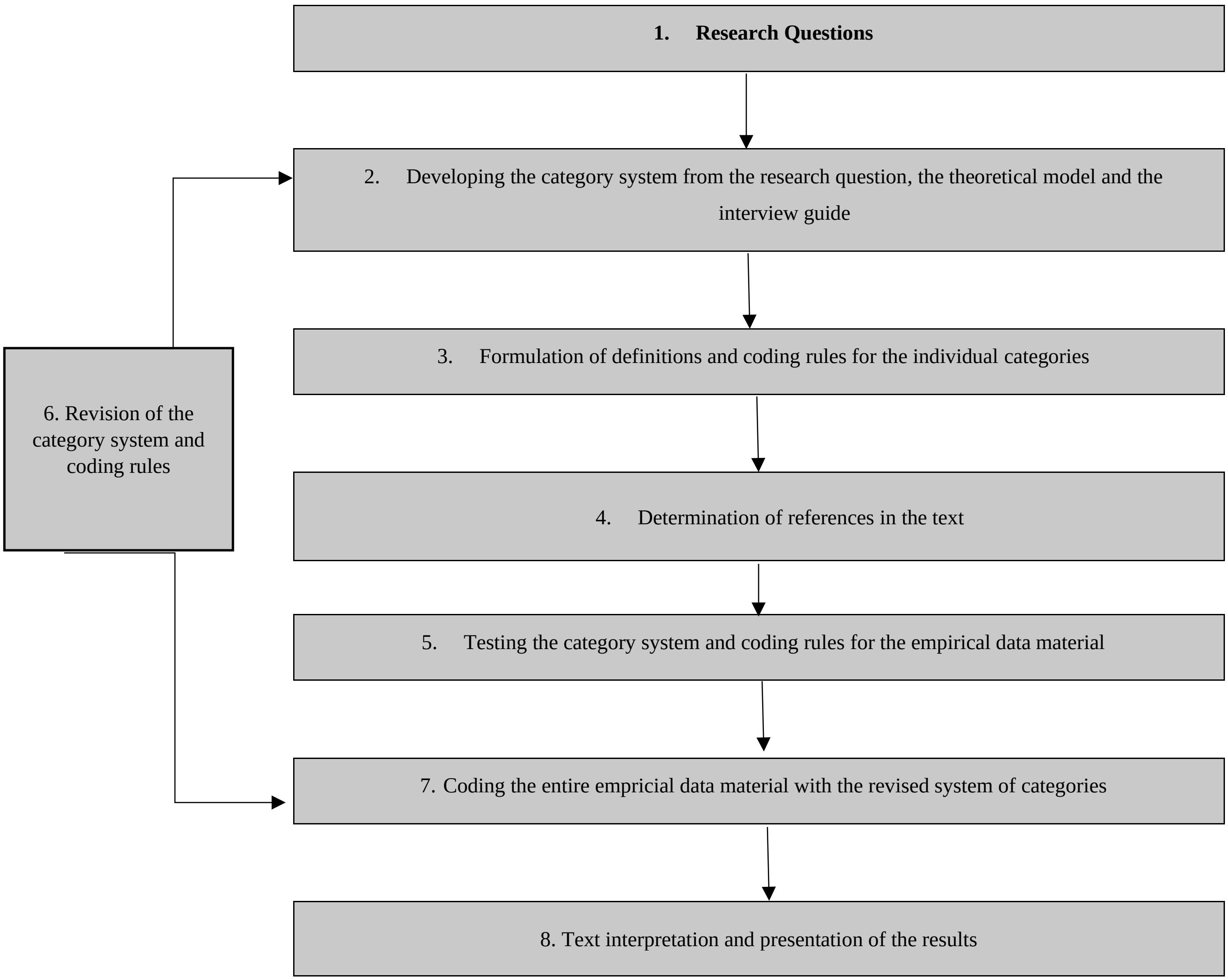

Figure 9: Qualitative content analysis following the content structuring procedure.
Source: see (Schreier, 2014, s.p.) and (Mayring 2020, 171, Mayring 2014), own illustration.

Mayring (2010, 2014) differentiates between four main forms of interpretation: *summarizing, explicating context analysis, structuring and mixed forms (qualitative and quantitative)* (Mayring, 2010, 164, Mayring, 2014, 6). During the development of the category system that serves to analyze the collected data for this master thesis, the focus was on the *structuring* procedure. The aim of the analysis is to filter out certain aspects of the material or to evaluate the material according to certain criteria (Mayring, 2014, 64). There are two basic steps in this form of structuring:

- The first deductive step is to create a list of topics taken from theory or previous studies. The empirical data material is then coded with these categories. If there is a large amount of material per category, inductive category formation should then be carried out.

- The second step is to *summarize* all of the coded material per category and defining the codes with memos (Mayring, 2014, 104).

4 Results

The interviews should provide insights into (i) how farmers in the Seewinkel region perceive climate change and related impacts on their farms and on themselves, and (ii) which adaptation measures (including irrigation) they have already implemented on their farms and intend to implement in their future. These insights are used to answer the research questions. The first subchapter summarizes farmers' beliefs in climate change (subchapter 4.1). Subchapter 4.2 deals with farmers´ perceived and expected changes in climate in the Seewinkel region. The next subchapter presents farmers' perceived impacts of climate change, both on their farms and themselves (subchapter 4.3). Subchapter 4.4 deals with farmers´ expectations of climate change impacts on their farms and in the Seewinkel region. Subchapter 4.5 discusses adaptation to climate changes. Inter alia, irrigation and personal adaptation are addressed. The interview results presents farmers' point of view. It should be noted that original quotes of the interviewees (in German) are provided in footnotes throughout the results chapter.

4.1 Farmers' belief in anthropogenic climate change and their appraisal of global climate change

A majority of interviewed farmers believes in global anthropogenic climate change. However, some farmers believe that climate change has only occurred for a certain period of time *"Climate change took place around 20 years ago"*[4] (Int_21) (anthropogenic climate change), while other famers believe that "*climate change has always existed"*[5] (Int_20) (natural climate change). GHG emissions are mentioned as the most common cause of global anthropogenic climate change. According to statements of famers, the influence of humans manifests itself mainly through industry (fossil fuels) and traffic (air traffic, car traffic and

[4] Original quote in German (Orig. q.): *„Klimawandel hat vor ca. 20 Jahren stattgefunden"* (Int_21).
[5] Orig. q.: *„Klimawandel hat es immer schon gegeben"* (Int_20).

shipping), which causes high GHG emissions. Furthermore, GHG emissions due to population growth is most often perceived to have global impacts. For instance, farmer perceive that, cars, fossil energy consumption and the use of plastic packaging or eating meat are the most relevant impacts of climate change on a global level.

Farmers perceive a change in the climate manifesting in changes in temperature and rainfall. In relation to temperature, a higher average temperature, persistent dry periods and the melting of glaciers are perceived as global impacts of climate change.
Farmers classify perceived global climate change in **two categories**: intensity and frequency. These two categories are examined in the four seasons, as farmers often describe climate change in the seasonal context.
In relation to the seasons, a distinction is made between the two categories of inter- and intra-seasonal changes. *Intra seasonal changes impact all changes that are assigned to a certain season. Climatic changes that have no seasonal context are referred to as inter seasonal changes*. The intensity of the climatic changes is influenced by farmers' perception of the severity in which a climatic change is present or pronounced. The frequency is based on the duration and increase or decrease of climate change through the farmers' perception (cf. Stöttinger, 2016, 36). The perceived climate change in *heavy precipitation*[6] is arranged with *intensity* and *frequency* and the climatic change in *precipitation distribution* [7] is only arranged with *frequency*.

In the course of the interview, farmers compare their observations with additional information sources. For instance, some farmers use mass media as common information source, and other farmers refer to conscious impressions that they themselves perceive in relation to impacts of climate change in the Seewinkel region and relate this to the global impact.

[6] Deutsch: Kode orig.: *„Starkniederschlag"*
[7] Deutsch: Kode orig.: *„Niederschlag – Verteilung"*

4.2 Farmers’ perceptions and expectations of climate change in the Seewinkel region

4.2.1 Farmers’ perceptions of climate change in the Seewinkel region

This subchapter describes how farmers perceive climate changes in the Seewinkel region. The results are shown schematically in Figure 10. Perceived changes in *intensity* are related to dry spells, drought heat and temperature rise in summer. Almost all of the interviewed farmers perceive, that it has on average been hotter and drier over the past few years. Not only the days are dry in summer, but also nights during summer months are perceived drier and warmer with temperatures above 20 °C. Looking back on the time since the farmers started working in agriculture, changes in precipitation are observed to be as intensive as a rise in temperature. Precipitation typically follows long-lasting dry phases and occurs in an intensified form. It is observed, that hail is basically not a noteworthy problem in the region. Hail as an impact of climate change is described as *“weakened in its intensity”*, with moving across the region in strips, so that few farms show annual hail damage. Wind and storm are perceived as *“always been there in the region”*. Some farmers have noticed that wind and storm increased in intensity over the years. In the winter season, farmers observe an intense rise in temperature with hardly any closed snow cover.

The winters are said to be milder and frosts are less, which increases the risk of late frosts in spring. Late frosts are perceived as one of the most intense climatic change impacts by almost all of the farmers interviewed in the viticulture sector. This climatic impact was described as enormous for the year 2016, but its intensity has not occurred again so far.

According to *frequency* in connection with dry spells, droughts heat and temperature rise, it is perceived that, in contrast to earlier, where in the summer months more days were perceived around 27 degrees and “*days around 30 degrees were exceptional phenomena, today the days around 30 degrees are reality and days around 27 degrees exceptional”*[8] (Int_18). In terms dry periods, they are not only observed in summer. According to the farmers, it already gets hotter in spring which lasts until autumn, so the farmers perceive that the transition seasons

[8] Orig. q.: *„[…] jetzt die Tage was über 30 Grad haben, Normalität ist, und die Tage mit 27 Grad eine Ausnahmeerscheinung, und wie ich ein Bub war, war das eine Sensation“* (Int_18)

spring and autumn no longer exist. The distribution of precipitation is noticed by most farmers in relation to frequency. The frequency of precipitation is observed to be decreasing and the distribution of precipitation has changed drastically in recent years. The precipitation distribution is no longer similar over the whole year but precipitation is mainly observed in spring. With regard to the distribution of precipitation, the farmers almost agree that the distribution of precipitation has changed drastically. According to this, precipitation is distributed differently over the year and therefore longer dry phases occur. When it rains, however, the rain usually comes more intensely, so that floods follow within a very short time. The interviewees consider precipitation to be an important factor. Often, changes in precipitation are related to the temperature rise: "*less precipitation, the precipitation distribution is no longer given over the whole year but is characterized by extreme precipitation events"*[9] (Int_04). Furthermore, yields began to fluctuate because of annual fluctuations in precipitation.

Wind and storm are observed as *always been there in the region* (see above). However, some farmers not only perceive wind and storm to be hefty in terms of its intensity but also in terms of its frequency throughout the whole year. The frequency of snow-poor winters has increased enormously over the last years. According to the farmers, the winters are getting milder every year. In particular, interviewed farmers who have been active in agriculture for longer than 30 years, have observed that the frequency of winters with little snow is increasing.

By and large, the interviewed farmers perceive that extreme weather events have increased in both, intensity and frequency over the years in the Seewinkel region. This is mainly due to the hot and dry summers, which have increased in intensity and frequency. Several farmers refer to the hot and dry vegetation period in 2019, where most farmers observe an increase in the average temperature in all seasons.

A general increase in temperature is perceived by the interviewed farmers. Related to this, heat and drought are mentioned in this context, what one farmer calls *"it gets hotter, drier. These are the 2 facial features"*[10] (Int_09). Some suggest that temperature rise and

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[9] Orig. q.: „*weniger Niederschlag, die Niederschlagsverteilung ist nicht mehr übers ganze Jahr gegeben, sondern wird durch extrem Niederschlagsereignisse geprägt"* (Int_04).

[10] Orig. q.: *„Es ist heißer, trockener, das sind die 2 Gesichtsmerkmale."*(Int_09)

precipitation sums change in cycles of 10 years. According to some farmers' statements a common process in the Seewinkel region is a change every few years, which lead to drought and heat years and to rainy years in a cycle: "*it used to be said that there will be seven fat years and then there will be seven lean years. That means that in the fat years it rains more [...] and then comes the lean years"*[11] (Int_13).

Most of the interviewees perceived hail and frost to decrease in frequency over the year and classified as no longer relevant in the region. The transition periods, which the interviewees feel only to a lesser extent in the region, is significant. Autumn and spring are perceived in their intensity as winter and summer. In addition, the loss of transition periods is described as follows in this context: "*the seasons are more or less history, the classic transition from winter to spring or from summer to autumn no longer exists"*[12] (Int_12). Figure 10 compares perceived climatic changes in the Seewinkel region with regard to seasonal and non-seasonal context.

Despite the inter and intra-annual variabilities and frequency and intensity of many climatic changes in the Seewinkel region, some farmers observe no to moderate climatic changes. The interviewees observe that the Seewinkel region is, among other things, characterized by drought and has always been: "*it is also logical [...] that we are an arid area and that not for 20 years but always"*[13] (Int_18). The distribution and intensity of precipitation as well as wind and storm are characteristic for the region: "*this transition period where it doesn't rain, we live in the Pannonian climate, 2003 was worse than last year, nobody wrote about the climate"*[14] (Int_19).

[11] Orig. q.: *„früher hat's immer geheißen, es kommen sieben fette Jahre und dann kommen sieben magere Jahre. Das heißt, bei den fetten Jahren regnet's mehr […] und dann kommen die mageren Jahre"* (Int_13).

[12] Orig. q.: *„die Jahreszeiten sind mehr oder weniger Geschichte, den klassischen Übergang von Winter auf Frühjahr oder von Sommer auf Herbst gibt es in dem Fall nicht mehr"* (Int_12).

[13] Orig. q.: „*logisch ist auch [...] dass wir ein Trockengebiet sind und das nicht schon seit 20 Jahren sondern immer*" (Int_18).

[14] Orig. q.: *„diese Übergangszeit wo es nicht regnet, wir leben im Pannonischen Klima, 2003 war es ärger als das vergangene Jahr hat kein Mensch über Klima geschrieben"* (Int_19).

Perceived changes in climate by interviewed farmers in the Seewinkel region.

With seasonal context (intra-seasonal) | **Without seasonal context (inter-seasonal)**

Climate change	Intensity	Frequency
Increase in annual mean temperature, heat	Rising temperatures in summer, related with more extreme hot days More extreme hot nights in summer with average temperatures above 20 degrees during the night Rising temperatures in autumn and winter	Prolonged or more frequent heat and drought periods from spring to autumn More frequent hot days and dry nights from spring to autumn Decrease of snowfall events in winter
Precipitation	More extreme heavy precipitation events after long dry periods, especially in spring and summer	Changes in precipitation distribution, with less frequent precipitation events in spring, summer and autumn
Wind and Storm	More extreme winds (higher wind speed) and storms	Increase in windy days and nights in spring and summer
Frost	More intense late frost events in spring	Decrease in frost days in winter
Hail	Less extreme regional hail events	Decreasing frequency of hail events

Inter seasonal and annual variabilities
Loss of transition periods. Disappearance of spring and fall Annual fluctuations in precipitation

Figure 10: Perceived changes in climate by interviewed farmers in the Seewinkel region. Source: own illustration.

4.2.2 Farmers' expectations of future climate change in the Seewinkel region

The majority of the interviewed farmers expect that temperatures will further rise and that extreme weather events such as heat and drought will increase in frequency and intensity until 2050. Furthermore, a change in precipitation distribution (away from the growing season is expected by many farmers. However, heavy precipitation events are expected to increase massively, which triggers anxiety about the future among farmers. Hurricane-like storms are also expected for the period until 2050. The interviewed vintners expect more late frost events, especially in combination with hail.

By contrast, some of the interviewed farmers expect no dramatic changes in climate until 2050.

If temperatures continue to rise, tourism in the region is expected to decrease until 2050, which would lead to a loss of earnings for direct marketers.

4.3 Farmers' perceptions of climate change impacts on their farms

4.3.1 Perceived climate change impacts by production activity

The perceived impacts are shown along the lines of the agricultural production activities: cropland and grassland farming, viticulture, fruit growing, vegetable growing and livestock farming. In addition, a distinction is made between perceived production-related and economic impacts on farms as well as labor-related impacts on the personal level of the farmers.

4.3.1.1 Cropland and grassland farming

The interviewed farmers in cropland and grassland farming indicate that these production activities are mainly characterized by the intensity and frequency of precipitation. On the one hand, on agricultural land cannot be driven after heavy precipitation events, which means that weed pressure may increase. On the other hand, some interviewees stated, that yields in cropland farming fluctuate, in particular due to annual fluctuations in precipitation, changed precipitation distributions and because of decreasing average annual precipitation: *''if you grow spring barley now, it used to be grown a lot, nowadays you are lucky if you can harvest* *it because there is no rainfall in spring"*[15] (Int_20). In contrast to this, some interviewees reported an increase in the number of field work days available due to drier weather conditions and lower average annual precipitation sums. The month of May 2019 is often referred to as an extreme example, since, according to the farmers, precipitation volumes were above average in this month, and cool and summery hot temperatures alternated within a very short time. Fluctuations in soil temperature and flooding of cropland are perceived as an impact of extreme weather conditions, which impacts the cultivation dates of some crops while other crops become emergency ripe. Harvest losses (physical) and losses in net returns (monetary) are mentioned as an impact of extreme weather events. According to the interviewees, harvest times in cropland have changed little, since they started working in agriculture.

Examples of perceived opportunities and risks related to drought, wind and precipitation by interviewed cropland and grassland farmers are summarized in Figure 11.

[15] Orig. q.: *„Wenn du jetzt eine Sommergerste anbaust, früher ist das oft angebaut worden, heutzutage hast du schon Glück, wenn du sowas dann ernten kannst, weil die Niederschläge im Frühjahr fehlen"* (Int_20).

	Opportunity appraisal	Risk appraisal
Drought	The interviewees perceive drought as a positive impact on harvesting conditions, as especially the grains can dry out faster.	Drought damage to crops is described as a negative impact. Drought is cited as the most common reason for crop losses.
Wind	Since wind allows water from excessive rainfalls to evaporate more quickly, according to the interviewees, mechanical weed control can be done more often.	The increase in the frequency and intensity of wind is rated as a risk. An upgrade in machenery is discussed in order to process the land faster on a few windless days.
Precipitation frequenczy, intensity	More field work days are available, as longer periods without precipitation are perceived.	Weed control is difficult because of intensive precipitation events, as the fields cannot be driven on.

Figure 11: Summary of the perceived opportunities and risks related to drought, wind and precipitation by interviewed cropland and grassland farmers in the Seewinkel region. Source: own illustration.

4.3.1.2 Viticulture

In viticulture the interviewed winemakers describe two main impacts in connection with perceived climate changes. On the one hand, the earlier ripening of the grapes and, related to that, the earlier start of the harvest. The interviewees stated, that in the last few decades the harvest time has shifted from late September – early October to now late August – early September: *"that within 50 years the average of the harvest, the harvest date, has moved forward by a month, that is certainly due to climate change"*[16] (Int_02). For some winemakers, this has the impact that the quality and sugar content of the wine decrease. They indicate that processing the grapes at cooler temperatures is beneficial for the quality of the wine.

On the other hand, there is Zweigelt disease or grape wilt, which is already a massive problem in the region: *"it not only impacts the Zweigelt, there are also other varieties that are impacted, you are still groping in the dark, but what you can, I believe, say, is that with*

[16]Orig. q.: „*Dass sich innerhalb von 50 Jahren der Durchschnitt der Ernte, des Erntedatums, um ein Monat vorverlegt hat, also dass ist sicher eine Klimaveränderung*" (Int_02).

extremes, weather extremes, wilting occurs more intensely"[17] (Int_12).
However, some winemakers point out that a direct connection between Zweigelt's disease and the climate change has not yet been proven.

