DISCUSSION PAPER 2018

LIFE AGRIADAPT: SUSTAINABLE ADAPTATION OF EU FARMING SYSTEMS TO CLIMATE CHANGE

1. Introduction

1.1 THE PROJECT LIFE AGRIADAPT

Climate change is one of the most important current challenges the world is facing, including the farming sector. Although some climatic changes can have a positive impact on European agriculture, most will have a negative impact and will affect regions already suffering from environmental degradation. Extreme weather events throughout Europe have led to fluctuations in the quality and quantity of harvested products. Losses in yield have already reached a level that threatens the existence of Farmers in Europe. They will have to adapt to a changing climate through measures that must be sustainable and go beyond mere adjustments in current agricultural practices. These measures can simultaneously lead to increased effectiveness, lower costs, new market opportunities and better preparation for future legal requirements.

AgriAdapt is a European project funded by the LIFE programme of the European Union. It will demonstrate how sustainable adaptation measures can help livestock, arable and permanent crop farms become more climate resilient. In addition, it will explore how the implementation of sustainable measures can have further positive effects on nature and the environment.

The project partners of AgriAdapt want to achieve transferable and practical results and communicate them to farmers and experts. To this end, information and teaching materials for agricultural education and training will be developed together with experts and specifically passed on to educational institutions and advice centres.

A main element of the project is the knowledge exchange with agricultural practitioners and experts and the presentation of project results. This will be done in the form of workshops, conferences and webinars, in order to involve stakeholders from agricultural associations, agricultural experts, public authorities, the food industry, insurance companies and science. Political representatives at regional, national and European level will also be informed through expert meetings so the project results can be taken into account in political decisions.

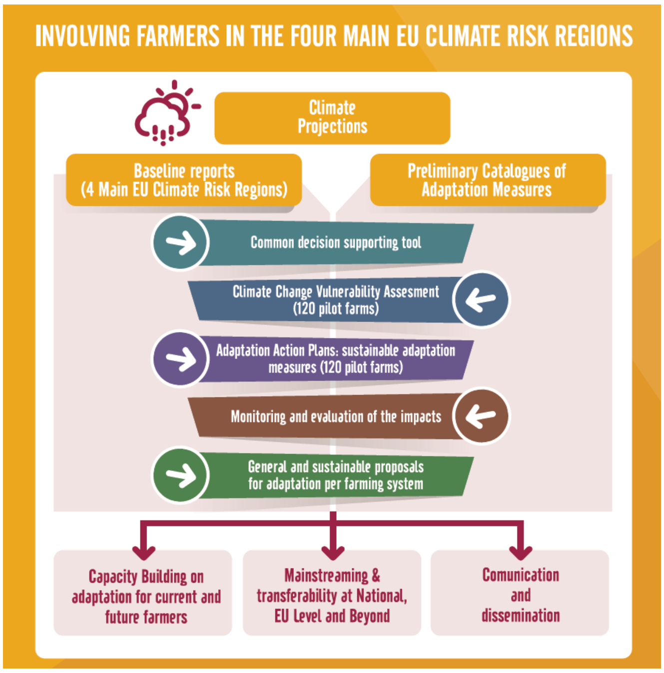

Figure 1: Overview of the project LIFE AgriAdapt

1.2 METHODOLOGY

The project partners have jointly developed a methodology to assess the vulnerability to climate change at farm level, both from an agricultural and an economic point of view. The vulnerability assessment will be conducted in the four main climate risk regions of the EU (Figure 2) on the 3 main farming systems (arable farms, permanent crops and livestock farms).