Examples of perceived opportunities and risks related to drought, mild winters and frost by interviewed viticulture farmers are summarized in Figure 12.

	Opportunity appraisal	**Risk appraisal**
Drought	According to the winemakers, dry summers are beneficial for the health of the grapes and vines because they become more resistant to fungi.	The winemakers state that droughts changes the pH value in the soil, in the grapes and in the wine, which can affect the health of the grapes and the taste of the wine.
Mild winters	Varieties such as Blaufränkisch or Syrah can ripen until late autumn and can be harvested later.	Pests no longer freeze in winter or stay longer in the region (e.g. mice gnaw on irrigation systems, starlings).
Frost	Varieties like Blaufränkisch and Syrah do not freeze in winter and do not have to be renewed.	Late frost was already causing major problems in viticulture. Especially in 2016 there was a massive frost problem, where most winemakers suffered enormous yield losses.

Figure 12*:* Summary of the perceived opportunities and risks related to drought, mild winters and frost by interviewed viticulture farmers in the Seewinkel region. Source: own illustration.

[17]Orig. q.: „*Es betrifft nicht nur den Zweigelt, es sind auch andere Sorten die betroffen sind, man tappt nach wie vor im Dunkeln, aber was man, glaube ich schon sagen kann, ist, dass unter Extreme, Wetterextreme die Welke verstärkt auftritt"* (Int_12).

4.3.1.3 Fruit growing

Some interviewed fruit producers were particularly impacted by hail damage in May 2019. While hail was described as no to moderate problem in other agricultural sectors, hail is perceived as a problem in fruit-growing, especially in apple production: *"we had hail in May this year and of course you saw that when the apples were harvested [….] it can be produced mainly pressed fruit and no longer fresh fruit and this is a loss of money"*[18] (Int_07).

Another specific problem that occurred in May 2019 was intensive precipitation followed by rapid temperature changes. As a result, fruit crops did not have time to mature and became emergency ripe.

Examples of perceived opportunities and risks related to drought, heat and frost by interviewed fruit growing farmers are summarized in Figure 13.

	Opportunity appraisal	**Risk appraisal**
Drought and heat	Due to droughts and the increase in hot days, fruit growers have observed an extended vegetation period. This is seen as an advantage in fruit growing, as the crops have more time to mature and can be harvested later.	According to the interviewees, fruit crops are more frequently affected by sunburn. The perceived increase in pest pressures due to rising temperatures becomes an additional problem. Due to a longer period of vegetation pests can survive for several generations.
Frost	If frost comes at the right time, pests can freeze to death in winter (e.g. codling moth).	Late frost is perceived as a massive problem for fruit producers. With reduced harvests and yield losses.

Figure 13: Summary of the perceived opportunities and risks related to drought, heat and frost by interviewed fruit growing farmers in the Seewinkel region. Source: own illustration.

[18]Orig. q.: „*Wir hatten heuer im Mai Hagel und das hat man dann natürlich bei der Ernte bei den Äpfeln auch gesehen [...] ist dann vor allem Pressobst und kein Frischobst mehr und sind Geldeinbußen"* (Int_07).

4.3.1.4 Vegetable growing

Similar to fruit growing, the interviewed farmers also notice new pests emerging in vegetable growing, since there is usually no snow and limited frost days in winter. Furthermore, in vegetable growing it is perceived that the vegetation period is longer, and that less light and energy have to be used in foil houses: *"we are earlier in vegetable growing, which is also positive, you can assert yourself on the market earlier"*[19](Int_09).

The frequency and intensity of winds are perceived as a problem with regard to foil houses. The wind damage is described as "enormous", facilities have to be renewed more often, with high economic and labor management impacts for producers.

The vegetable producers point out that they can benefit from rising temperatures through longer cultivation and harvesting dates, whereby the positive impacts partly outweigh the negative.

Examples of perceived opportunities and risks related to temperature rise, drought and wind by interviewed vegetable farmers are summarized in Figure 14.

[19] Orig. q.: „*Wir sind auch im Gemüsebau früher dran was auch positiv ist, man kann früher am Markt gehen*" (Int_09).

	Opportunity appraisal	**Risk appraisal**
Rise in temperature and drought	Due to the rising temperatures and the associated change in cultivation time, according to the interviewees, the harvest can take place earlier. Vegetable growers can profit from this economically, as the product can be offered on the market earlier and can be grown longer due to the later onset of winter frosts.	Vegetable producers attribute increasing drought damages to vegetables to rising temperatures in connection with a lack of precipitation. Pests are increasingly observed and new pest populations can establish.
Wind	Wind is called "healing" for the cultures, because like in viticulture, due to the lack of moisture, fungi are less resistant.	Due to more intense winds, foil houses and systems have to be replaced more often.

Figure 14: Summary of the perceived opportunities and risks related to temperature rise, drought and wind by interviewed vegetable farmers in the Seewinkel region. Source: own illustration.

4.3.1.5 Livestock farming

Farmers interviewed in livestock farming perceive direct and indirect impacts of climate change on production and profitability.

In case of dairy sheep, it is reported that climate change mainly impacts milk yield, which decreases especially in extreme heat.

Poultry and pigs cannot regulate their own body temperature. Under extreme heat, the interviewed farmers observe that the yield of eggs in poultry farming decreases. When keeping pigs outside, they point out that they get sunburned and the skin turned red.

Indirect impacts can occur if feed production and availability are impacted: *"in poultry you can tell by the feed prices when the harvests are weaker, by whatever, when it rains too little or too much, that the feed becomes more expensive, or at the moment it is cheaper"*[20] (Int_03).

[20] Orig. q.: „*Im Geflügel merkt man das durch die Futterpreise, wenn die Ernten schwächer sind, durch was auch immer, wenn es zu wenig regnet, oder zu viel regnet, dass das Futter teurer wird, oder momentan ist es günstiger*" (Int_03).

Examples of perceived opportunities and risks related to temperature rise, drought and wind by interviewed livestock farmers are summarized in Figure 15.

	Opportunity appraisal	Risk appraisal
Rise in temperature and drought	A positive impact can be demonstrated by indirect effects. Due to the drought, feed production can be positively influenced as grain and hay dry out faster.	There can be indirect negative impacts, if too little hay or grain is available for feed production due to drought damage. Direct impacts can arise if milk yield of dairy sheep or egg production in poultry decreases.
Wind	Since poultry and pigs cannot regulate their body temperatures themselves, wind can cool down more quickly their temperatures, despite the heat.	Because of intense winds, the stables have to be aligned against wind damage.

Figure 15: Summary of the perceived opportunities and risks related to temperature rise, drought and wind by interviewed livestock farmers in the Seewinkel region. Source: own illustration.

4.3.2 Perceived climate change impacts on agricultural production in the Seewinkel region

Lower yields are observed in cropland, mainly due to the unfavorable distribution of precipitation and drought which impacts the production level directly. In the event of intense precipitation, the cropland cannot be cultivated for some time, which increases weed pressure extremely and has an impact on the production. Especially for farmers who own a lot cropland, this is increasingly becoming a problem, since if the land dries out quickly, all land would have to be cultivated immediately. If the precipitation distribution is unfavorable, grain losses of 2,000 kilos than in a year with average precipitation are reported, which means that less grain can be sold. For the quality of maize, farmers would prefer to thresh at a higher humidity. However, this is no longer possible due to the lack of precipitation. During hot days over 30 °C, the growth of the crops is restricted and some of them become emergency ripe. This was observed especially with potatoes, which means that less potatoes can be produced and sold. Summer cereals such as spring barley can sometimes no longer be grown because it is already too dry for it in spring, which has an impact on total production of spring barley.

Most of the farmers interviewed in grassland farming produce feed for livestock farming. Indirect impacts of climate change in the Seewinkel region are observed through changes in precipitation distribution and increased droughts. Interviewed farmers stated, that because of lower yields due to the unfavorable distribution of precipitation and droughts in the last three years, too little feed is available for their own livestock. Food that is not available has to be bought, which is associated with high costs.

On the other hand, drought makes hay extraction easier. Hay is perceived to dry faster than it used to and can therefore be used more quickly as feed, which has a positive impact on livestock production.

Due to rising temperatures, especially in winter, pests and weeds are perceived as a massive problem on cropland. Due to intensive cultivation in combination with monocultures and droughts, the western corn rootworm does not freeze in winters and affects especially seed corn cultivation. Not only in the cultivation of seed corn, but also in the cultivation of sugar beet, shorter pest intervals of the beet weevil are observed due to the milder winter. The two weeds, thorn apple and ragweed are perceived as a major problem on cropland in the Seewinkel region. With intensive wind and rising mean annual temperatures, these weeds can distribute more widely and germinate better, which can have a negative impact on production in the long term.

The interviewed farmers perceive positive impacts on production in the context of new crops and longer cultivation times. The climatic conditions for new varieties to mature and flourish are valued positively.

Energy savings are perceived in foil houses. Using the example of cannabis plants, it can be observed that the cultivation period has been shortened from 4 weeks some years ago to 3 weeks today.

The increase in the annual mean temperature impacts viticulture particularly in terms of earlier harvesting. The time of harvesting the grapes has shifted significantly. The interviewed winemakers stated, that this shift clearly affects the quality of the grapes and the production level. For the quality of the grapes and wine, it would be beneficial to process the grapes in the cellar at cooler temperatures. The consequence is that the grapes have to be cooled down with a lot of energy. If this is not possible, the wine could get a vinegar tinge and would not

be drinkable. The increasing heat and drought in spring and summer bears additional risks. Yield damages caused by drought and sunburns are increasingly observed on vine and grapes. Grape wilt or Zweigelt disease is perceived as a massive problem in the region as well and has an enormous impact on production levels. This disease may reduce the weight of the grapes. However, the origin and occurrence of the disease are not yet scientifically clear. Nevertheless, the interviewed winemakers observe an increased incidence of wilt under extreme weather conditions. An increased incidence of pests is observed as well. Furthermore, starlings cause massive yield losses, due to the earlier ripening of the grapes. When it comes to soil conditions, the pH value suffers from drought. In addition, drought is a stressful situation for vine, as the nutrient supply and the nutrient transport from the soil into the vine is disturbed, which impacts the production level negatively in the long term.
Advantages of drought and wind in viticulture are mentioned. Fungi are less resistant, which has a positive impact on the quality of the grapes, which results in a positive production impact.

In 2015 and 2016, there were two massive climatic events that were reported by the interviewed winegrowers. First, intense precipitation in 2015, where interviewed vintners reported crop failures between 80% and 94%. One winemaker reported, that due to the rot, *"not a single red wine was bottled in this year"*. Second, there was a late frost event in 2016, which also resulted in massive crop losses in April of this year.

In viticulture, heavy precipitation events, Zweigelt disease and starlings as a result of the rise in annual temperature and late frost events are cited by the interviewed winemakers as the most frequent causes of yield losses on production level.

Hail is perceived as a moderate problem in viticulture in the Seewinkel region because, unlike in the past, hail appears in strips, which, however, is more intense when a vineyard is impacted and thus causes a loss of yield.

The increasing number of hot days with temperatures above 30 °C in spring and summer is perceived to cause damages to some fruit crops. Using the example of strawberries, the interviewed fruit growers observe that crops became emergency ripe in spring 2019, which impacted the production level negatively. Due to temperature fluctuations in May between 15 °C and 30 °C, strawberries did not have time to ripen properly. They stayed small and turned

red, which led to a decrease in the production quantity.
Using melons as another example, increasing heat and drought damages are observed. The leaves of the melons dry out on heat days, which means that the culture is not shaded and is therefore damaged.

As with strawberries, growth disorders are observed for apple trees due to increasing heat in summer. The quality of apples suffers and such apples can only be processed into pressed fruit. Pest intervals are perceived to increase more rapidly in fruit growing. For instance, it has been observed that the codling moth produces three (instead of two) generations, which impacts the production level negatively in the long term. Due to the increasing annual mean temperatures and the resulting longer vegetation period, the pest does not freeze in winter.

In contrast to other agricultural production activities, hail is observed as a massive problem in fruit growing. Especially when it comes to apple growing, hail caused damages in May 2019. The apples are provided with dents and can only be processed into pressed fruit, which resulted in yield and income losses.

Due to the increase in the annual mean temperature and the resulting longer vegetation period, some fruits can mature longer. Using the example of apples, it can be observed that, due to longer ripening, the apples still gain weight in late summer, which impacts the production level positively in the long term.

Similar to fruit growing, crops in vegetables suffer from increasing drought and heat in spring and summer. According to the interviewed vegetable producers, damages to vegetables can be observed not only outdoors but also in greenhouses and foil houses. Using the example of tomatoes, some vegetable farmers perceive that the culture does not ripen properly and that growth stops at temperatures above 30 °C. This also makes it difficult to breed cultures, as pollination cannot take place once growth has ceased. In addition, as in other agricultural production activities, an increase in the pest intervals is perceived, for example cotton bollworm.

More intense winds often rub the fruits against each other, which leads to damages and losses. By contrast and similar to viticulture, drought in connection with wind has a positive impact on vegetable growing. Fungi are less resilient. Due to an increase in the annual mean temperature, year-round vegetable production has become possible, which has a positive impact on production level. Using the example of radishes or lettuce, farmers observed that the cultivation time is shortened, and as a result, the vegetable mature earlier or can be harvested later in the year.

Livestock suffers from extreme heat temperatures in summer. In livestock farming, losses are being taken due to rising temperatures. Using the example of dairy sheep, farmers observed that performance decreases with increasing temperatures. The sheep eat less and drink a lot, as a result, milk yield decreases. In poultry production, the egg yield declines in summer. Free-range husbandry has become almost impossible for domestic pigs. It is observed by farmers, that extreme heat leads to sunburn.
In case of cattle farming, the impacts of climate change are still felt the least by the interviewed farmers.

Basically, climate change in almost all agricultural production activities were perceived to impact the quality of crops positively. Most of the interviewed farmers stated, that if the precipitation comes at the right time, better quality can be achieved, which results in a positive impact on production level.

4.3.3 Perceived climate change impacts on farmers' income in the Seewinkel region

Lower yields in cropland and grassland farming resulting from climatic changes have an economic impact on farms. Due to indirect impacts on feed production, feed has to be purchased, which results in additional expenses on farm. As a result, farmers may need to delay investments.

Due to increasing climate change, some farmers have to take additional insurance (e.g., hail or frost insurance in viticulture), where a high premium is due. In addition, equipment for adaptation measures, such as nets against starlings, has to be purchased, which comes with high costs. Equipment needs to be renewed, e.g., if irrigation systems are damaged by mice that no longer die in winter (gnawing hoses, especially with drip irrigation).

Lower harvests and yield losses in fruit and vegetable production resulting from climate change also cause income losses. For example, crops that are billed by weight can no longer bring the expected income. If apples are damaged, they can only be marketed as pressed fruit and not as fresh fruit in direct marketing, which also results in a loss of income.

On the other hand, due to the increase in the annual mean temperature, year-round vegetable production is possible, which means that vegetables can be marketed all year round. This has a positive impact on a broader annual turnover.

Storm damages to foil houses or stables must be renewed, which results in additional costs.

Tourism plays a major role in the Seewinkel region. Direct marketing benefits from rising temperatures in spring and autumn. Some farmers also aim to open pensions all year round.

On the other hand, the interviewed farmers stated that hot temperatures in summer lead to a negative impact on tourism in the region, because if the summer temperatures are too hot, less tourism is perceived in the region.

4.3.4 Perceived climate change impacts on the personal level

Labor economy impacts arise, if work in the midday heat is necessary. The majority of the interviewed farmers stated, that it was no longer possible to work in the midday heat, especially in high summer temperatures, and adaptation has to be made to working hours, this will be necessary mainly due to the postponement of the cultivation and harvest dates to hot summer days.
Some farmers also report that there is not only a monthly shift, but also a shift in time in cultivation and harvest dates. Planning is therefore seen as difficult for farmers.
In addition, farmers perceive positive personal impacts. The fact that the extremely cold winters no longer exist and the autumn records an increase in the average annual mean temperature not only brightens the minds of farmers, but there is also the possibility of cultivating new varieties in the Seewinkel region. This can also result in lower heating costs, not only in the own household but also on the farm.

In addition, suddenly occurring climatic changes trigger physical stress on farmers. Fears that temperatures will continue to rise cause despair. Among the interviewed winemakers, attention is also drawn to hail and frost events that could occur more frequently in the region again. In livestock farming and cropland, existential fears due to rising temperatures are reported. Here, for some farmers, the successor is placed under a question mark, should the temperatures continue to rise in the future, above all the fear of animal diseases triggered by climatic changes, as well as the financing of some devices for machine measures is addressed.

4.3.4.1 Farmers' avoidance thinking

Interviewed farmers wish that climate change will not progress any further, on a global level or in the Seewinkel region itself. In addition, the farmers wish that groundwater level in the Seewinkel region will not drop any further and that irrigation measures will be restricted. In connection with irrigation, the fear of increase in diesel fuel or CO2 tax is perceived.

Life in the Seewinkel region is described as fate. Some farmers see it as a fate to live in this region and therefore to have to find adaptation measures. Human adaptability is also defined as fate. From birth, man is open in spirit to adapt to new conditions.

The Pannonian climate is characterized by a seven-year period. Seven years with drought and heat and seven rainy years should alternate: *"the Pannonian climate is what we have. It will stay that way, we all swam 4 years ago or 5 years ago when it was extremely wet and now it is extremely dry, and it will be the seven - year period again, in 2-3 years it will rain again and then we have the wet year again"*[21] (Int_19).

Some interviewed farmers portray climate change on a global level as scaremongering and hype in the media landscape.

4.4 Farmers' expectations of future climate change impacts

Climatic change is expected to have a negative impact on the production of cultures as well as economic and work-related consequences. Production-related downtimes and poor quality are expected which would lead to financial losses. Massive changes are expected in livestock farming till 2050. Farmers expect more diseases and pests because of high temperatures: *"in livestock production, for example, bluetongue is now emerging, a typical story that is transmitted via insects that originate from the southern countries and always wander with the warmth and of course I'm scared because I'm the first in Austria there in the far east"*[22] (Int_16). Bluetongue disease is transmitted via midges, whereby the tongues of the animals

[21] Orig. q.: „*Das pannonische Klima ist das Klima was wir haben. Das wird so bleiben, vor 4 Jahren sind wir alle geschwommen oder vor 5 Jahren, da war es extrem nass und jetzt ist es extrem trocken, und es wird wieder das 7 Jahre Periode, in 2-3 Jahren wird es wieder ordentlich regnen und dann haben wir wieder das nasse Jahr"* (Int_19).

[22] Orig. q.: „*bei den Tieren kommt jetzt zum Beispiel die Blauzungenkrankheit auf, eine typische Geschichte, das wird über so Insekten übertragen, die an und für sich in den Südländern waren und mit der Wärme immer wandern und ich natürlich Angst habe, weil ich in Österreich der Erste bin, da ganz östlich"* (See_IP16).

turn blue in the end stage. Apart from the fact that animals would likely die from the disease, this would cause great damage to the farm.

Impacts on workload can arise, for example, due to more intensive irrigation which is implemented because of rising temperatures or due to wind damage to foil houses that have to be rebuild afterwards.

4.5 Agricultural adaption in the Seewinkel region

4.5.1 Adaptation measures already implemented in the farm production process

The following subchapter includes already implemented adaptation measures to climate change by the interviewed farmers in the Seewinkel region. The adaptation measures are presented for the various agricultural production activities.

4.5.1.1 Cropland and grassland farming

Farmers in the cropland and grassland farming have already implemented some adaptation measures to adapt to climate change in the Seewinkel region. Incremental and systemic adaptation measures play a major role on the farms of interviewed farmers. In particular, soil cultivation and changes in crop rotations for weed and pest control are mentioned to be important.