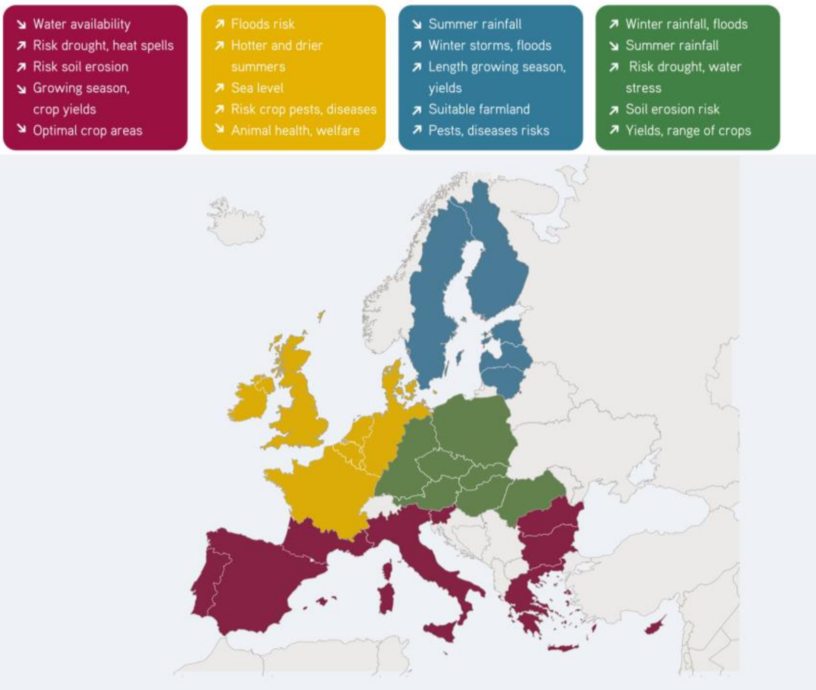

Figure 2: Four climate risk regions in the EU and the risks resulting from climate change in each of them. Red - Southern climate risk region, yellow – atlantic climate risk region, green – continental climate risk region, blue – northern climate risk region

Each of the four project partners, in Spain, France, Germany and Estonia, will assess the vulnerability of 30 pilot farms (EU-wide 120 farms) and develop a farm specific action plan with sustainable adaptation measures. Throughout the project, the action plans will be revised and updated. The results will be summarised according to the feasibility of sustainable adaptation measures. Recommendations of sustainable adaptation measures will then be made for the three main farming systems per climate risk region.

In preparation for the vulnerability assessment, a baseline report was elaborated in which the global climate change and climate change in the four European climate risk regions is described, as well as its effects on agriculture. At the same time, a catalogue of measures was drawn up, listing sustainable adaptation measures for the three farming systems. The sustainability of the measures was assessed by taking its effects on water, air, soil, biodiversity, economy and social aspects into account. Furthermore, in order to assess the impact of climatic indicators on different crops, crop passports were compiled. These describe the sensitive phases of the plants and the critical agro-climatic indicators, which will play an important role during the vulnerability assessment.

The aim of the vulnerability assessment is to sensitise farmers on the topic of climate change and its effects, and to reduce agricultural and economic vulnerability to climate change by recommending sustainable adaptation measures. The vulnerability assessment is conducted on farm level and can be used in the four main climate risk regions of the EU. Following farming systems are assessed:

- Arable farms
- Livestock farms (Beef, dairy cows and pig fattening)
- Permanent crops (apple farms and vineyards)

The vulnerability assessment consists of four steps:

- **Step 1** What is the current farm vulnerability to climate change? (2000-2016)
- **Step 2** What is the farm vulnerability to climate change in the near future? (coming 30 years, without adaptation measures)

- **Step 3** Awareness raising of all possible adaptation options available at farm level
- **Step 4** Elaboration of an action plan for the sustainable adaptation to climate change

The extent of the vulnerability (risk) of a farm combines the probability of the frequency of occurrence of climatic stress (exposure) with the extent of the consequences (impact), such as yield reduction. The vulnerability is represented by a matrix, which combines exposure x impact. The basis for this is the yields of the last 10-15 years, which can either be provided by the farm or otherwise taken from the statistical office for the corresponding district. This yield data is linked to the climatic records of the last 30 years: which were the years with the lowest yields, how often did these years occur? The ACZ tool (AgroClimaticZone), developed by the French partners, brings this data together and can represent over 60 agro-climatic indicators for the past and the near future (e.g. precipitation in July/August, number of hot days >25°C in May/June...).

The source of the meteorological data used in the vulnerability assessment is the data portal Agri4Cast of the European Commission. This is the only, to us known, platform which has homogenous meteorological data for the whole of Europe. For the project we used recorded recent past climatic data and climate projections. The past data is available from 1975 to the last calendar year with a total of 12 climate variables (daily frequency), including the variable of evapotranspiration. Data for the near future (NF) - coming 30 years - is available for climate projections with the SRES scenario A1B and three models. A total of nine climate variables are available for each of these climate models.

During the first pilot farm visit, information such as UAA, cultivated crops, livestock, weather events and its effects on the farm was gathered. Then the vulnerability assessment was conducted. With this assessment, the current and near future vulnerability can be shown for arable crops, livestock and permanent crops. This assessment was shown during the second pilot farm visit, at which possible sustainable adaptation options were discussed with the farmer.

2 Vulnerability Assessment at Farm Level

The 126 pilot farms are distributed over the four climate risk regions, in Spain (Southern region), France (Atlantic region), Germany (Continental region) and Estonia (Northern region). The distribution can be seen in Figure 3.

Figure 3: Distribution of the 126 pilot farms in the project LIFE AgriAdapt

2.1 DESCRIPTION OF PILOT FARMS

The pilot farms are distributed over the farming systems arable farming (57 farms), dairy farms (30), beef cattle (8), pig fattening farms (4), sheep farms (3), processing tomato farms (6), vineyards (10) and orchards (8) (Table 1). In total there are 97 conventional and 29 organic pilot farms, the number of organic farms being around 30 % in each country.