4.5.1.1.1 Incremental adaption measures

Due to increasing average annual temperatures, agronomic measures are mainly implemented. Many farmers refer to use of conservation tillage. On the one hand, many farmers rely on reduced or on no till in cropland, especially in grain cultivation. Their main motivation is to keep the humus layer and thereby reduce water loss: *"with grain we actually do more no-till, not like with the plow, but straight on the corn, for example, cultivating once and then sowing, so that we don't loosen up so deeply so that we get the water"*[23] (Int_13). In order to be able to work without plowing, the field is mulched and loosened after the harvest to preserve the humus layer in soil and on surface. On the other hand, some farmers plow almost their entire cropland.

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[23] Orig. q.: *„beim Getreide machen wir eigentlich mehr Direktsaat, also nicht mehr so wie mit dem Pflug, sondern gleich auf den Mais zum Beispiel, einmal grubbern und dann hineinbauen, damit wir nicht so tief auflockern, damit wir das Wasser erhalten"*(Int_13).

In order to combat the weed pressure, which increases due to rising temperatures, especially in spring and autumn, farmers rely on mechanic weed control, which means that machines have to be constantly upgraded. In order to reduce weeds such as ragweed or thorn apple or to prevent pests, monocultures are avoided by some of the interviewed farmers, as these would create a suitable habitat for weeds and pests. The choice of variety is considered to be decisive in adapting to increasing annual mean temperatures. Not only drought-resistant and heat-resistant varieties are crucial in adaptation. The use of new varieties is also becoming increasingly important in the region. If appropriate conditions are created, varieties such as rice and ginger can be cultivated without any problems due to the changing climatic conditions: *"you can also cultivate several cultures here, if you adapt them to the origin where they grew, that's rice in this case, that's ginger, you just have to create the appropriate conditions"*[24] (Int_19). It is important to create appropriate soil conditions for these varieties, so attention is paid to a slightly sandy, humus-rich soil.

Crop rotations are mentioned as important, too. For example, legumes are used as catch crops by some farmers, whereby especially alfalfa clover is often used. Furthermore, maize cultivation has been reduced by about a third by some farmers, in order to make intensive irrigation measures affordable.

The adaptation of cultivation and harvest times are also crucial. Growing and harvest time have to be adapted due to the increasing annual mean temperature, especially in spring and autumn: *"I don't grow maize on April 15th where it doesn't help me, I just take my time until May 10th and grow it, growing times are postponed"*[25] (Int_17).

With respect to changes in precipitation patterns and heavy rainfall events, greening is used in cropland over the winter. The crop rotation and the use of crops that have a better water absorption capacity are seen as an important agronomic adaptation measure.

As an adaptation measure against wind and storms, wind protection belts are used more often. However, many farmers think that there are too few in the region and should be reforested. To

[24] Orig. q.: *„[…] kann man mehrere Kulturen, wenn man sie anpasst an den Ursprung wo sie gewachsen sind, auch hier kultivieren, das ist Reis in dem Fall, das ist Ingwer, man muss halt die entsprechenden Voraussetzungen schaffen"* (Int_19).

[25] Orig. q.: „*ich baue nicht den Mais da an am 15. April, wo er mir nichts bringt, ich lasse mir einfach Zeit bis am 10. Mai und baue ihn an, Anbauzeitpunkte verschieben sich"* (Int_17).

prevent frost damage, frost cultivation is carried out in January and is intended to prevent frost damage in spring.

Working hours in summer are adapted depending on the temperatures. Above all, starting work earlier in the morning and stopping earlier in the afternoon in order to avoid heat temperatures of up to 35 °C is clearly practiced. The interviewed farmers often also take a longer break at lunchtime and continue working in the evening. Protective clothing - especially sun protection and adequate hydration - and drinking plenty of water are important priorities if working in the midday heat. Some of the interviewed farmers have also invested in air conditioning in the household in the past few years. It is stated that due to rising temperatures at night, it is difficult to do physically strenuous work during the day.

When it comes to the financial management of the interviewed farmers, more insurance policies have been concluded in recent years. In cropland and grassland farming sector, insurance is mainly taken in the areas of drought, frost and hail.

4.5.1.1.2 Systemic adaptation measures

In the case of systemic adaptation measures, all interviewed farmers invest in various tools, equipment and irrigation systems. Upgrading the irrigation systems is crucial to all interviewed farmers who have already introduced irrigation on their farm. The air conditioning of work equipment is also important. Farmers often invest in air conditioning systems on tractors and harvesting machines in order to be physically prepared for high summer temperatures of around 35 °C. Upgrades are not only being for the farmer himself, investments are also being made in sun protection for harvesting machines. For example, sun protection was implemented on a potato harvester to protect and shade the crops during harvest. Due to the distribution of precipitation and heavy rain events, farmers have fewer days of field work per year. Farms with a wide range benefit from this, with areas at different locations, as dry areas can be cultivated in the meantime. According to the windbreak belt, agroforestry is another crucial adaptation measure. With agroforestry, the crops cannot only be protected against wind and storm, but at the same time shade is provided on hot days.

4.5.1.1.3 Transformative adaptation measures

Transformative adaptation measures concern the conversion of farms to organic or biodynamic farming methods as well as taking up additional production activities or non –

agricultural secondary activities. The interviewed farmers state, that the conversion of the farms to organic and biodynamic farming methods can create advantages over conventional farms. Soil can form a better humus layer and thus store more water, which requires less intensive irrigation of crops. Diversification of crops is seen as an advantage, as it enables the farmers to adapt in the event of climatic failures.

Figure 16 summarizes the adaptation measures that have already been carried out in cropland and grassland farming in the Seewinkel region.

	Incremental adaptation measures		Systemic adaptation measures	Transformative adaptation measures
subcategories	**Agronomic**	**Work organization and financial management**		
Increase in annual mean temperature, heat	Conservative tillage (e.g., direct seeding) Mulching Mechanical weed control Heat-resistant varieties Crop rotation Humus build - up Adapting time of cultivation and harvest	Adapt working hours Protective clothing - (especially sun protection) Adequate hydration - (especially drinking water) Adhere to the cultivation plan (depending on the weather) Drought insurance	Investments in: Irrigation systems Air-conditioned work equipment incl. (sun protection on work equipment)	Conversion to organic or biodynamic farming Diversification
Precipitation	Drought resistant varieties Winter greening Crop rotation	——	——	——
Wind and storm	Windbreak belt	——	Agroforestry	——
Frost	Frost cultivators	Frost insurance	——	——
Hail	——	Hail insurance	——	——

Figure 16: Adaptation measures implemented by the interviewed cropland and grassland farmers in the Seewinkel region. Source: own illustration.

4.5.1.2 Viticulture

The choice of varieties is a crucial adaptation measure for winegrowers in order to prevent adverse impacts of climate change. The mechanical grape harvest at night is getting more and more important for interviewed winemakers because cooler temperatures during harvest are beneficial for the quality of the grapes.

4.5.1.2.1 Incremental adaptation measures

The interviewed winemakers in the Seewinkel region have already implemented agronomic adaptation measures. Above all, tillage and foliage work in the vineyard is adapted to rising annual mean temperatures. On farms with livestock, manure from their own production is used as green manure in the vineyard. This has advantages, because manure does not have to be bought. Greening and humus formation are used as important adaptation measures against rising annual mean temperatures. In order to prevent sunburns on grapes, foliage work is adapted by the winemakers. It is important to keep more leaves on the vines in the grape zone with direct sunlight and only defoliate the shady side so that there is a passage of wind. Most of the interviewed winemakers consider adapting canopy management to be crucial. Soil cultivation is mainly carried out in optimizing wheel marks. Most farmers state, that they only drive on every second row of the vineyard to prevent soil compaction. In addition, the cultivated rows allow natural greening in the winter months: *"in my case, the soil is no longer cultivated from September onwards, there is natural greening, I do not have to irrigate, I optimize my passages in the vineyard, I make sure that I don't keep any wheel marks"*[26] (Int_18). In case of soil cultivation, care is taken to conserve and protect the soil in the vineyard in order to keep the pH value as low as possible, as this can impact the grapes and thus the quality of the wine. In order to adapt to heat and drought manual work in the vineyards is crucial. Manual processing is always used for foliage work, as it is easier to estimate how much foliage is protective for grapes and vines: "*that varieties that are more prone to sunburn or heat, that I adapt the foliage work so that I no longer defoliate or partially defoliate, that I tend to produce more shade, although there is always such a dichotomy. On the one hand it should be airy, the grapes and the foliage wall should be well ventilated, because you have fewer fungi and diseases in there, but on the other hand you should have shade because of the sun, so you have to make a little compromise"*[27] (Int_15). In order to prevent fungi, pests and weeds, spraying in the vineyard is adapted to rising temperatures. Here, however, the advantage is, that fewer sprayings were carried out in 2019 than in previous years, since drought is a clear antagonist to fungi. In addition to spraying, yield regulations are also carried out on grapes. In order to increase the quality of sugar production and to protect the plants against drought and heat, the yields of the grapes are regulated before harvest. In order to optimize the sugar content, harvest time of grapes is adapted in addition to yield regulations. Every year before grapes are harvested, the

[26] Orig. q.: „*bei mir wird der Boden ab September nicht mehr angegriffen, da ist eine natürliche Begrünung drinnen, ich bin ohne Bewässerung durchgekommen, ich optimiere meine Fahrten im Weingarten ich schaue, dass ich keine Fahrgassen behalte"*(Int_18).

[27] Orig. q.: „*das Sorten, die eher einen leichteren Sonnenbrand oder hitzeanfällig sind, dass ich da die Laubarbeit anpasse, so, dass ich nicht mehr alles entlaube oder teilentlaube, dass ich eher mehr Schatten produziere wobei es ja immer so ein Zwiespalt ist, einerseits sollst du luftig, sollen die Trauben, soll die Laubwand gut durchlüftet sein, weil da hast du weniger Pilz und Krankheiten drin, andererseits sollst du aber wegen der Sonne eine Beschattung haben, da musst du so ein bisschen einen Kompromiss treffen"*(Int_15).

winemakers measure the sugar levels with a refractometer. If the degrees are in the optimum value around 16 °C, they are harvested.

In order to prevent yield losses due to changes in the distribution of precipitation and heavy rain, farmers focus on humus formation and conservation tillage. An adaptation measure against fungal infestation is taken by spraying with biological agents. Especially in organic and biodynamic viticulture, the risk of infestation with *Oidium sp.*[28] is very high due to heavy precipitation events and the associated increase in humidity.

A windbreak belt at the beginning of the vineyard row is a safe adaptation measure against winds and storms for the winemakers. In addition, the interviewed winemakers stated, that due to the winds and storms in the Seewinnkel region, the posts in the vineyards have to be moved, as there is a risk of the rows of vineyards being knocked over: "*the wind is fully attacking and you can only react to the fact that you don't have a post every 6 meters as you used to, but that you have to put one every 4 meters, because otherwise the wind or the strong wind pushes the line down*"[29] (Int_15).

To prevent frost damage to the vines, straw bales are lit at the end of the vineyard. This procedure was mainly carried out in April 2016, as the late frost damage to the vines was enormous that year. The straw bales are immediately extinguished after lighting. The resulting smoke darkens the sky, so that the rising sun does not thaw the frosted grapevines too quickly, this can be slowed down by the resulting smoke and frost damage to the vine can be reduced or even prevented.

Personal adaptation is taken by adapting the working hours. The winemakers stated that, work starts very early and stops again in the early afternoon, when temperatures are hot in summer. This is because the work performance was observed to decreases considerably when working in the heat. Some farmers state, that they avoid working in the midday heat not only for personal well-being, but also because the plants should not be worked, as the vines are exposed to a higher level of stress due to the heat. If working in the midday heat cannot be

[28] Echter Mehltau der Weinrebe.

[29] Orig. q.: „*der Wind greift voll an und da kannst du nur reagieren darauf, dass du nicht wie Früher, was weiß ich 6 Meter einen Pfosten drinnen hast, sondern dass du sehr wohl auf 4 Meter einen stellen musst, weil sonst drückt der Wind, oder der Starkwind die Reihe nieder*" (Int_15).

avoided, the interviewed winemakers rely on protective clothing and adequate hydration. Since more work is done manually in viticulture, the air conditioning of the work equipment is less important.

The mechanical harvesting of the grapes at night is being used more often in the Seewinkel region. Since the grapes are to be processed in the cellar at cooler temperatures, as this has a profitable impact on the quality of the wine, the grapes are usually harvested with the harvesting machine at night. In order to guarantee a good quality of the wine, the mash is also cooled down with a cooling system in the cellar before processing: "*we help ourselves by harvesting the white wines with the machine at night or early in the morning, or when the mash or grapes come home, that we then quickly cool the mash down*"[30] (Int_02).

When it comes to the financial management of the winegrowers, hail and frost insurance is most common. Since the late frost event in 2016, more winemakers have concluded frost insurance than in previous years.

4.5.1.2.2 Systemic adaptation measures

Systemic adaptation measures are implemented in viticulture, especially for investment in irrigation systems. The increased occurrence of pests in spring due to little frost and milder winters causes increased damage to drip irrigation systems of the winemakers. These have to be constantly upgraded and renewed. Investments are made in machinery that is used to adapt to climate change. For example, investments are made in defoliation devices, which are only used sporadically, as manual labor can be regulated more easily, and stock clearing devices, which are used when the vines have been damaged by frost. Investments are also made in a knife roller, which is used to roll in the greenery. This is described as being safer than cultivating.

According to the winemakers, starlings cause the greatest damage in viticulture. It has been observed that starlings stay longer in the Seewinkel region due to the summery autumn temperatures until the end of October. Because the ripening times of the grapes and thus harvest time is earlier compared to the past, starlings find sufficient food in vineyards as early

[30] Orig. q.: „*wir helfen uns durch das, dass wir die Weißweine eben mit der Maschine in der Nacht ernten oder zeitlich in der Früh, bzw. wenn sie dann heimkommt die Maische oder die Trauben, dass wir dann schnell die Maische runter kühlen*" (Int_02).

as the end of August. The winemakers prepare against starlings by netting the vines. However, this is described as a very time-consuming and costly work, which is mainly used in winegrowing communities close to the lake.

The switch to new varieties is indicated as a systemic adaptation measure in viticulture, as this is a long-term decision. As in cropland, winemakers also decide to plant new varieties. For example, when it comes to new plantings, attempts are made to avoid the Zweigelt variety and instead plant late ripening varieties like Blaufränkisch, Merlot, Cabernet Sauvignon or Syrah. These varieties are not considered to be native to the Seewinkel region, but are now used as reliable to adapt to rising temperatures in summer or autumn: *"whether it's Syrah or Merlot or Cabernet Sauvignon. I mean, these are varieties that have not really matured in our region for a long time. In the meantime, these are varieties where you know, ok you can rely on them, they grow very well in a totally hot summer and then come to maturity when weather in autumn is good"*[31] (Int_05). Whole pigeon fermentation is also used for these varieties in organic and biodynamic viticulture.

If late frost damage occurs, vines have to be replaced, which is considered labor-intensive and costly.

To prevent damage from hail, hail nets are attached to the vines. The installation of hail nets, like starling nets, is labor-intensive and costly, which is why most winegrowers prefer hail insurance.

4.5.1.2.3 Transformative adaptation measures

Conversion to organic and biodynamic farming is very important in the region's viticulture. Some winemakers were able to omit irrigation by switching to organic or biodynamic farming methods, since the emerging biodiversity and the increase in soil water content in the vineyard is supposed to provide water for the vine. Creating a safety buffer which can be harvested in the event of climatic failures, or extending the storage capacities in order to stock good vintages is also used in viticulture in order to be protected from climatic failures. Adaptation

[31] Orig. q.: „*ob es jetzt Syrah ist oder Merlot oder Cabernet Sauvignon. Ich meine das sind so Sorten, die lange noch nicht wirklich reif geworden sind in unserer Region. Inzwischen sind das Sorten wo man weiß, ok auf die kannst du dich verlassen, die durchtauchen wunderschön einen total heißen Sommer und kommen dann in die Reife wenn der Herbst schön wird"* (Int_05).

measures that have already been carried out in viticulture in the Seewinkel region are listed in Figure 17.

	Incremental adaptation measures		**Systemic adaptation measures**	**Transformative adaptation measures**
Subcategories	**Agronomic**	**Work organization and financial management**		
Increase in annual mean temperature, heat	Humus formation Adapting foliage work to avoid sunburn Conservative tillage and erosion protection (e.g., not plowing too deeply, greening) Green manure Manual processing of the vines Adapting harvest time to optimize sugar content Yield regulations	Adapting working hours Machine harvest at night Protective clothing - (especially sun protection) Drinking enough	Investment in Cane clearing device Defoliator Air-conditioned work equipment Knife roller Cooling systems to regulate the temperature of the grapes Nets against starlings Switching to new varieties: Heat-resistant varieties Late ripening varieties Replacement of Zweigelt Whole grape fermentation	Conversion to organic or biodynamic farming Create safety buffers to be prepared in the event of crop failures.
Precipitation	Humus formation Greening Injections with biological agents	——	Investment in irrigation systems	——
Wind and Storm	Maintain windbreak belts Moving vineyard poles	——	——	——
Frost	Light straw bales	Frost insurance	Investments in new vines	——
Hail	——	Hail insurance	Investments in hail nets	——

Figure 17: Adaptation measures implemented by the interviewed viticulture farmers in the Seewinkel region. Source: own illustration.

4.5.1.3 Fruit growing

Some fruit producers perceive shading and irrigation as significant adaptation measures. In fruit growing, irrigation is used not only because of rising mean annual temperatures, drought and heat, but also as frost irrigation. Undersowing e.g., in melons should serve as biological weed control.

4.5.1.3.1 Incremental adaptation measures

In order to adapt to rising mean annual temperatures, farmers in the Seewinkel region paid more attention to the foliage work in the apple orchards. This offers more shade to trees that grow on gravely soils. Like winemakers, apple growers also adapt foliage work and make sure that trees on the sunny side are increasingly covered with foliage. Greening between the rows of trees is crucial. In apple growing, care is taken to ensure that the rows are not open: "*to increase foliage on trees on gravely soils. We try to have a green meadow between the rows of trees too, so don't destroy the surface and avoid that we have desert-like conditions, so the green grass is very important for us"*[32] (Int_07).

Foliage work is often done by manually in apple growing in the Seewinkel region, as it is easier to estimate how many leaves are useful against solar radiation. In order to provide additional protection against solar radiation and prevent sunburn, the apple growers spray fine sand. This is like a "sun cream on apples" and protects the apples against the apples being damaged and ensures that they can be used as fresh fruit.

Tillage without plow is implemented as an important adaptation measure for melons and strawberries. By working mechanically without a plow, water can be better stored in the soil and humus formation is supported. Weeds are used as undersown crops in melon production, which should serve as a shade for the melons. If melons are without any shading, it has been observed, that the leaves become dry and the culture is damaged by drought. In strawberry production, additional mulching takes place in order to retain the moisture and to protect the crop from damages from heat and dryness.

[32] Orig. q.: „*Bäume auf Schottergrund, dass, die vermehrt Laub haben. Und wir versuchen eben auch in den Fahrgassen eine grüne Wiese zu haben also nicht aufreißen und schauen, dass wir Wüstenähnliche Verhältnisse haben, also für uns ist das grüne Gras sehr wichtig"* (Int_07).

In order to protect fruits against heavy precipitation events, soil cultivation with sufficient greening that supports humus formation is crucial for fruit producers. In addition, some conventional fruit growers use biological agents against pests and fungi and are planning to switch completely to organic cultivation in the future, as this strengthens plant and soil health, and thus protects against damage from heavy precipitation events.

Maintaining wind protection belt as an adaptation measure against wind and storm events is significant in the fruit growing sector of the region. For example, apple farmers implemented fences to protect the apple trees and also placed additional, non – apple trees on the edge to offer less surface to the wind: "*Well, we have all fenced our apple orchards, so we then also plant elderberry trees or hornbeams next to the fence, such that we have a bit of wind protection"*[33] (Int_07).

In apple growing in the Seewinkel region, frost sprinkling is used to prevent late frost damage. This means that the apple trees have to be irrigated as early as spring to avoid late frost damage, because the blossoms of the apple trees are very sensitive to frost. Frost sprinkling works as follows. If the applied water freezes on flowers or buds, heat of crystallization is given off to the plant tissue and prevents them from reaching sub-zero temperatures. If the iced blossoms thaw again after the cold snap has subsided, the water absorbs the heat given off during icing. However, this process no longer harms the plants and protects them from frost damage. However, a sufficient effect is only created if the ice formation and thus the heat dissipation takes place continuously and is repeated more often (Vieweg, 2018).

With regard to work organization and personal adaptation measures, when working on hot days and in the midday heat, care must be taken to wear protective clothing and to drink enough. The fruit producers in the Seewinkel region also adapt their working hours in order to avoid the midday heat in summer as much as possible.

With respect to financial management, the fruit growing producers have adapted with insurances against frost and hail in recent years.

[33] Orig. q.: „*Also, wir haben unsere Apfelgärten alle eingezäunt also wir tun dann schon auch Holunderbäume setzen oder Hainbuchen am Zaun, wo wir eben dann doch ein bisschen Windschutz haben"* (Int_07).

4.5.1.3.2 Systemic adaptation measures

Ongoing investments in irrigation systems and air-conditioned equipment are implemented by fruit producers in the Seewinkel region. If working in the midday heat cannot be avoided, work that could be carried out in air-conditioned work environments is done. Sun protection is implemented on harvesting machines to protect crops and workers from sun and drought damage during harvest.

Since switching to new varieties in fruit production is a long-term decision, this is structured as a systemic adaptation measure. Fruit producers in the Seewinkel region adapt to frost, especially when they choose varieties that ripen late. For instance, in apple cultivation, later shoots are taken to protect the flowers against late frost in spring.

Figure 18 lists already implemented adaptation measures in fruit growing in the Seewinkel region:

	Incremental adaptation measures		Systemic adaptation measures	Transformative adaptation measures
Subcategories	**Agronomic**	**Work organization and financial management**		
Increase in annual mean temperature, heat	Shading Adapting foliage work to avoid sunburn Greening (e.g., between rows of trees) Conservation tillage Humus formation Seeding weed Mulching Manual processing Customize sprayings	Adapting working hours Protective clothing - (especially sun protection) Drinking enough (especially water)	Investment in Irrigation systems Air-conditioned work equipment (e.g., sun protection on harvesting machines) Switching to heat resistant varieties	—
Precipitation	Humus formation Greening Injections with biological agents	—	—	—
Wind and Storm	Maintaining windbreak belt	—	—	—
Frost	Frost irrigation	Frost insurance	Late ripening varieties	—
Hail	—	Hail insurance	—	—

Figure 18: Adaptation measures implemented by the interviewed fruit farmers in the Seewinkel region. Source: own illustration.

4.5.1.4 Vegetable growing

Wind protection belts have become firmly established in vegetable growing and, according to some vegetable producers, will become even more important in future to protect crops. For field vegetables, old varieties are mainly used, which can grow without irrigation outdoors.

4.5.1.4.1 Incremental adaptation measures

In order to protect themselves from rising annual mean temperatures in vegetable growing, vegetable farmers rely on heat- and drought-resistant varieties. Outdoor tomatoes are also grown on straw in order to retain moisture and protect them from drying. Irrigation has to be adapted accordingly. In addition, the vegetable producers in the Seewinkel region are increasingly using old native varieties. These varieties are said to be better able to cope with the increasing annual mean temperatures, drought and heat than cultivated varieties or new breeds: "*we work with plants from the open population, that means old varieties*"[34] (Int_09).

Varieties, where seeds are produced directly on the farm in order to adapt them to the location, are becoming increasingly important. This is mainly true for tomatoes and paprika. In order to build sufficient humus in the soil, soil cultivation and greening are used.
In vegetable growing, the time of cultivation and harvest has shifted in the Seewinkel region. It is important to adapt cultivation dates to the maturity of the crops to avoid sunburn damage. Advantages arising from climate change for vegetable growing are seen in the fact that vegetable producers can grow longer in autumn due to rising temperatures, according to statements by vegetable farmers, this enables them to produce longer and thus offer their products on the market longer in the year.

In order to protect themselves against precipitation events, the vegetable producers rely on humus formation. In addition, diversification increases, away from monocultures. Mixed cultivation of specific vegetables gain is importance because, the cultures can "help" each other and protect against damage from heavy rainfall events: "*it is not a monoculture but we rather do it in a mixed form, now there are a few that are bushier, a few are more delicate and all that can help to support each other. This is the natural, our answer is the natural change in relation to heavy rainfall and extreme sunlight*"[35] (Int_05).

Wind protection plays an important role as an adaptation measure for interviewed vegetable producers. Farmers stated, that there are few windbreaks available in the Seewinkel region and that their field vegetables suffer severe damage from wind and storms.

Implemented personal adaptation measures are indicated by farmers referring to sufficient hydration and protective clothing when working in the heat. Vegetable producers describe the change of working hours as difficult. Since the working hours are shorter, more people are employed on the farms, which results in additional costs. In order not to endanger their own

[34] Orig. q.: „*wir arbeiten mit Pflanzen aus der offenen Population, das heißt alte Sorten*" (Int_09).

[35] Orig. q.: „*es ist nicht monokulturell gesät sondern wir machen das in Mischform, jetzt sind da ein paar die sind buschiger, ein paar sind zarter und all das kann sich gegengeistig helfen und unterstützen, das ist die natürliche, unsere Antwort die natürliche Veränderung bezüglich Starkregen und extreme Sonneneinstrahlung*" (Int_05).

health and safety and that of the employees, the interviewed vegetable producers offer annual skin tests.

Adaptation measures in financing management relate to in hail insurance. Frost is less of a problem for vegetable growers.

4.5.1.4.2 Systemic adaptation measures

As in other agricultural production activities, investments in irrigation systems are of great importance for the interviewed vegetable producers. Irrigation systems that wear out or are damaged have to be continuously renewed, since irrigation in vegetable is described as indispensable in the Seewinkel region. Investments in air-conditioned work equipment are also common practice in order to protect themselves from hot temperatures when working.

Switching to new varieties that are not native to the Seewinkel region is perceived as a positive adaptation measure by the vegetable producers. Some producers changed their varieties: "*that individual crops that were previously not indigenous now grow wonderfully, for example artichokes"*[36] (Int_09).
Other vegetable producers cover their vegetable in the field with foils. This is used as a heat cushion for the crops and also protects against direct sunlight.

Others ferment vegetables. Thereby, the crops can be processed and sold even with damages from drought or heat and do not have to be disposed. Fermentation also ensures a long shelf life and vegetables can be consumed in years when producers experience yield losses.

The implementation of wind protection systems is crucial. Storm events often cause serious damage to foil and glass houses, which have to be renewed, with enormous costs and work.

4.5.1.4.3 Transformative adaptation measures

Transformative adaptation measures refer to the conversion to organic farming. For interviewed vegetable producers, organic farming is a sufficient mean of adapting to rising annual mean temperatures. The use of biological agents can strengthen the humus formation in the soil, which means that the soil and plants are better protected against climatic failures.

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[36] Orig. q.: „[…] *dass einzelne Kulturpflanzen die was früher nicht heimisch gewesen sind jetzt wunderbar gedeihen, Beispiel Artischocken"* (Int_09).

Figure 19 summarizes the adaptation measures that have already been implemented by vegetable producers in the Seewinkel region.

	Incremental adaptation measures		**Systemic adapataion measures**	**Transformative adaptation measures**
Subcategories	**Agronomic**	**Work organization and financial management**		
Increase in annual mean temperature, heat	Using heat and drought resistant varieties Re-implementation of old varieties Conservation tillage Greening Humus formation Changes in cultivation and harvest dates	Adapting working hours Protective clothing - (especially sun protection) Drinking enough (especially water) Skin tests	Investment in Irrigation systems Sir-conditioned work equipment Switching to heat resistant varieties Processing vegetables e.g., fermentation	Conversion to organic farming
Precipitation	Humus formation Greening Cultivate mixed forms	—	—	—
Wind and Storm	Maintain windbreak belt	—	Investment in windbreak systems Investment in foil houses	—
Frost	—	—	—	—
Hail	—	Hail insurance	—	—

Figure 19: Adaptation measures implemented by the interviewed vegetable farmers in the Seewinkel region. Source: own illustration.

4.5.1.5 Livestock farming

Most of the interviewed farmers have adapted stables to climate change in recent years. Shading is crucial in outdoor livestock farming. For this purpose, e.g., trees are planted and keeping livestock in forests was considered.

4.5.1.5.1 Incremental adaptation measures

Livestock production suffers from rising annual mean temperatures and hot summer days in the Seewinkel region. Interviewed livestock producers pay special attention to the care of the animals in order to protect them from direct sunlight. Above all, adequate shading outdoors is crucial. In poultry farming, for example, sufficient shade was provided by planting about 200 nut trees on farm. The interviewed poultry producers observed, that poultry spend more time under the nut trees or bushes at hot temperatures. Sometimes they look for protection in the stable, as it is often cooler than outdoors due to the draft. In pig farming, wallows are provided for pigs outdoors. Dairy sheep reduce feed intake at hot temperatures and sufficient water supply needs to be ensured. In addition, customers should be made aware of the changing climate conditions in direct marketing conditions: "*that's the nice thing about direct marketing, when you are directly at the customer to the people, it says "aha there are effects, he can't feed his sheep, there is no cheese for that" and only then do people realize so in the sense that you wake up people's consciousness a bit"*[37] (Int_16).

In cattle husbandry, attention is paid to a varied diet in the form of hay and silage (silage in all possible plant forms).

4.5.1.5.2 Systemic adaptation measures

The main systemic adaptation measure in livestock production is the adaptation of the barn orientations, so, the animals can be protected against most climate impacts. Additional foil tunnels are being implemented in stables to protect against wind and storm. In poultry farming, roller blinds were implemented in the barn to protect against heat and cold and heating the barn is not necessary: *"we have a stable that can be regulated with roller blinds, so we have no heating inside, we just have to regulate it ourselves, that we adapt the roller blinds, through the temperatures that they open or close themselves, depending on the situation"*[38] (Int_03).

In pig and cattle production, care is taken to choose robust varieties that can cope better with hot temperatures. In pig farming, this is mainly achieved through adaptable species such as Mangalitza and Turopolje.

In cattle husbandry, Angus cattle are considered to be particularly resistant to heat and drought. The breeding also goes in the direction of fair-skinned animals.

[37] Orig. q.: „*das ist das Schöne an der Direktvermarktung, wenn du direkt am Kunden an den Leuten bist, sagt es "aha da gibt es doch Auswirkungen, der kann seine Schafe nicht füttern, dafür gibt es keinen Käse" und dann wird es den Leuten erst bewusst, also in der Hinsicht, dass man das Bewusstsein der Leute ein bisschen Wach rüttelt"* (Int_16).

[38] Orig. q.: „*wir haben einen Stall den man regulieren kann mit Rollos, also wir haben keine Heizung drinnen, wir müssen das halt selber regulieren, dass wir die Rollos einstellen, durch die Temperaturen, dass sie sich halt selber aufmachen oder zumachen je nachdem"* (Int_03).

Figure 20 lists the adaptation measures that have already been implemented in livestock farming in the Seewinkel region:

	Incremental adaptation measures		**Systemic adapataion measures**	**Transformative adaptation measures**
Subcategories	**Agronomic**	**Work organization and financial management**		
Increase in annual mean temperature, heat	Shading in free range husbandry e.g., through trees or shelters Cooling by water points e.g., wallows Adapting the feed (varied nutrition hay, silage)	—	Adapting stables Breeding of robust species	—
Precipitation	—	—	Adapting stables	—
Wind and Storm	—	—	Adapting stables Foil protection on the stable	—
Frost	—	—	—	—
Hail	—	—	Adapting stables	—

Figure 20: Adaptation measures implemented by the interviewed livestock farmers in the Seewinkel region. Source: own illustration.

4.5.2 Farmers´ adaptation appraisal

Farmers' adaptation appraisal considers the perceived self-efficacy of adaptation measures and perceived adaptation costs.

4.5.2.1 Perceived self-efficacy of adaptation measures

The interviewed farmers are generally satisfied with the adaptation measures they have already implemented. Adaptation also shows initial effects against climate-related failures.

Adaptation measures that have already been implemented are showing effects. The use of irrigation systems, especially drip irrigation in viticulture, is perceived to be always effective against heat and drought damage. In order not to expose the crops to the blazing sun, foliage management is adapted, especially in viticulture and fruit growing. This also shows beneficial

effects and is considered as a crucial adaptation measure. Since greening contributes to humus formation and thus strengthens soil and crops, the interviewed farmers perceive conservation tillage as an effective adaptation measure as well. Both natural greening through grass and manure from farmers own livestock production are perceived as effective.
The first important step to an effective adaptation measure takes place on a mental level. It is important for farmers to first find the right adaptation measure and to plan it step by step in order to be convinced of the effectiveness of the adaptation measure itself.

4.5.2.2 Perceived efficacy of adaptation measures

Adaptation measures are always associated with risks. Risks can for example, be increased through additional costs for adaptation measures. The falling groundwater table is also seen as a high risk in the Seewinkel region.

Interviewed farmers perceive the possible scarcity of groundwater, which is essential for crop irrigation, as the highest risk. Farmers fear for their existence, if there is no water available for irrigation. Due to mild and dry winters in recent years and due to decrease in average precipitation, a significant drop in the groundwater level has been observed.

For some farmers it would be an advantage to have more harvests throughout the year due to rising temperatures and a longer growing season. For others, this possibility would be associated with a higher risk, as this would involve additional expenses and, above all, additional work.

Not only is the scarcity of groundwater perceived as a risk, there are also risks that adaptation measures such as irrigation could become more expensive in the future. For instance, some farmers fear the introduction of a CO2 tax on diesel, which would also threaten the existence of some farmers.

In municipalities close to the lake and reeds, it has become almost impossible for interviewed winemakers to green vineyards. They observed that geese, which are often in the reeds, go to the green areas of the vineyards to feed, which is also perceived as a high risk.

Most farmers perceive the conversion to new varieties, which is already possible in the Seewinkel region due to rising temperatures, as an advantage. For other farmers, this switch could pose a high risk. Since varieties that are considered to be indigenous in Austria or especially in the Seewinkel region will likely be substituted, this could also mean yield losses, especially for winemakers in the region.

In general, the interviewed farmers perceive a low to moderate risk of climate change since it has not yet caused too much damage to crops and soil, and no costly or time-consuming adaptation measures had to be carried out until now.

Because cultivation in the vineyard has been optimized (e.g., no driving on the soil in winter, spraying in two rows), this represents a low risk as an adaptation measure, as there is less additional work.

4.5.2.3 Perceived costs of adaptation measures

In most cases, the implementation of adaptation measures causes considerable costs for individual farmers in particular if machines have to be upgraded or renewed. During the interview, farmers were asked how they estimate the costs of already implemented adaptation measures.

Figure 21 summarizes how farmers perceive the costs of implemented adaptation measures.

Perceived adaptation costs	Experiences underlying the costs perceived
High costs due to adaptation	Due to machinery upgrade Due to purchases of biological sprays Due to investments in nets against starlings and hail Due to investments in irrigation systems (except for viticulture) Due to investments in wind protection systems Due to purchases of insurance
Low costs due to adaptation	Due to low investments in irrigation systems in viticulture, as in this production activity is irrigated less Due to investments in adaptation devices that compensate for the costs of other adaptation measures (e.g. a knife roller in viticulture) Due to greening

Figure 21: Overview of adaptation costs perceived by the interviewed farmers in the Seewinkel region. Source: own illustration.

Above all, the interviewed farmers state, that investments in machinery, which are necessary to adapt to climate change, are high. For instance, interviewed winemakers invest in stock clearing equipment and new vines, as these need to be replaced after late frost damage. Those investments considered to be high.

Most interviewed (conventional) farmers often use pesticides approved for organic farming, as these are intended to increase the humus content in the soil. These farmers perceive the cost of organic pesticides as high in contrast to pesticides approved for conventional farming.

To prevent starling damage, interviewed winemakers attach nets to their vines in the Seewinkel region. Hail damage should also be prevented by attaching those nets. The netting of the vineyards is perceived as very costly. Not only the purchase of the nets, but also the working time for deploying and the subsequent disposal of the nets is perceived costly.

The majority of the interviewed farmers perceives investments in irrigation systems as enormously high (except for viticulture). Irrigating is, however perceived essential, especially for growing vegetables in the region. Irrigation systems need to be constantly renewed and upgraded, as rodents or small game often cause damage. Additional costs incurred for diesel are also very high.

In recent years, the interviewed farmers recognized more damage to foil houses from storms. These damages have to be corrected continuously and foil houses have to be re-covered. In addition, the interviewed farmers often established wind catchers or wind protection belts to protect crops from possible wind damage, whereby sometimes high costs can arise.
Purchasing insurance products in agriculture are associated with high premiums. Some of the farmers consider the insurance premiums to be too high and therefore do not purchase insurance products. In years without climatic damage to the crops, insurance premiums can be saved.

The implementation of irrigation systems in viticulture results in lower costs. The interviewed winemakers stated, that drip irrigation also needs new implementations, but these implementations are associated with lower costs than with other irrigation systems.
By investing in new machinery, costs for other adaptation measures can in turn be saved. For

example, an investment was made in a knife roller, which ensures better incorporation of greening in viticulture. It was stated that by investing and using a knife roller, less intensive irrigation is required and thereby the cost of diesel can be reduced. The costs for greening are also offset by public payments.

4.5.2.4 Perception of irrigation as adaptation measure

Irrigation of crops, vegetables, orchards and vineyards is crucial to prevent crops against water stress and drought damages in the Seewinkel region. The interviewed farmers give different reasons for using irrigation systems. However, irrigation is mainly used due to rising temperatures in spring and summer, and related increased evapotranspiration to protect the plants from drought and heat damage and to avoid yield and harvest losses.

Figure 22 summarizes the perceived relevance of irrigation as adaptation measure.

Perceived relevance of irrigation as climate change adaptation measures	Farmers' reasons to appraise irrigation as relevant
High relevance of irrigation	To secure farm income Due to rising temperatures in spring To avoid sunburns on culture To reduce or avoid drought damages to crops To reduce or avoid frost damages to crops and fruits To maintain cultures which are not deeply rooted To maintain crops on gravely soils
Medium relevance of irrigation	For deep-rooted cultures As greening as adaptation measure compensates irrigation Due to the price effect on the market (Since products on the market cost too little, irrigation is dispensed with in order to save costs)
Low relevance of irrigation	For deep-rooted cultures To reduce work load
High relevance in the future (irrigation planed)	Due to rising temperatures in summer

Figure 22*:* Perceived relevance of irrigation as adaptation measure by the interviewed farmers in the Seewinkel region. Source: own illustration.

Most of the interviewed farmers consider irrigation to be highly relevant in order to achieve secure minimum yields. The farmers perceive a considerable increase in the average temperatures in spring. Therefore, they consider it necessary to use irrigation at this time of the year: *"especially after sowing, it was already so dry in March, April in recent years. The seeds germinated wonderfully and then as young plants, as seedlings, simply dried out because there was no water for 2- to 3 weeks. Otherwise, they do not germinate in the phase without rain and without reasonable strong morning dew"*[39] (Int_05).

Especially in vegetable and fruit growing, irrigation is considered essential. The plants are already irrigated in spring in order to prevent drought damage and sunburns in summer. In apple orchards, spring irrigation is also used to prevent late frost damage.
Irrigation is also considered relevant in cropland and viticulture in the Seewinkel region. Interviewed farmers observe, that with some crops such as alfalfa even an irrigation of 30 - 40 mm is no longer sufficient to protect the crop from damage caused by drought. It is feared, that if the annual mean temperatures continue to rise, alfalfa will no longer grow in the Seewinkel region. In viticulture, irrigation is mainly used in vineyards on gravel soils, as these are very susceptible to drought.

Due to the use of drip irrigation in viticulture and partly in vegetable growing, the farmers experienced, that water could be saved in this way. Drip irrigation is called the "most gentle" irrigation system. If other adaptation measures such as greening show effects, irrigation systems are only used sporadically. Many interviewed farmers implement or apply irrigation only if they consider it efficient. Mainly in cropland, some farmers only irrigate in years when the product prices are high. Other farmers see no need to irrigate cereals, as it would not be economically viable.

Three of the interviewed farmers (i.e., two winegrowers and one crop and grassland farmer) stopped irrigating a few years ago, due to cost and labor intensity of irrigation. Another interviewed farmer who runs a mixed farm irrigates his vegetables, but not his vineyards. A few years ago, this farmer made a conscious decision against irrigation in the vineyards, as the

[39] Orig. q.: *„speziell eben nach der Aussaat also sprich März, April in den letzten Jahren schon so trocken war, dass die Samen wunderbar gekeimt sind und dann als Jungpflanze, als Keimlinge dann einfach vertrocknet sind, weil da 2-3 Wochen kein Wasser war, weil sonst keimen sie in der Phase nicht aus, also in der Phase ohne Regen ohne vernünftigen starken Morgentau"* (Int_05).

vines are deeply rooted and therefore have sufficient access to the groundwater. One interviewed farmer did not use irrigation in 2019 due to time and labor constrains. Another interviewed farmer in cropland stated, that the introduction of irrigation on his farm is to cost intensive but it would be necessary to introduce irrigation because the crops suffer from heat and drought. The interviewed farmer would need additional labor to implement irrigation systems, but this would not be profitable. For another two farmers in viticulture and cropland, irrigation would be planned if the mean annual temperatures continue to rise in future.

Most of the interviewed farmers are not aware of the groundwater abstraction regulation which exist in the Seewinkel region. Likewise, the majority of the interviewed farmers does not keep records of annual water abstractions for irrigation. In 2019, 8 out of 18 interviewed farmers who irrigated their crops kept records of water abstraction for irrigation. According to the farmers, these records are for personal use only. Maintenance and cleaning of the wells is controlled by the district administration and punished for non-compliance.

According to the regulation of the district administration, irrigation is generally allowed between March and November. Under special conditions (e.g., foil houses), irrigation water can be withdrawn from the groundwater body all year round.

If the restrictive phase is reached and announced, the following restrictions come into force (Bezirkshauptmannschaft Neusiedl am See, 2015):

I. No irrigation of cereals

II. No irrigation of vineyards with the exception of vineyards where drip irrigation is used

III. Irrigation with nozzle diameters > 10 mm only at night (from 19:00 to 08:00).

IV. No irrigation of sunflowers, rape and peas

The warning phase is valid before or after the restrictive phase.

The Seewinkel water management differences between four groundwater standards:

1. Discharged groundwater standard
2. Warning groundwater standard

Warning phase

3. Middle level between warning and border groundwater standard
4. Border groundwater standard

Restrictive phase

Ad) Warning phase

The warning phase begins when the groundwater standard falls below the warning groundwater standard and ends when the discharged groundwater standard is exceeded.

As soon as the warning phase begins, according to the Bezirkshauptmannschaft Neusiedl am See (2015) it is advisable to consider water-saving measures.

Ad) Restrictive phase

The restrictive phase begins when the groundwater standard falls below the border groundwater standard and ends when the mean level between the warning and border groundwater standard is exceeded again (Bezirkshauptmannschaft Neusiedl am See, 2015).

According to most interviewees, it would be necessary to take action as soon as possible to maintain the groundwater standard and to protect the groundwater. In addition, records should be kept by every farmer in the region and regular controls should be carried out by the responsible authorities in order to prevent the maximum groundwater abstraction from being exceeded.

The majority of the interviewed farmers manage their own wells and obtain the irrigation water from groundwater reserves. Others obtain their irrigation water from surface water or from public water supply networks.

Drip irrigation is the primary irrigation system used by the interviewed wine growers. In vineyards where there is no possibility of implementing drip irrigation, a barrel of water is used for flooding. Surface irrigation and sprinkler irrigation are primarily used in cropland and for growing field vegetables- and fruits. Drip irrigation is used if vegetables are grown in foil and glass houses.

Most of the interviewed farmers use diesel generators to power the irrigation systems. Since some farmers are concerned about the introduction of a CO2 tax, they are thinking of switching to photovoltaic systems in the future, as there is long sunshine in the Seewinkel. However, photovoltaic systems are considered to be expensive to implement.

Due to the falling groundwater level in the Seewinkel region, farmers were asked about *regional strategies* for groundwater management. Most of the interviewed farmers perceive drip irrigation as the “most gentle” irrigation system, as it is considered to be more water-saving than sprinkler systems. Grassland and cropland (e.g., cereals) are considered to be irrigation extensive cults, since there is no need for irrigation for these crops, whereas potato and vegetable production are considered irrigation-intensive. With respect to long - term developments, the interviewed farmers would plead for a strategic decision by politicians, with irrigation-intensive crops and irrigation systems in the Seewinkel region receiving less support. In addition, the interviewed farmers support to restrict irrigation to heat nights, since there is little to no evaporation, as well as the introduction of controls for groundwater withdrawal. Retention basins and ponds, which are supposed to hold precipitation in the region, as well as soil conservation to save water, would also be regional strategies that are being considered effective by the interviewed farmers. In addition, most interviewed farmers support water saving in agricultural production in the Seewinkel region.

4.5.3 Adaptation measures perceived relevant for the future

The interviewed farmers mentioned further adaption measures in the various production activities to climate change. Here, further reasons for delaying these adaptation measures are summarized. They have not yet been implemented or are still being planned, e.g., due to time and cost management.

The interviewed cropland farmers are very interested in adaption measures to prevent drought damages. Based on information from other countries, they think that greening also help to prevent from drought damages in the Seewinkel region. In addition, the interviewed cropland farmers have already informed themselves about other farming methods to adapt to climate change in the future. These includes, above all, the cultivation of diversification of crops and improved wind protection belts as a prevention against drought and wind damage. The possibility of harvesting twice in one growing season would be an advantage for interviewed cropland farmers. The cultures would have to be adapted: "*you can harvest certain things twice. For instance, if you have a winter barley, you could still grow green beans, that is certainly possible in our region, that you can harvest twice. You just have to use the right crops"*[40] (See_IP11).

Some cropland farmers already cultivate new varieties, for others there is a need to change, but specialist knowledge is lacking.
The winegrowers are concerned with greening their vineyard. Further adaptation measures are to be taken in order to prevent climatic damage with "the right" greening management. Investments in center pivot irrigation systems to prevent late frost damage and black nets, which are not only intended to keep starlings away from the grapes, but also to protect against direct sunlight, are also being considered.

The long sunshine in the Seewinkel region can be utilized by investing in photovoltaic systems for irrigation. Not only interviewed winemakers but also farmers focusing on other agricultural production activities perceive the switch to photovoltaic systems as a way to produce electricity more cheaply and sustainably.

When replanting grapevines, heat-resistant and late ripening varieties should be taken into according to the interviewed winemakers.

In fruit growing, hail nets are increasingly being considered as an adaptation measure, since fruit growing in the region seems to be most frequently impacted by hail damage. In melon production, farmers think about sowing rye which should provide shade for the melons. Interviewed fruit producers mainly want to use old, local cultures in the Seewinkel. This should be taken into account for new plantings.

According to the interviewed vegetable producers, afforestation of wind protection belts should be pushed. Some vegetable producers are already planning to implement appropriate

[40] Orig. q.: „*Gewisse Sachen kannst du eh schon zweimal ernten, z.B. wenn du eine Wintergerste hast, könntest du noch Fisolen anbauen, das ist sicher schon möglich bei uns, dass du 2 Ernten einfahren kannst, musst halt nur die richtigen Kulturen nehmen"* (See_IP11).

wind protection belts to protect their vegetables. The changeover to new varieties and old local varieties is also an important part of vegetable growing in the Seewinkel region. Vegetable farmers stated, that they would be ready to switch to new varieties at any time, but there is a lack of knowledge about cultivation.

In livestock farming in the Seewinkel region, air conditioning systems are to be implemented in stables if temperatures continue to rise in summer months. In addition, sprinkler systems for cooling are to be expanded in poultry keeping. Dairy sheep are to be exchanged for traditional racka sheep. Racka sheep were mainly kept in the Seewinkel region in earlier years. It is well known that they can cope with drought events. Milk yield from racka sheep is, however, lower than from dairy sheep, which could result in reduced yields.

In pig farming, it would be desirable to keep the pigs in a forest, as there would be enough trees for shade, but this is not permitted due to current animal welfare loss.

In all agricultural production activities, additional adaptation measures are already being considered. Future adaptation measures will be crucial to deal with climate changes. However, some farmers would like to have more information or an exchange with other farmers about appropriate adaptation measures, as there is insufficient expertise.

Planning additional adaptation measures depends also on whether a suitable farm successor is interested. Adaptation measures are taken more frequently once the question of farm succession has been clarified. In contrast, no adaptation measures are planned in the future if there is no successor to the farm.

Figure 23 summarizes the adaptation measures perceived relevant for the future.

Adaption measures	**Reasons for delaying these adaptation measures**
Options of adapting the farm to climate change	
Greening	To prevent a humus layer
Warehousing	To protect against climatic failures
Changing to new varieties	In order to be able to protect the costs of the farm
Application of hail or black nets	To protect crops from hail and heat failures in viticulture
Implementation of photovoltaic systems	To save electricity costs for irrigation
Implementation of wind production systems	To protect crops from wind failures
The use of heat- and drought resistant varieties	To protect the farm against economically losses
No options for adaptation	
Cost management	Insurance premiums are too high
Adaptation of stables	Prohibited by animal welfare law (stable alignment and shading by trees)
Unnecessary	Because of no potential successor

Figure 23: Overview of adaptation measures perceived relevant for the future by the interviewed farmers in the Seewinkel region. Source: own illustration.

5 Discussion

This chapter discusses the results achieved and the methods applied for this master thesis. The results are reflected in the context of the theoretical Model of Private Proactive Adaptation to Climate Change and additional literature. Subchapter 5.1 discusses perceived changes in climate in the Seewinkel region. Furthermore, perceived climate change impacts on the farms are discussed (subchapter 5.2) whereby opportunities and risks are considered. Results on already implemented adaptation measures in response to perceived climate changes are discussed in subchapter 5.3. and farmers adaptation intentions are discussed in subchapter 5.3.2. Subchapter 5.4 discusses the methods used in this master's thesis.

5.1 Farmers´ perceived changes in climate in the Seewinkel region

The interviewed farmers perceive a significant increase in annual mean temperature in the Seewinkel region, compared to the time when they began working in agriculture. In addition, changes in extreme events such as storm and wind, hail, heavy rainfall and frost are perceived. The farmers also report that spring and autumn transition seasons become warmer. The four seasons are said to be no longer perceived. Summer temperatures prevail in spring and autumn. Furthermore, the winters are perceived as milder. It can be said that temperatures below zero were observed only a few days in winters in the past couple of years.

Blaschke and Gschöpf (2011) characterize the Seewinkel as the deepest landscape in Austria with hardly any elevations, which makes the Seewinkel a region with little precipitation, very warm and windy, to which the Pannonian climate can be attributed (Blaschke and Gschöpf, 2011, 3).

Furthermore, wind and storms are perceived as always present in the region, whereas vegetable producers suffered more from wind damages in foil houses in the last few years. Hail damages have decreased over the last years. The farmers in viticulture perceive that hail comes in stripes and the farmers are thus spared from hail damage more often. All farmers in all production activities suffer from heat- and drought damages on their crops.

With regard to intensity and frequency of extreme events, the interviewed farmers reported, that both have been increasing over the past few years. Apart from the increase in intensity of heat waves, heavy precipitation events are observed as well. The farmers observed heavy precipitation events particularly after long periods of droughts. Furthermore, a reduction in precipitation events is reported for the spring and summers.

Mean annual temperatures and precipitation events in the Seewinkel region increased in the period 1966 to 2007. However, a decrease in precipitation and an increase in mean annual temperatures was measured between 1997 and 2004. These changes also affected the falling water levels of Lake Neusiedl (APPC, 2014, 363). It can therefore be assumed that the farmers' perception that there are 7 dry and 7 rainy years in the Seewinkel region, is refuted by the literature.

Chimani et al. (2015) shows, that all considered climate models show a significant increase in the annual and seasonal mean temperature throughout the semi-arid parts of Austria in the periods 1986 – 2010 against 1961 – 1985. Considerable decadal fluctuations can be observed in precipitation in whole Austria (Chimani et al., 2015, 56).

An increase in temperature is expected to increase evaporation. The extent to which this will impact the demand for groundwater will, especially in the Seewinkel region, also depend on its use for agricultural irrigation (BMLFUW, 2017c, 83).

The following steps are recommended steps to ensure sustainable management of agricultural irrigation in the Seewinkel region (Lebensministerium, 2012, 29):

- Monitoring of the actual use of groundwater, as in some areas the water consensus is exceeded.
- Consideration of climate change adaptation needs when issuing permits for groundwater use.
- Investment incentives for farmers to switch to water-efficient irrigation systems
- Extensive research on water abstraction in a region and development potentials, taking into account regional climate scenarios, as well as the efficiency of irrigation systems in terms of energy and water consumption.

All farmers perceive changes in the climate in the Seewinkel region. Most farmers relate the changes to anthropogenic activities. Some farmers perceive the changes in climate as a natural process for the Pannonian climate and think that alternations between dry and rainy years are the natural course of the Pannonian climate. However, it is well known that the Neusiedler

See is one of the few steppe lakes in Europe. A period of dehydration is typical for a steppe lake. The Neusiedler See dried up twice in the 18th and 19th centuries which was mainly due to natural impacts (APCC, 2014, 362).

5.2 Farmers' perceived impacts of climate change on their farms

The interviewed farmers notice opportunities and risks due to climate change on their farm. Cropland and grassland farming are particularly suffering from increasing droughts. Drought is mentioned as the most common reason for harvest and yield losses (monetary). The farmers observed that crops stop growing at temperatures above 30 °C. Summer cereals such as spring barley are therefore difficult to cultivate in the region. By contrast, certain plants such as hay or cereals dry out more quickly due to rising temperatures and dry weather conditions.

Farmers perceived impacts are confirmed in the literature. For summer cereals such as spring wheat or barley, yields have been modelled to decrease in dry regions, mainly due to the lack of water in summer. Drought stress is to be expected more often for sugar beet cultivation if summer precipitation further decreases. In addition, higher night temperatures could have a negative impact on sugar beet yields. However, sugar beet and potato cultivation could benefit from a longer growing season (APCC, 2014, 499f). Lethal maximum temperatures above 35 °C are reported for maize, whereby the grain filling phase is suggested to be the most temperature sensitive crop development stage (Sánchez et al., 2014).

Increasing intensity of wind is evaluated as a positive impact by some farmers. For instance, agricultural land dries faster after extreme precipitation events. This means that land can be cultivated more quickly after heavy rainfall in order to avoid weed pressure, for example.

Also, an increase in the number of days available for field work due to dry conditions, combined with an extended vegetation period, allows certain machine capacities to be reduced as a cost factor, as reported by Eitzinger (2007, 3).

Due to the average increase in temperatures, especially in winter, it can be observed that pests appear more frequently. In both sugar beet and corn cultivation, the shepherds no longer freeze off in winter and can occur at greater intervals. Especially the corn rootworm does not freeze off in seed corn cultivation.

The literature summarizes, that southeast Austrian farmers discovered the first western corn rootworms on their fields between 2002 and 2014. Their spread and establishment may be influenced by bio-physical factors, but also by farmers activities as well as people´s activities such as tourism. The farmers were informed about the beetles by representatives of agricultural companies or colleagues, among others, or found them in their maize fields. Although farmers implemented measures to regulate the western corn rootworm, it still occurs (Kropf et al., 2020, 1ff).

For viticulture, a clear shift in the ripeness of grapes is reported by the interviewed farmers. They observed that, unlike in the past, at the end of September - beginning of October, today the grapes are already ripe at the end of August - beginning of September. The much earlier ripening of the grapes, which can be traced back to the increasing annual mean temperatures, however, also harbors some risks for the quality of the grapes and especially the wine. It would be better to process the grapes at cooler temperatures, otherwise the sugar content in the grapes and in the wine will suffer.

Another important characteristic is the Zweigelt disease or grape wilt in viticulture in the Seewinkel region. The problem of Zweigelt's disease seems to cause yield losses for all of the interviewed winemakers. Researchers has not yet identified the reasons for the increasing challenges with the Zweigelt diseases in the Seewinkel region. However, the interviewed farmers observed that the disease occurs more intensely under extreme weather conditions.

Stress-related physiological diseases such as grape wilt can be attributed to changes in climatic conditions caused by drought due to increased nutrient stress or an unbalanced nutrient supply. In connection with drought stress, the uptake of nutrients by the vine deteriorates, which leads to grape wilting (APPC, 2014, 503).

Late frost and heavy precipitation followed by hail are described as the greatest problems in viticulture. These climatic impacts are observed to be enormous in the Seewinkel region. Due to heavy precipitation and late frost events in 2015 and 2016, there were harvest losses of 80 - 90%. Hail events have been observed to decrease in frequency in the Seewinkel region, but they can occur and lead to harvest and yield losses.

Late frost and hail have become a major problem across Austria (e.g. Eitzinger, 2007, 3) and also affect especially for apple growers in the Seewinkel region. On the other hand, if the frost comes at the right time, pests can freeze over the winter and thus present fewer problems.

Wine and fruit crops are exposed to year-round weather. Higher temperatures lead to an earlier onset and faster phenological development, which is particularly favored by milder winters and warmer springs. However, it also increases the risk of late frost. Viticulture is generally more drought-resistant, whereas fruit growing is sensitive to drought and is dependent on irrigation (APCC, 2014, 501).

Due to rising annual mean temperatures, interviewed vegetable producers benefit significantly by being able to offer their products on the market very early in spring. Because of the reduction of frost and due to the milder winters, crops grow longer in the year. On the other hand, due to the increasing annual mean temperature and the lack of precipitation, increased drought damage and sunburns have been found on crops by interviewed vegetable producers in the Seewinkel region. In addition, more frequent pests on crops are observed.

Model results from Schönhart et al. (2018) reveal potential impacts of climate change on Austrian agriculture, and highlight regional differences between the semi-arid eastern and the more humid western regions. Particularly in the western part of Austria, changes in precipitation patterns combined with a temperature rise and related longer vegetation periods as well as increased atmospheric CO_2 concentration, can stimulate plant growth. In the semi-arid Seewinkel, however, precipitation is limiting plant growth (Schönhart et al., 2018, 507).

As mentioned by some of the interviewed vegetable producers, the literature also shows that an extension of the vegetation period is an advantage in the cultivation of vegetable crops, which allows an additional cultivation cycle per year. On the other hand, heat stress in crop cultivation will likely increase in the future (APCC, 2014, 500).

Economic impacts can arise due to the increasing annual mean temperature, as products can be offered on the market all year round.

Direct impacts in livestock farming due to the increasing annual mean temperature can arise as milk yield from dairy sheep and egg yield in poultry farming have been reported to decrease in the Seewinkel region. In general, animals suffer from a rise in the mean annual temperature. For example, sunburns have been observed on domestic sows in free-range husbandry.

Indirect impacts can arise when feed production is negatively affected by drought. Less feed is available due to drought damage to grain and hay. On the other hand, hay and grain dry out faster due to increasing annual mean temperatures. This is also found in other studies (e.g. Martinsohn and Hansen, 2013, 1ff).

A study in Lower Saxony shows positive direct effects of climate change on dairy farms. Farms benefit from the general warming, as maize, as a forage crop, has better growing conditions (Martinsohn and Hansen, 2013, 19).
Direct impacts are observed by heat stress in poultry by interviewed farmers, for example, which is increased by daytime temperatures of over 30 °C and lack of cooling at night. The feed intake decreases and the water consumption increases. In laying hens, this can be observed, for example, in a decrease in egg size or in a decrease in laying performance, since energy consumption increases as less energy is available for other bodily functions. Pigs start panting when exposed to heat stress and try to evade the heat by laying down in cool places. If there is no burrow available, the animals also lay in their excrement, which is associated with considerable pollution and possible diseases of the animals (APCC, 2014, 519f).

Tourism offers considerable economic advantages in the Seewinkel region. Regional tourism is particularly important for direct marketers. However, the interviewed farmers observed that at temperatures above 30 °C in summer, less tourism takes place in the Seewinkel region.

The climatic impact of drought is perceived as the biggest problem for interviewed farmers in the Seewinkel region. Drought can be defined very differently because of its strong dependence on time and space, as well as its effects (Bender and Schaller, 2014, 18). Strauss et al., (2013) define drought as the meteorological drought. This is a deficit in precipitation in a specific region and over a specific period of time. An agricultural drought results from insufficient water supply for agricultural crops, which can lead to a reduction in crop yields in the affected region. Furthermore, crop yields can be further influenced by increasing temperature or wind speed, which can lead to a soil moisture deficit due to a higher evaporation rate (Strauss et al., 2013,1). From a statistical point of view, drought is a rare extreme event that occurs with a certain probability of recurrence (Bender and Schaller, 2014, 18). For Austria, it was found that long-term effects of increased drought events on production and harvest predominate in the eastern and northeastern parts of Austria. In years where precipitation sums are similar to those of previous years, a minor impact on the crop yield is observed even if temperatures rise (Strauss et al., 2013, 8f).

5.3 Adaptation measures already implemented and farmers adaptation intensions

5.3.1 Adaptation measures already implemented

Most often, *incremental* adaptation measures are implemented by interviewed farmers. Agronomic measures such as soil-conservation measures (including cultivation without plowing and humus formation) are particularly important in order to decrease water loss on agricultural areas. Particular attention is paid to weed control by means of mechanical weed management and to the abandonment of monocultures. Further implemented agronomic adaptation measures are the cultivation of new varieties, which up to now are not considered indigenous to the Seewinkel region, as well as the reuse of old varieties and the use of heat and drought-resistant varieties. In addition, in order to prevent damage to crops due to heat and drought, the time of cultivation and harvest is adapted. Further incremental adaptation measures are the adaptation of foliage work. In order to avoid sunburns, foliage work is carried out much more often manually than previously by machine. For example, more leaves can be left on the sunny side. In vineyards, farmers sometimes only used every second row in order to avoid compaction. This is perceived to result in better pH values in the soil, which are important for the quality of the grapes and the wine. In order to prevent fungi, diseases and weeds, sprayings are carried out. Some of the conventionally managed farms using biological agents. In addition, apples are sprayed with fine sand, which should serve as sunscreen for the apples. In livestock husbandry, sufficient shade is provided by trees and embankments. In addition, the feeding is adapted to prevent heat stress in animals.

As an overview, a few major adaptation measures can be described for crop farming, which need to be adapted to local conditions for implementation.

Suggested short term adaption measures

- Soil - water conserving tillage methods
- Dry and heat resistant varieties in cultivation

- Adaptation of cultivation times and field work to temperature changes
- Adaptation of crop rotation
- Ensuring measures for frost protection and hail protection
- Adaptation in livestock farming e.g., heat protection

Suggested medium term adaption measures

- Improvement of irrigation infrastructure and technology
- Breeding stress tolerant varieties
- Development of operational monitoring systems for pests and diseases
- Risk distribution through diversification
- Increase of storage capacity for inputs and outputs
- Evaporation reducing measures, especially in drylands, such as windbreak hedges (Eitzinger, 2010, 9ff).

The following adaptation measures seem to be of major relevance for *livestock farming*:

- Adapting the stable systems to ensure the well-being of the livestock can avoid a drop in performance in the event of increasing heat waves.
- Cooling of the stables by means of water mist or cooling plates is a crucial adaptation measure.
- Open stable systems with free movement of the animals, also outdoors, offer the greatest security for the well-being of livestock. Free movement with shelter options or cooling options, for example cattle showers or wallows for pigs and sprinkler systems for poultry, offer advantages.
- Hygiene measures to prevent emerging diseases should be conducted regularly.
- Effective monitoring of diseases in livestock is important for prevention (APPC, 2014, 792f).

In order to compensate for damage caused by heavy precipitation events, greening winter cover crops and crop rotations are used.

Wind protection belts and agroforestry play a major role in compensating for wind and storm damage to crops.

Late frost is a major problem in viticulture in the Seewinkel region. To prevent late frost damage to the crops, bales of straw were set on fire at the end of the vines.

Incremental adaptation in financial management is above all, the conclusion of an insurance. Insurance against drought, frost and hail are often taken out.

As reported in Mitter, et al., (2017b) taking out crop insurance is judged controversially. While on the one hand interviewed farmers perceive these adaptation measure as promising, on the other hand a delay in systemic and transformative adaptation due to the publicly funded insurance premiums is perceived (Mitter et al., 2017b, 62).

Systemic adaptation measures primarily relate to upgrading irrigation management, warehousing and investment in airconditioned work equipment. In addition, systemic adaptation measures concern investments in nets against starlings in viticulture. In order to ensure balanced greening in the vineyard, the interviewed vintners invested in a knife roller. Grapes are sometimes harvested mechanically at night in order to be able to process them at cooler temperatures. If this is not possible, investments in a cooling system are necessary to cool the grapes before processing.

The use of new varieties is a long-term decision in viticulture. The rise in average temperatures, especially in autumn and winter, allows new varieties to establish themselves. The interviewed farmers observed that varieties such as Blaufränkisch and Syrah already have better ripening opportunities than 10 years ago.

Since the ripening phase of the grapes takes place in a warmer climate under higher temperature conditions, which leads to increased acid degradation due to higher day and night temperatures. This leads to the development of changed fruit aromas, there is a shift in the range of grape varieties up to later ripening varieties in viticulture (APPC, 2014, 502).

Transformative adaptation measures concern the conversion to biological or biodynamic cultivation, as well as the broad positioning of the farm. Some winegrowers have already opted for transformative adaptation measures and have switched to organic or biodynamic farming methods, as more biodiversity can better compensate for a water deficit in the vineyard.

Interviews with farmers in the Mostviertel and Southeast Styria, show, that they consider fundamental changes in the type of farm. Systemic and transformative adaptation measures are seen as long-term, which should be prepared over several years. In contrast to incremental adaptation, they are usually associated with higher costs and risks (Mitter et al., 2017b, 62).

Personal adaption measures are often taken by adapting working hours, to avoid working in the midday heat. When temperatures are above 30°C in summer, farmers typically start work early and stop in the early afternoon, because it was observed that the work performance decreases considerably when working in the heat. Protective clothing - especially sun protection and adequate hydration - and drinking plenty of water are important priorities if working in the midday heat cannot be avoided. Investing in air-conditioned work equipment and in air conditioning in own households are among the most important personal adaptation measures.

Another adaptation measure is to observe the weather conditions and to adhere the cultivation plan to them. Information about the weather (e.g., by using weather apps) may enable adequate adaptation. Some farmers are well informed about climate change adaptation in agriculture. Their information source are agricultural magazines, weather records on their farms as well as personal exchange with scientists (Mitter et al., 2019, 811).

Due to dry climate conditions, irrigation plays an important role as an adaptation measure in the Seewinkel region. 18 out of 24 interviewed farmers irrigated their agricultural crops in 2019. In cropland and grassland management, irrigation is of medium to high relevance. For seed corn, for example, irrigation is considered essential, whereas grain is barely irrigated. Interviewed farmers state, that irrigation of their crops is price-dependent. If the product achieves a good price on the market, crops are irrigated, if it does not, irrigation is suspended for the year. Organically farmed areas are barely irrigated. In viticulture, some farmers consider irrigation to be unnecessary, since grapevines are considered to have deep roots. Irrigation on grapevines is often described as damaging to the culture. Winegrowers who lease or buy vineyards on which irrigation systems are already installed, give notice to remove them immediately. Fruit and vegetable producers consider irrigation to be essential. All of the interviewed farmers in fruit and vegetable production use irrigation.

For irrigating agricultural crops, the interviewed farmers mainly use water from groundwater with own wells. In cropland, sprinkler irrigation is mainly used, whereas surface irrigation is used in grassland farming. Drip irrigation is largely used in viticulture in the Seewinkel region and partly in fruit growing. Sprinkler irrigation is used in vegetable growing. The irrigation systems are mainly powered by a diesel generator.

A disadvantage of the rising temperatures arises from the more frequent use of irrigation. The use of irrigation has a significant impact on the water balance due to the drainage ditches and the large number of extraction wells. Salt lakes, which make the Seewinkel not only a special wetland area, but also an important tourist area, are dependent on groundwater. The salt lakes in the Neusiedler See - Seewinkel National Park are supplied with salt from the salty soil layers via a capillary rise. The existing drainage ditches, however, repeatedly lead to low groundwater levels, which means that the salt supply is no longer sufficient. By contrast, very high groundwater levels lead to waterlogging. Both effects can be managed with dams and drainage ditches (Blaschke et al., 2011, 3ff).

5.3.2 Farmers' adaptation intensions

Adaptation includes responses to consequences of climate change, regardless of whether they have already been experienced or are likely to take place in future. Adaptation is a repetitive process of defining the problem, planning and implementing measures or monitoring and reviewing implemented measures with regard to new information, risks or regulations (Bender and Schaller, 2014, 12f).

Intended adaptation measures are the use of irrigation, the adaptation of manual processing and the use of greening measures. Interviewees who deal more often with the topic of climate change adaptation seem to have a higher intention to adapt because they are better informed about different adaptation measures.

An assessment of the farmers own ability to effectively carry out adaptive behavior can be described as a person's self - efficacy. Providing behavioral advice on specific adaptation measures can improve perceived self – efficacy (Osberghaus et al., 2010, 6).

Intended adaptation to climate change is always associated with risks. It can be observed that high risks are perceived mainly due to the scarcity of groundwater, which is essential for the irrigation of agricultural crops, or due to the high costs associated with the use of adaptation measures. Low risks are perceived for the use of old varieties and new cultivars that are not yet typical for the Seewinkel region. Low risks are also perceived for the optimization of the working procedures. High risks caused by bottlenecks in the groundwater lead to fears among interviewed farmers, as they fear that they will not be prepared for future failures due to drought. Low risks arise partly due to capacity bottlenecks which, however, can expand into major risks in the future, as financial bottlenecks may arise or there is not enough manpower.

In order to preserve groundwater and protect the groundwater table from further lowering, farmers suggest limiting the total amount of irrigation. Since the irrigation water extraction from the groundwater body is not yet subject to controls, this should be started as soon as possible by interviewed farmers. Furthermore, the interviewed farmers observe that drip irrigation uses less water than surface irrigation or sprinkler irrigation over the year. The interviewed farmers think that it is the responsibility of politicians to make strategic decisions. According to farmers, it is most urgent to keep irrigation at a moderate level.

The implementation of adaptation measures may be restricted due to high costs or laws. For example, the insurance is perceived too expensive by some farmers and keeping livestock in forest is prohibited by law and thus not considered as an adequate adaptation measure.

As confirmed by the literature, farmers who perceive climate change as a risk also report to take adaptation measures. Farmers’ perception of climate change was based on their beliefs, knowledge and experience of the dependence of agricultural activities on natural resources. Farmers’ adaptation decisions were found to be influenced by socio-economic and cultural factors (Ngyuen et al., 2016, 213).

When it comes to avoidance, the interviewed farmers hope that global warming will not progress any further neither on a global nor on a regional level (wishful thinking). It can be observed that reference is increasingly made to events in the past, such as “*the Neusiedlersee had already dried up”* or “*the Danube had already dried up and then came rainy years again”*. It is hoped that if these events should repeat, rainy years will follow. Furthermore, future wishes concern the region's irrigation system. It is hoped that water will not become scarce and policymakers will not restrict irrigation. By and large, future desires relate to changed climatic conditions without drought and rainy years are expected in the next decades. Fatalism is largely affected by future generations. It can be observed that interviewed farmers no longer sincerely value the land they own. Not appreciating this will also be passed on to future generations. The interviewed farmers thus recommend that future generations should focus on fixed incomes.

When it comes to climate change impacts on a regional level, farmers perceive this as a fate. The 2016 frost event in viticulture is seen as such a fate event, because it happened unexpectedly and farmers were unable to take appropriate adaptation measures beforehand.

Some farmers deny climate change and expect no impact on their farm in the future. The media seem to have a major influence on interviewed farmers, with climate change being perceived by farmers as man-made and freedom-robbing. Other farmers portray climate change as controlled scare tactics from satanic circles. Fears of existence due to climate change and the fear that climate change will continue and even reinforce until 2050 are described by most farmers. Associated with this are fears of diseases and fungi on livestock and crops, which are caused by climate change. Furthermore, fears of a future price drop on the agricultural market are described, as well as fears of a CO_2 tax and water scarcity, since irrigation of agricultural crops in the Seewinkel region is perceived essential.

According to Mitter et al., (2019) farmers express wishful thinking by expecting adverse impacts of climate change to occur in the future, but, unlike other farmers, expect that they will not be affected. Fatalism is expressed by negative feelings about climate change. These farmers are not aware of effective and efficient adaptation measures, they see the future of agriculture as very difficult, and they do not constitute adaptation intentions. They describe their farm as small with little adaptability and no chance of long-term survival (cf. Mitter et al., 2019, 814). Also, some interviewed farmers in the Seewinkel region see the future of agriculture difficult for small business farms. They do not believe that small farms below 10 ha will exist in 2050.

Figure 24 summarizes the factors influencing farmers’ adaptation intensions and the factors why farmers do not form adaptation intension

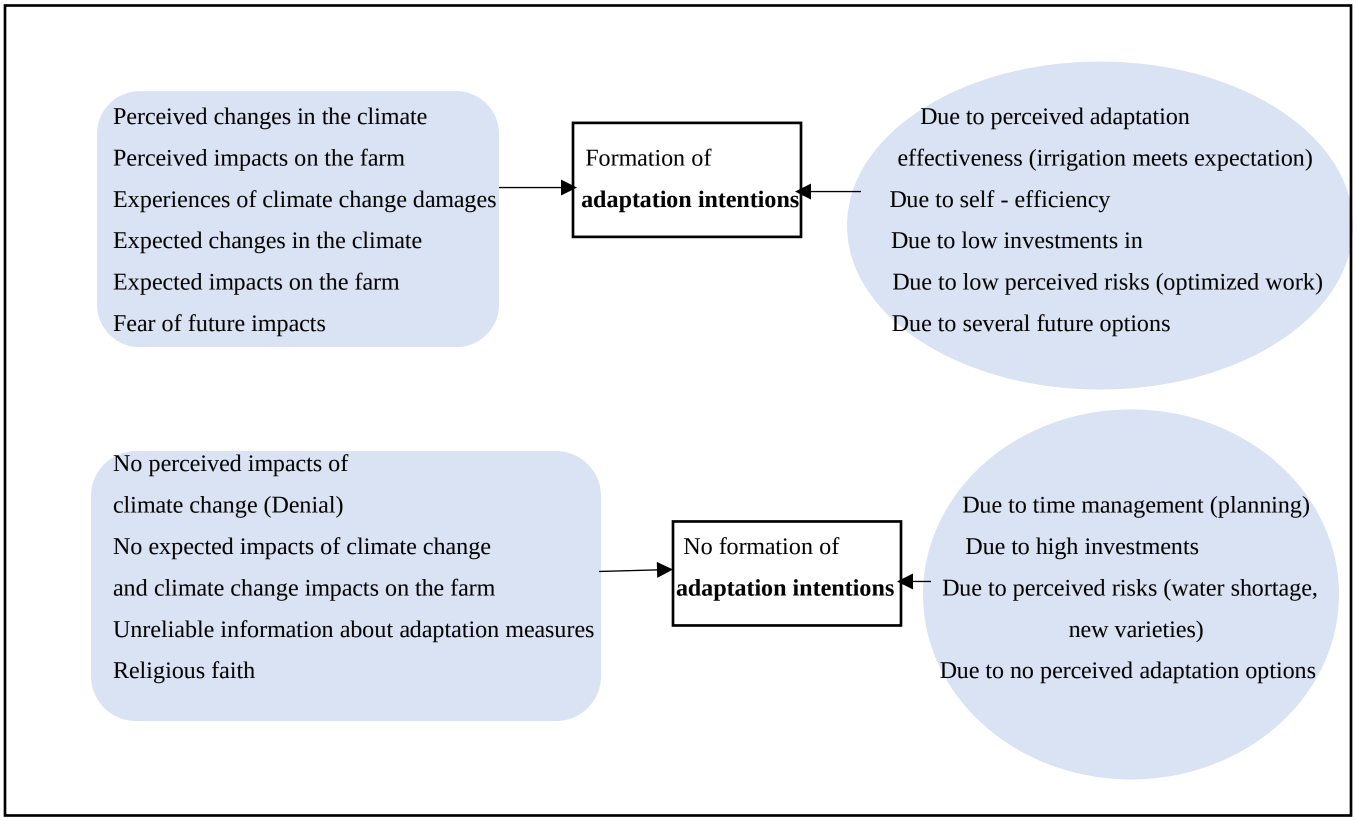

Figure 24: Factors influencing the formation of adaptation intentions. Source: Own illustration based on Stöttinger, 2016.

5.4 Expected future developments

Farmers assume that climatic changes will continue to increase until 2050. Interviewed farmers observe that changes in heat, aridity and temperature rise will continue in the future. Wind and storm, frost and heavy rainfall are also expected to take off in the future. Precipitation will in some cases be less and less distributed, so that dry phases are expected to dominate. On the other hand, some interviewed farmers think that no climatic changes will occur in the future.

Climate model results show a further increase in temperature until 2050. Warming makes it very likely that heat waves will increase in frequency, intensity and duration, and it is also very likely that the number of frost days will decrease. Based on the climate models, it is uncertain whether changes in wind speed will occur (APPC, 2014, 303ff).

Climatic change is expected to have further impacts on the production and quality of agricultural products in the next decades. On the one hand, financial losses are expected due to massive damages to the crops and the associated increase in irrigation. On the other hand, there is fear of poor yield quality due to rising temperatures. In addition, as temperatures rise, farmers expect a higher workload because to do as irrigation will become vital in all production activities. The interviewed farmers already talked about existential fears due to expected lower incomes in the future. In the next few decades, tourism will change in the Seewinkel region, as guests are already absent when the temperatures are too hot. This could cause serious existential damage, especially for direct marketers.

Expected future impacts of climate change based on the climate scenarios for Austria are shown in Figure 25.

Agriculture	**Water management**	**Tourism**
Extension of growing season	Increase in potential evaporation due to higher temperatures and a longer growing season.	Year-round tourism due to the increase in the annual temperature.
Shifting precipitation from the growing season to winter	Decrease in snow precipitation and the duration of the snow cover in winter.	Decrease in ice and frost days, advantages and disadvantages in winter tourism.
Decrease in the frequency of precipitation during the summer months	Increase in winter precipitation, decrease in summer precipitation	Change in the amount of precipitation and its seasonal distribution, advantage in summer tourism.
The frequency of dry periods will increase	Rise in the water temperature in the groundwater.	Rise in the water temperature of Lake Neusiedl.
Increase in the heat load on plants	Decrease in groundwater recharge.	Pollution of the water quality (algae) of Lake Neusiedl.
Decrease in soil water content and thus increased drought stress	Increase in water demand in agriculture (BMLFUW, 2017a, 44).	Rise in hot days in summer (over 30°C) Advantages and disadvantages of summer tourism - escape from cities in urban areas, but possibly also too hot in the Seewinkel region.

Crops could disappear completely from use due to increased temperatures. Risk of biodiversity reduction.		Decline in biodiversity and changes in the landscape (of great importance in the Seewinkel National Park area) (BMLFUW, 2017a, 45).
Occurrence of invasive pathogens and diseases in plants and livestock.		
Decrease in the performance of farm animals		
Change in physiological performance and quality of crops (BMLFUW, 2017a, 43f).		

Figure 25: Expected future impacts of climate change by interviewed farmers in the Seewinkel region. Source: own illustration, see BMLFUW, 2017a, 43ff.

According to the majority of the interviewed farmers, the greatest future challenges are climate change and the scarcity of groundwater for irrigation. If drought and heat continue to increase in the future, groundwater availability for irrigation is expected to be crucial for farming. Fruit and vegetable growing in particular are already dependent on irrigation. This could lead to major yield losses and thus to a loss of income, which it is very difficult to compensate for.

Farmers perceive public payments for the agricultural sector differently. Some farmers perceive them as an opportunity to establish subsidies for adaptation to climate change. Others, perceive public payments as a risk and justify this with the fact that the market for agricultural goods would regulate itself without subsidies and subsidies would “postpone” or delay existing or newly developing problems. One of the mentioned developments in the design of public payments is, for example, the discontinuation of funding for greenery.

In livestock farming, trade regulations are addressed as a major challenge. The farmers report that it has become very difficult in some cases to keep animals on their farm due to the trade regulations. They expect that these trade requirements could be tightened further until 2050, which could further reduce the number of livestock farms in the Seewinkel region.

Understanding the perception of farmers can help policymakers understand current decisions on farms and adaptive behavior of farmers in order to develop conducive political frameworks. Understanding socio-cultural and economic factors that lead to changes in climate perceptions can help integrate climate education and communication into adaptation research (Ngyuen et al., 2016, 214).

5.5 Discussion of the methods

The interview guide was most important for conducting the interviews and facilitated a smooth communication during the interviews. The qualitative content analysis followed the research questions defined in chapter 3.4.1.

Most of the interviewees answered the researcher's questions directly and specifically. Some interviewees were a bit dissolute in answering the questions and started a discussion about political and social factors related to climate change. Therefore, the researcher was challenged to direct the interviewees along the topics of the interview guide. The interview questions were generally easy to understand for the interviewees. Some interviewed farmers, repeated the questions and in some cases asked the researcher for clarifications. Some interviewees could not answer selected questions, because they have not yet planned any adaptation measures or do not feel sufficiently informed about issues related to adaptations to climatic changes. Some interviewees doubted being the right person for the interviews because they thought to have not enough information about climate change. However, the researcher motivated all interviewees by making clear that their personal perceptions and expectations are of interest for this research.

The researcher was very friendly welcomed by all interview partners. Usually, a tour through the farm was offered before or after the interview, and samples of the farm products were also provided. Some interviewees were politically active or held a position in the Seewinkel region's irrigation association. These interviewees were particularly keen to discuss political issues and to find solutions for groundwater scarcity in the region. Some of the respondents run their business with direct marketing or operate guest rooms or a tavern and were thus able to answer questions about tourism in the Seewinkel region. Interviewees with long experience and sufficient information on the subject of agriculture and climate change answered the questions with much detail, in contrast to interviewees with less experience in agriculture.

Before the interview started, a data sheet was filled out. During this process important conversations arose in advance of the interview. However, the researcher pointed out that these conversations would better fit during the interview.

The analysis of the collected empirical data was based on a qualitative content analysis (e.g., Mayring, 2014, Mayring, 2019). Categories and codes that reduce the text material to linguistic short formulas were developed to structure, summarize and understand the meaning of the text, i.e., the transcribed interviews. The text analysis focuses on the deductively and inductively developed codes and the developed category system. Text content that is not addressed in the codes and categories and goes beyond the research questions was not taken into account (Mayring, 2019, s.a.).

6 Conclusion and outlook

The use of a qualitative approach seems reasonable for answering the research questions of this master thesis. Qualitative, semi – structured interviews were carried out in the Seewinkel region. As Austria's driest region, the Seewinkel offers interesting insights on perceived climate change impacts on agricultural production. Furthermore, most of the interviewed farmers have already implemented adaptation measures and intend to adapt to expected changes and impacts of climate change in the future.

The Model of Private Proactive Adaptation of Climate Change developed by Grothmann and Patt (2005) was used as a theoretical basis for this qualitative research. The model offers an understanding of socio - cognitive processes of farmers, which was well - suited for the research questions raised in the master thesis.

For the most part, farmers fear about future impacts of climate change. For planning adaptation measures, the willingness to adapt, personal flexibility, flexibility on the farm as well as exchange between farmers seem to be advantageous. Farmers who do not feel adequately prepared for climatic changes have greater fears of losses.

Apart from the perception of having to adapt to climate change in order to be able to take advantage of new opportunities and minimize risks, other intentions such as access to adaptation intensions as well as adaptation costs. Another aspect is the question of the successor. If a potential successor is available on the farm, adaptation intentions are higher than if there is no successor. In the future, the market price for a product seems to be important if adaptation measures are planned to be carried out or not by the interviewed farmers. An important aspect in planning suitable adaptation measures is the expertise that farmers often lack. Farmers should be able to access knowledge on climate change adaptation through sufficient and tailored sources of information.

Adaptation intentions are influenced by avoidances, whereby the belief in anthropogenic climate change on a global level is an important aspect. Information on global climate change is often obtained from mass media. Not all farmers are aware of global climate change, and they distinguish between natural progression and anthropogenic climate change.
Most farmers perceive climate change on global and local levels and are already implementing adaptation measures, which mainly relate to management, such as soil

cultivation and investments in efficient irrigation systems. Further adaptation measures are planned in the future, in particular if climatic is expected to change considerably.

Based on this empirical results, future research should focus on dry production areas in Austria, where the results from this thesis can serve for first instructions. Furthermore, production areas with sufficient precipitation of agricultural production are of interest to discuss behavioral differences.

Perceived impacts of climate change and adaptation intentions at the farm level offers a broad spectrum of research that should be further investigated in future. Both, dry regions in which drastic adverse impacts of climate change can be expected and wet regions where beneficial impacts may prevail should be considered.

Policy makers may support future adaptation in farming. Farmers perceive subsidies as both an opportunity and a challenge in coping with climate change. Policies could, however, facilitate climate change adaptation for farmers and contribute to the prevention of groundwater scarcity, since groundwater is not only essential for irrigation but also for the preservation of the characteristic salt lakes in the region. In addition, some laws can make it also difficult to implement adaptation measures, which is particular important for livestock farming in the Seewinkel region. These laws could be rethought.

Several farmers who are directly affected by climate change are willing to take appropriate adaptation measures. However, farmers often feel not sufficiently informed and there is a lack of knowledge about appropriate adaptation measures. Agricultural extensions and the agrarian education system could offer more information on various adaptation measures such as conservative tillage or humus formation.

Most farmers perceive saving groundwater, monitoring of groundwater abstraction and controlled irrigation at night as important.

One of the perceived biggest challenges besides climate change are product prices. Farmers perceive product prices as threatening their existence. Prices cannot be directly influenced by political decisions. However, direct marketing and the supply of regional products in supermarkets should be supported, which is important for some farmers. Grape prices are perceived to be pushed down by large landowners.

By and large, agricultural policy may foster capacity building and provide infrastructural, organizational and financial support to strengthen the farmers' intention to adapt and enable future generations to continue their farms.

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Appendix

Appendix I: Interview protocol

Interviewprotokoll

Ort: Datum:

Interviewnr.: Dauer:

InterviewpartnerIn:

- Gesprächsatmosphäre (Stimmung, Verhalten der interviewten Person(en):

- Interaktionen zwischen GesprächspartnerInnen:

- Auffallende Themen (die durch die Forschungsfragen nicht thematisiert wurden):

- Störungen des Interviews (Kinder, Radio, etc.):

- Sonstige Besonderheiten:

Appendix II: Interview guide:

Interviewleitfaden

Einführung	
Danke, dass Sie sich für das Interview Zeit nehmen und damit einen Beitrag zu meiner Masterarbeit leisten. Nach dem Datenschutzgesetz bin ich verpflichtet, eine **schriftliche Einverständniserklärung** für das Interview und seine Auswertung einzuholen. Ich werde das Interview mit einem Diktiergerät aufnehmen und dann verschriftlichen. Ihre Angaben werden vertraulich behandelt und alle identifizierenden Merkmale, wie Name, Alter oder Orte werden anonymisiert, sodass man nicht auf Ihre oder andere Personen rückschließen kann. Dazu erhalten Sie von mir eine **Vertrauensschutzerklärung.** Gelegentlich werde ich Stichwörter niederschreiben, wenn mir etwas einfällt, zu dem ich eventuell noch Fragen stellen möchte. Das dient aber nur dazu, dass ich den Roten Faden nicht verliere.	Das Interview wird in etwa **eine Stunde** dauern und ist in **drei Themenbereiche** gegliedert. Es ist dann zu Ende, wenn Sie das Gefühl haben, dass wir die einzelnen Themenbereiche ausreichend abgehandelt haben. In meiner Arbeit beschäftige ich mich damit, wie Landwirte und Landwirtinnen in der Region Seewinkel klimatische Veränderungen wahrnehmen und bewerten. Die Region Seewinkel grenzen wir entsprechend des lokalen Grundwasserkörpers *[Karte vorlegen]* ab. Mich interessieren Ihre ganz **persönlichen Erfahrungen und Meinungen.** Ein Richtig oder Falsch gibt es nicht, Ihre Meinung ist das was zählt. Ich werde im Interview offene Fragen stellen, auf die Sie in Ihren Worten antworten. Bitte erzählen Sie mir einfach, was Ihnen zu den Fragen in den Sinn kommt. **Haben Sie noch Fragen?**

Hauptfrage	**Unterfragen, Notizen**	**Check/Memo**
I. Wahrgenommene klimatische Veränderungen, betriebliche und persönliche Auswirkungen		
1. Einstig In meiner Arbeit geht es um klimatische Veränderungen in der Region Seewinkel und deren Auswirkungen auf die Landwirtschaft. Bitte sagen Sie mir zu Beginn, **was Ihre Meinung** zum Klimawandel ist.	Glauben Sie persönlich an einen vom Menschen verursachten Klimawandel?	
2. Wahrgenommene klimatische Veränderungen Rückblickend auf die Zeit seit Sie in der Landwirtschaft tätig sind – inwiefern haben sich Ihrer Meinung nach die klimatischen Bedingungen **<u>in der Region Seewinkel</u>** verändert?	Klimatische Veränderung 1: Klimatische Veränderung 2: Klimatische Veränderung 3:	Temperatur Niederschlag Extremwetterereignisse: Hagel, Starkregen, Dürre, Hitze, Nässe Wind, Sturm

	Welche anderen klimatischen Veränderungen nehmen Sie in der Region Seewinkel bereits wahr?	
3. Wahrgenommene betriebliche Auswirkungen Welche Auswirkungen haben die von Ihnen geschilderten klimatischen Veränderungen auf **Ihren Betrieb?** Inwiefern wirkt sich (Klimatische Veränderung 1) auf Ihren Betrieb aus? Und was (Klimatische Veränderung 2, 3 etc.) betrifft, welche Auswirkungen nehmen Sie auf Ihrem Betrieb wahr?	Auswirkungen zu klimatischer Veränderung 1: Auswirkungen zu klimatischer Veränderung 2: Auswirkung zu klimatischer Veränderung 3: Im Zusammenhang mit dem Klimawandel werden positive und negative Auswirkungen diskutiert. Welche **positiven** Auswirkungen nehmen Sie auf Ihrem Betrieb wahr? Welche **negativen** Auswirkungen nehmen Sie auf Ihrem Betrieb wahr?	Ertragsänderungen Krankheiten, Schädlinge bei Pflanzen und Tieren Verfrühte Reife, Erntebedingungen Wirtschaftlich, finanziell Organisatorisch Arbeitswirtschaftlich Unkraut Sturmschäden in Folienhäuser, Stallungen Weniger Spritzen aufgrund der Trockenheit
4. Wahrgenommene persönliche Auswirkungen Sie haben (Klimatische Veränderung 1) angesprochen. Inwiefern wirkt sich (Klimatische Veränderung 1) **auf Sie persönlich** aus? Was (Klimatische Veränderung 2, 3 etc.) betrifft, welche persönlichen Auswirkungen haben Sie bereits wahrgenommen?	Auswirkungen zu klimatischer Veränderung 1: Auswirkungen zu klimatischer Veränderung 2: Auswirkung zu klimatischer Veränderung 3: Welche **positiven** persönlichen Auswirkungen nehmen Sie wahr? Welche **negativen** persönlichen Auswirkungen nehmen Sie wahr?	Psychische / physische Erkrankungen Unfälle, traumatische Erlebnisse Existenzängste Wetterfühligkeit Allergien

II. Anpassung an klimatische Veränderungen		
5.1 Persönliche Anpassung an klimatische Veränderungen Generell geht man davon aus, dass sich Landwirtinnen und Landwirte an klimatische Veränderungen anpassen können, um Gefahren zu minimieren oder neue Chancen zu nützen.	Persönliche Anpassungsmaßnahme 1: Persönliche Anpassungsmaßnahme 2: Persönliche Anpassungsmaßnahme 3:	Proaktiv / reaktiv Bewässerung Reduzierte Bodenbearbeitung Verschiebung Anbau/Saattermine Züchtung/Anbau neuer Sorten Umstellung (bio ↔ konv),

Sie haben eben Auswirkungen des Klimawandels auf Sie **<u>persönlich</u>** beschrieben. Wie gehen Sie mit (Auswirkungen 1, 2 etc.) persönlich um? Inwiefern passen **Sie sich <u>persönlich</u>** an (Auswirkung 1, 2 etc.) an? **5.2 Betriebliche Anpassung an klimatische Veränderungen** Welche Rolle spielen klimatische Veränderungen für Entscheidungen auf **<u>Ihrem Betrieb?</u>** Welche Maßnahmen setzen Sie auf Grund der von Ihnen geschilderten Auswirkungen auf **<u>Ihrem Betrieb</u>** bereits um? Wie gehen Sie mit (Auswirkung 1, 2 etc.) auf **<u>Ihrem Betrieb</u>** um? Inwiefern **planen** Sie noch weitere Anpassungsmaßnahmen auf **<u>Ihrem Betrieb</u>** umzusetzen?	Wie zufrieden sind Sie mit persönlicher Anpassungsmaßnahme 1,2, 3? Betriebliche Anpassungsmaßnahme 1: Betriebliche Anpassungsmaßnahme 2: Betriebliche Anpassungsmaßnahme 3: ***Bereits umgesetzte <u>betriebliche</u> Anpassungsmaßnahmen*** Inwieweit erfüllt (Anpassungsmaßnahme 1,2 etc.) Ihre **Erwartungen** für **den Betrieb?** Wie bewerten Sie die **Kosten** von (Anpassungsmaßnahme 1,2 etc.)? Welche Veränderungen haben Sie seit der Umsetzung von (Anpassungsmaßnahme 1, 2 etc.) auf **Ihrem Betrieb** bemerkt? ***Geplante <u>betriebliche</u> Anpassungsmaßnahmen*** Aus welchen Gründen **<u>planen</u>** Sie, Anpassungsmaßnahme 1, 2 etc. auf **Ihrem Betrieb** (nicht) umzusetzen?	Veränderung der Fruchtfolge, Zwischenfrüchte, Hagelnetze, Versicherungen Weidesysteme, Kühlung und Klimaanlagen, Beratung, Einsatz von Technologien, Aufgabe von marginalen Feldern/Standorten, Diversifizierung, Monitoring bei Schädlingen und Krankheiten, Arbeitsorganisation Schutzkleidung, Arbeitskleidung Pause zu Mittag
6. Bewässerung Sie haben die **Bewässerung** von landwirtschaftlichen Kulturen (nicht) angesprochen. Dieses Thema möchte ich jetzt noch etwas genauer behandeln. Bitte erzählen Sie mir, welche Rolle die Bewässerung von landwirtschaftlichen Kulturen auf Ihrem Betrieb spielt?	Aus welchen Gründen setzen Sie (Bewässerungsmaßnahmen) auf Ihrem Betrieb ein? Seit wann setzen Sie Bewässerungsmaßnahmen auf Ihrem Betrieb ein? Inwieweit haben sich die betrieblichen Bewässerungsmaßnahmen seit der Einführung auf Ihrem Betrieb verändert? Können Sie mir bitte mehr darüber erzählen, wie Sie Bewässerungsmaßnahmen auf Ihrem Betrieb umsetzen?	Bewässerte Kulturen Bewässerungszeitpunkt z.B. in Kooperation mit anderen Betrieben oder einzelbetrieblich

	Wie gehen Sie mit möglichen Wasserengpässen um? / Wie wird in der Bewässerungsgenossenschaft mit möglichen Wasserengpässen umgegangen? Wie werden Vorschriften betreffend die Wasserentnahme in Ihrer Bewässerungsgenossenschaft eingehalten? Welche regionalen Strategien zur Grundwasserbewirtschaftung halten Sie für zweckmäßig? Inwiefern könnten diese aus Ihrer Sicht verbessert werden?	 Betriebsbuch für Brunnen, Führung und Aktualisierung von Unterlagen in der Genossenschaft,

III. Zukunft: Erwartete klimatische Veränderungen und Auswirkungen		
7. Erwartete klimatische Veränderungen Wir haben bisher über die Vergangenheit und die Gegenwart gesprochen. Nun möchte ich mit Ihnen einen Blick in die Zukunft werfen. Welche klimatischen Veränderungen erwarten Sie **in der Region Seewinkel** in Zukunft?	Klimatische Veränderung 1: Klimatische Veränderung 2: Klimatische Veränderung 3:	Trendentwicklung Extremwetterereignisse (Intensität, Häufigkeit)
8. Erwartete betriebliche Auswirkungen Was denken Sie, wie wird sich die erwartete klimatische Veränderung (1, 2 etc.) auf **Ihren Betrieb** auswirken?	Welche **Chancen** sehen Sie auf Grund veränderter klimatischer Bedingungen in der Zukunft für Ihren Betrieb? Welche **Risiken** erwarten Sie auf Grund veränderter klimatischer Bedingungen in der Zukunft für Ihren Betrieb?	Organisatorisch Arbeitsorganisation Einkommensveränderung
9. Erwartete Anpassungsfähigkeit Welche Möglichkeiten sehen Sie, **Ihren Betrieb** langfristig erfolgreich an klimatische Veränderungen anzupassen? Sehen Sie noch weitere Möglichkeiten für Ihren Betrieb, mit den erwarteten Auswirkungen klimatischer Veränderungen umzugehen?	***Wenn wenige/keine Anpassungsmöglichkeiten wahrgenommen werden:*** Was denken Sie, aus welchen Gründen gibt es für Ihren Betrieb kaum Möglichkeiten, sich an klimatische Veränderungen anzupassen?	Fermentation Veredelung Lagerung Saisonal Regional

10. Förderliche und hinderliche Rahmenbedingungen Veränderungen am Betrieb können z.B. durch politische, rechtliche oder institutionelle Rahmenbedingungen beeinflusst werden. Was denken Sie, welche Rahmenbedingungen müssen erfüllt sein, damit eine Anpassung ihres Betriebes an klimatische Veränderungen gelingen kann? Wo sehen Sie Hindernisse, Ihren Betrieb in Zukunft erfolgreich an klimatische Veränderungen anzupassen? Welche Hilfestellungen könnten die langfristig erfolgreiche Anpassung ihres Betriebes an klimatische Veränderungen erleichtern?		Politische, rechtliche, institutionelle Rahmenbedingungen Wasserregulierung Infrastrukturbereitstellung (technisch, finanziell, Beratung)
11. Abschluss Wir haben jetzt ausführlich über klimatische Veränderungen in der Region Seewinkel, mögliche Auswirkungen auf Ihren Betrieb und bereits umgesetzte bzw. geplante Anpassungsmaßnahmen auf Ihren Betrieb gesprochen. Zum Abschluss möchte ich noch zwei Fragen stellen: Wenn Sie über Ihren Betrieb hinausschauen und einen Blick in die Region werfen. Wie stellen Sie sich die Landwirtschaft in der Region Seewinkel im Jahr 2050 vor? Was sehen Sie bis 2050 als die größte Herausforderung - für die Entwicklung der Landwirtschaft in der Region Seewinkel? - für die Entwicklung Ihres Betriebes? Möchten Sie noch etwas zum Thema ergänzen, was bisher nicht angesprochen wurde?		

Können Sie mir weitere Landwirtinnen und Landwirte aus der Region Seewinkel für ein Interview empfehlen?

Vielen Dank für das Gespräch und Ihre wertvollen Beiträge.

Appendix III: Data sheet

Strukturdatenblatt

Interviewer: ____

Datum: ______________________ PLZ: _______________________________

Daten zur Person

1. Geschlecht: ◯ weiblich ◯ männlich

2. Geburtsjahr: __________________

3. Über welche **landwirtschaftliche Ausbildung** verfügen Sie? (Mehrfachnennung möglich)

◯ ausschließlich Praxis ◯ landwirtschaftliche Fachschule

◯ landwirtschaftliche Meisterausbildung ◯ landwirtschaftliche Matura

◯ landwirtschaftliches Studium

4. Berufserfahrung im Sektor Landwirtschaft: _________ Jahre

5. Seit wann sind Sie Betriebsleiter/in? Seit: _________ (Kalenderjahr) ◯ bin ich nicht

Daten zum Betrieb im Wirtschaftsjahr 2019

6. Erwerbsform:

◯ Haupterwerb, seit: _________ ◯ Nebenerwerb, seit: _________

7. Bewirtschaftungsweise:

◯ Konventionell, seit: ______________ ◯ Biologisch, seit: _________

◯ Umstellungsbetrieb, seit: _________ bis: _________

8. Arbeitskräfte:

	Fam.eigene Arbeitskräfte (mit Betriebsleiter/in)	Fremdarbeitskräfte	
ganzjährig Vollzeit			Anzahl der Personen
ganzjährig Teilzeit			Anzahl der Personen
fallweise/saisonal			Anzahl der Personen

9. Mit welchen **Personen** treffen Sie gemeinsam wichtige **betriebliche Entscheidungen?**

◯ niemandem ◯ (Ehe-)Partner/in ◯ Eltern/Schwiegereltern

◯ Kind/er ◯ andere Personen: ____________________________________

10. Betriebsform:

◯ Marktfruchtbetrieb ◯ Futterbaubetrieb ◯ Veredelungsbetrieb

◯ Dauerkulturbetrieb ◯ Landwirtschaftlicher Gemischtbetrieb

Bieten Sie auf Ihrem landwirtschaftlichen Betrieb, Nebentätigkeiten im Bereich Fremdenverkehr, Beherbergung, Buschenschank oder sonstige Freizeitaktivitäten an?
Ja, welche: ____ ◯ Nein

11. Bewirtschaftete Fläche:

Bewirtschaftete **Gesamtfläche:** ________________ ha

davon Eigengrund: ________________ ha davon Pachtgrund: ________________ ha

davon im Gebiet des Nationalparks Neusiedler See-Seewinkel: ________________ ha

davon unter Glas/Folie: ______________ ha

Acker: ________________ ha Grünland: _______________ ha

Weinbau: ________________ ha Obstbau: _______________ ha

Gemüsebau: ________________ ha Wald: _______________ ha

Sonstige: ________________ ha

Befinden sich auf der von Ihnen bewirtschafteten Fläche **eines oder mehrere Windräder?**

◯ Ja, Anzahl: _________________ ◯ Nein

12. Art und Anzahl der **Tiere im Jahresdurchschnitt:**

Rinder und Kälber: ________________ Stück Schweine: ________________ Stück

Einhufer: ________________Stück Schafe und Ziegen: ________________ Stück

Geflügel: ________________ Stück Andere Tiere: ____________________________

13. Bei welchen der folgenden **ÖPUL-Maßnahmen** nehmen Sie teil?

◯ Begrünung von Ackerflächen ◯ Mulch- und Direktsaat ◯ Erosionsschutz Obst, Wein, Hopfen

◯ Bodennahe Ausbringung flüssiger Wirtschaftsdünger und Biogasgülle

◯ Naturschutz (WF) ◯ Naturschutzfachlich wertvolle Pflegefläche (WPF)

◯ Biologische Wirtschaftsweise ◯ Anbau seltener landwirtschaftlicher Kulturpflanzen (SLK)

◯ Tierschutz (Weide oder Stallung)

14. Bewässerung:

Bewässerbare Fläche*: _______________ ha davon ohne Pumpe bewässerbar: _______________ ha

**** Fläche, die bewässert werden könnte,*** *d.h. Fläche, die erforderlichenfalls mit den am Betrieb verfügbaren technischen Einrichtungen und der verfügbaren Wassermenge bewässert werden könnte.*

Im Jahr 2019 tatsächlich bewässerte Fläche: _________________ ha

Kulturen, die **vorrangig bewässert** werden und durchschnittliche, jährliche Bewässerungsmenge

Kulturen	Bew.menge (mm)	Kulturen	Bew.menge (mm)
◯ Getreide	_______________	◯ Mais	_______________
◯ Eiweißpflanzen	_______________	◯ Kartoffeln	_______________
◯ Zuckerrüben	_______________	◯ Raps	_______________
◯ Sonnenblumen	_______________	◯ So. Kulturen am Ackerland	_______________
◯ Feldgemüse	_______________	◯ Folienhäuser	_______________
◯ Weingärten	_______________	◯ Obstgärten	_______________

Woher beziehen Sie das Wasser für die Bewässerung der von Ihnen bewirtschafteten Flächen?

Außerhalb des Betriebs	Im Betrieb
◯ aus gemeinsamen Wasserversorgungsnetzen	◯ Grundwasser (eigener Brunnen)
◯ Oberflächenwasser aus Seen, Flüssen	◯ Oberflächenwasser (Teiche, Staubecken)

Welches Bewässerungsverfahren wenden Sie auf Ihrem Betrieb an? (Mehrfachnennung möglich)

	Beregnung (Sprinkler-bewässerung)	Tröpfchen-bewässerung	Oberflächen-bewässerung
Acker	◯	◯	◯
Grünland	◯	◯	◯
Weingärten	◯	◯	◯
Obstgärten	◯	◯	◯
Feldgemüsebau	◯	◯	◯
Folienhäuser	◯	◯	◯
Sonstiges: __________________	◯	◯	◯

Wie wird die **Bewässerungspumpe** auf Ihrem Betrieb angetrieben?

◯ Dieselaggregat, Traktorantrieb od. ähnl. ◯ Reiner Pflanzenölantrieb

◯ Elektroantrieb (Netzstrom) ◯ Elektroantrieb (Inselanlage Photovoltaik)

◯ Sonstiges: ________________________________

Wann wurde das Bewässerungssystem **implementiert** und zum letzten Mal **erneuert?**

◯ Implementiert im Jahr: _______________ ◯ Erneuert im Jahr: _______________

Führen Sie **Aufzeichnungen** zur betrieblichen Bewässerung?

◯ Ja ◯ Nein

Wenn ja, wären Sie bereit diese für wissenschaftliche Zwecke zur Verfügung zu stellen? ◯ Ja ◯ Nein

Welcher **Bewässerungsgenossenschaft** gehören Sie an? ____

Vielen Dank für Ihre Unterstützung!

Appendix VI: Summary on the interviewees (demographic data) and their farms (farm structural data)

	Code	# of IP	Gender	Age	Farm typ[1]	Main production activity	Farm size[2] in ha	Irrigated in 2019	Cultivation system[3]	Type of contact[4]
1	Int_ 01	1	M	61	Crop	Viticulture	2.50	No	C	P
2	Int_ 02	1	F	49	Crop	Viticulture	3.5	Yes	O	P
3	Int_ 03	1	M	71	Crop	Viticulture	32	No	C	P
4	Int_ 04	1	F	56	Crop Livestock	field crops, viticulture, poultry	45.6	Yes	O	P
5	Int_05	1	m	35	Crop Livestock	field crops, viticulture, grassland, fruit growing, forest, cattle, equine, poultry, fattening pigs, sheep and goats	2100	Yes	O	G
6	Int_06	1	m	53	Crop Livestock	viticulture, vegetable growing, poultry, fattening pigs, sheep and goats	5	Yes	O	G
7	Int_07	1	m	46	Crop Livestock	field crops, vegetable growing, fruit growing, forest, fattening pigs, poultry, sheep and goats	29	Yes	O	G
8	Int_08	1	f	44	Crop	fruit growing	10	Yes	C	G

9	Int_09	1	f	56	Crop	field crops, viticulture	60	Yes	C	G
10	Int_10	1	m	54	Crop Livestock	vegetable growing, fruit growing, poultry	40	Yes	O	G,I
11	Int_11_01/ Int_11_02	2	m/f	55/32	Crop	field crops, vegetable growing	58	Yes	O	G
12	Int_12_01/ Int_12_02	2	m/f	50/-	Crop	field crops, vegetable growing, fruit growing	74	Yes	C	G,I
13	Int_13	1	m	36	Crop	viticulture	24	Yes	C	G
14	Int_14_01/ Int_14_02	2	m/f	50/-	Crop	field crops, viticulture	146	Yes	C	G,I
15	Int_15	1	m	58	Crop	field crops	370	No	O	I
16	Int_16	1	m	47	Crop	viticulture	16	Yes	C	I
17	Int_17	1	m	5	Crop Livestock	field crops, grassland, sheep and goats	105	Yes	O	G,I
18	Int_18	1	m	24	Crop Livestock	field crops, grassland, cattle	1080	Yes	C and O	G
19	Int_19	1	m	53	Crop	field crops, grassland viticulture	45	Yes	C	G,I
20	Int_20	1	m	69	Crop	field crops	20	Yes	O	I
21	Int_21	1	m	50	Crop	field crops	285	No	O	P

[1]Farm type: Crop production (Crop) Livestock production (Livestock).

[2]Farm size: including own and leased land, including cropland, grassland, forest, orchards and vineyards.

[3]Cultivation system: C (conventional), O (organic).

[4]Gatekeeper strategy: based on the contact list provided by regional extension experts; I: Internet resources; P: Personal network

Appendix V: Additional rules for transcription of the interviews:

- Breaks were documented with <*>[41].
- If the interviewee has emphasized certain statements, these were highlighted with CAPITAL LETTERS.
- If the interviewee sighed or laughed, this was indicated.
- If the interviewee did not finish a sentence, this was indicated </> to recommend the end of a sentence.
- If the quality of the recording was inadequate and a word or phrase was not understandable for the transcribing person, this was documented **<(XXX)>**.

[41] One second break is: <*>. Two seconds break is: <**>.

Appendix VI: Table that indicates the average annual irrigation volume (l) or the frequency and average duration of irrigation in the vegetation period of different crops of the individual farmers.

	Grain	Protein crops	Sugar beet	Field vegetables	Vineyards	Corn	Potatos	Foil houses	Orchards	Area actually irrigated in 2019 in ha
IP01										3
IP03					2x[42]					5.5
IP04					2x 40l					150
IP05				6x						0.5
IP06				100l					30l	0.7
IP07									10x	10
IP08					5x	6x	6 – 10x			53

[42] x = in the vegetation period

IP09				15l 3x						35
IP10								200 l		6
IP11				10x		5x		30x	5x	39
IP12					2x 24h					24
IP13		150l 5x	210l 7x		3x	210mm 7x				47
IP15					1.6l 24h					7
IP16						21h / ha				23
IP17						5x				50
IP18			4x 14h			4-5x				25
IP19	14x									24

Appendix VII: Code book for the analysis of the interview

Wahrgenommene klimatische Veränderungen_glob	**Wahrgenommene klimatische Veränderungen_Seewinkel**	**Wahrgenommene Auswirkungen_betr**	**Wahrgenommene Auswirkungen_pers**	**Bewässerung**
KW- Auswirkungen_whg: glob	Klimatische Veränderungen: keine whg: reg	KW - Auswirkungen_whg: betr: pos: arbeitswirtschaftlich	KW - Auswirkungen: pers_whg: positiv	Bewässerung: Relevanz: hoch
KW- Veränderungen_glob: Menschlich	Klimatische Veränderungen: reg: whg: Hitze	KW - Auswirkungen_whg: betr: pos: ökonomisch	KW - Auswirkungen: pers_whg: neg	Bewässerung: Relevanz: niedrig
KW- Veränderungen_glob: Natürlich	Klimatische Veränderungen: reg: whg: Trockenheit	KW - Auswirkungen_ whg: betr: pos: Produktion_Qualität		Bewässerung: Relevanz: keine
KW-Auswirkungen_keine whg: glob	Klimatische Veränderungen: reg: whg: Temperaturanstieg	KW - Auswirkungen_ whg: betr: pos: Produktion_Menge		Bewässerung: Relevanz: geplant
KW-Ursachen_whg	Klimatische Veränderungen: reg: whg: Dürre	KW - Auswirkungen_whg: betr: neg: arbeitswirtschaftlich		Bewässerung: Trockenheit
	Klimatische Veränderungen: reg: whg: Sturm / Wind	KW - Auswirkungen_whg: betr: neg: ökonomisch		Bewässerung: Frost
	Klimatische Veränderungen: reg: whg: Hagel	KW - Auswirkungen_whg: betr: neg: Produktion_Qualität		Bewässerung: Niederschlag
	Klimatische Veränderungen: reg: whg: Starkniederschlag	KW - Auswirkungen_whg: betr: neg: Produktion_Menge		Bewässerung: Vorschriften

	Klimatische Veränderungen: reg: whg: Niederschlag	KW - Auswirkungen_keine whg: betr		Bewässerung: regionale Strategien
	Klimatische Veränderungen:reg:whg: Frost			Bewässerungssystem
	Klimatische Veränderungen: reg: whg: mildere Winter			
	Klimatische Veränderungen: reg: whg: Extremwettererereinisse			
	KW - Veränderungen_whg: Übergangszeiten			

Anpassung an klimatische Veränderungen_pers	**Anpassung an klimatische Veränderungen_betr**	**Anpassung_Bewertung**
Anpassung: pers: umgesetzt: Hitze	Anpassung: Fachwissen	Anpassung: Risikoabschätzung_whg: hoch
Anpassung: pers: umgesetzt: Stimmung	Anpassung: betr: umgesetzt: Hitze	Anpassung: Risikoabschätzung_whg: niedrig
Anpassung: pers: geplant	Anpassung: betr: umgesetzt: Trockenheit	Anpassung_Selbstwirksamkeit
	Anpassung: betr: umgesetzt: Temperaturanstieg	Anpassung_Wirksamkeit der Maßnahmen
	Anpassung: betr: umgesetzt: Dürre	whg. Kosten: hoch
	Anpassung: betr: umgesetzt: Sturm / Wind	whg: Kosten: niedrig
	Anpassung: betr: umgesetzt: Hagel	

	Anpassung: betr: umgesetzt: Starkniederschlag	
	Anpassung: betr: umgesetzt: Niederschlag	
	Anpassung: betr: umgesetzt: Frost	
	Anpassung: betr: umgesetzt_Weinbau	
	Anpassung: betr: umgesetzt_ Obstbau	
	Anpassung: betr: umgesetzt_Gemüsebau	
	Anpassung: betr: umgesetzt_Ackerbau	
	Anpassung: betr: umgesetzt_Tierhaltung	
	Anpassung: betr: umgesetzt_Systemisch	
	Anpassung: betr: umgesetzt_Organisatorisch	
	Anpassung: betr: umgesetzt_Inkrementell / Agronomisch	
	Anpassung: betr: umgesetzt_Transformativ	
	Anpassung: Möglichkeiten	
	Anpassung: betr: nicht umgesetzt	

Klimatische Veränderungen erw_Seewinkel	**Anpassungsfähigkeit_erw_betr**	**Klimatische Auswirkungen_erw_betr**	**Klimatische Auswirkungen_erw_pers**
Klimatische Veränderungen: reg: keine erw	Anpassungsfähigkeit: erw: betr: gegeben	KW- Auswirkungen: erw: betr: arbeitswirtschaftlich	KW- Auswirkungen: erw: pers: neg
Klimatische Veränderungen: reg: erw: Hitze	Anpassungsfähigkeit: erw: betr: nicht gegeben	KW- Auswirkungen:erw: betr: ökonomisch	
Klimatische Veränderungen: reg: erw: Trockenheit		KW - Auswirkungen: erw: betr: Produktion_Qualität	
Klimatische Veränderungen: reg: erw: Temperaturanstieg		KW - Auswirkungen: erw: betr: Produktion_Menge	
Klimatische Veränderungen: reg: erw: Dürre		KW- Auswirkungen: erw: betr: neg	
Klimatische Veränderungen: reg: erw: Sturm / Wind		KW - Auswirkungen: erw: betr: pos	
Klimatische Veränderungen: reg: erw: Hagel			
Klimatische Veränderungen: reg: erw: Starkniederschlag			
Klimatische Veränderungen: reg: erw: Niederschlag			
Klimatische Veränderungen: reg: erw: Frost			

Klimatische Veränderungen: reg: erw: mildere Winter Klimatische Veränderungen: reg: erw: Extremwetterereignisse			
Klimatische Veränderungen: reg: erw: Übergangszeiten			

Rahmenbedingungen	**Vermeidung**	**Seewinkel_2050**	**Betrieb_2050**
Rahmenbedingungen_förd: Veranstaltungen / Beratung / Information	Bewertung_Wunschdenken	Vorstellungen Seewinkel: 2050	Herausforderungen 2050: betr: Anpassungen
Rahmenbed_hind: Veranstaltungen / Beratung / Information	Bewertung_Verweigerung	Herausforderungen 2050: reg: Anpassung	Herausforderungen 2050: betr: Klima
Rahmenbedingungen_förd: Förderungen	Bewertung_Fatalismus	Herausforderungen 2050: reg: Klima	Herausforderungen 2050: betr Bewässerung
Rahmenbedingungen_hind: Förderungen	Bewertung_Religiöser Glaube	Herausforderungen 2050: reg: Bewässerung	Herausforderungen 2050: betr: Politik
Rahmenbedingungen_hind: Tierschutzgesetz	Bewertung_Ängste	Herausforderungen 2050: reg: Erntehelfer	Herausforderungen 2050: betr: Investitionen
Rahmenbedingungen_förd: Infrastruktur		Herausforderungen 2050: reg: Politk	

Rahmenbedingungen_hind: Infrastruktur		Herausforderungen 2050: reg: Unabhängigkeit	
Rahmenbedingungen_förd: Organisatorisches		Herausforderungen 2050: reg: Erntehelfer	
Rahmenbedingungen_hind: Organisatorisches		Herausforderungen 2050: reg: Preis	
Rahmenbedingungen_hind: Verordnungen			
Rahmenbedingungen_förd: Bürokratie			
Rahmenbedingungen_hind: Bürokratie			
Rahmenbedingungen_förd: Kontrollen			
Rahmenbedingungen_hind: Kontrollen			
Rahmenbedingungen_hind: Markt			