Table 1: Distribution of farming systems of the 126 pilot farms in the four climate risk regions

	Arable	Tomato	Orchard	Vineyard	Dairy	Beef	Pork	Sheep
Southern	6	6	1	7	6	5	-	1
Atlantic	36	-	-	-	7	1	-	-
Continental	12	-	3	3	8	-	4	-
Northern	13	-	4	-	9	2	-	2

The pilot farms in the respective countries were selected in order to depict the variation of farms within each climate zone. This can be seen in the variation of pilot farm size (Table 2) and in the variability of farming practices. The greatest variation in size was in Estonia and Spain, but France and Germany also have pilot farms with big variations in farm size.

Table 2: Pilot farm size in the different project countries, shown in hectare (ha) utilised agricultural area (UAA)

Farm size (ha UAA)	Minimum	Average	Maximum
Southern	1	235	1715
Atlantic	48	164	380
Continental	6	113	322
Northern	10	725	3770

The soil organic matter content of the pilot farms was mostly homogenous per climate zone. The highest number of pilot farms with a low soil organic matter content lie in the Southern climate zone (represented by the pilot farms in Spain and in the South of France). The pilot farms further north tend to have a higher soil organic matter content (Figure 4). The highest number of pilot farms with a high soil organic matter content are in Germany (Continental climate zone) and in the North of France (Atlantic climate zone). Over all the pilot farms, the soil organic matter is stable in most cases. A decrease in soil organic matter content is mainly seen in the Southern climate zone (France and Spain), with about 15 pilot farms reporting a decrease.

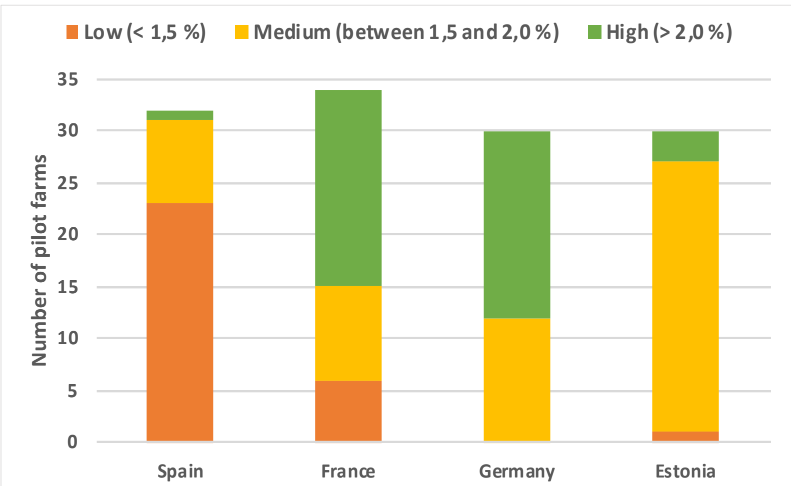

Figure 4: Soil organic matter content (in %) of the pilot farms in Spain, France, Germany and Estonia.

2.1.1 Cereal crop farms

Table 3 shows the variation in pilot farm size of the cereal crop farms. The average size of pilot cereal farms increases from South to North, the largest cereal farms lying in Estonia. Although the cereal farm sizes are much larger in Estonia, the crop diversity on farm is not much higher than in Germany or France (Figure 5Figure 5) and the genetic diversity is lower (Figure 6). Figure 6 shows the number of hectares per variety cultivated – the higher the number the lower the genetic diversity on farm. The number of hectares per variety is higher in Estonia, probably due to the larger farm size. In Spain, France and Germany, the genetic diversity is more similar, being the highest in Spain.

Table 3: Farm size of cereal pilot farms. Area show in ha UAA.

Farm size (ha UAA)	Minimum	Average	Maximum
Southern (n = 6)	11	146	400
Atlantic (n=26)	76	160	380
Continental (n=12)	31	185	527
Northern (n=13)	65	1026	3770

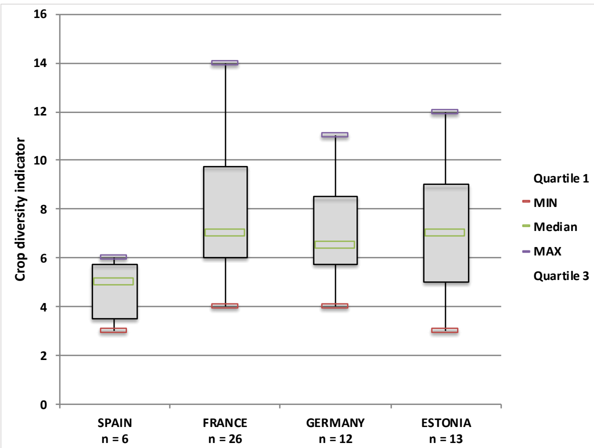

Figure 5: Crop diversity on farm. Amount of different crops on farm

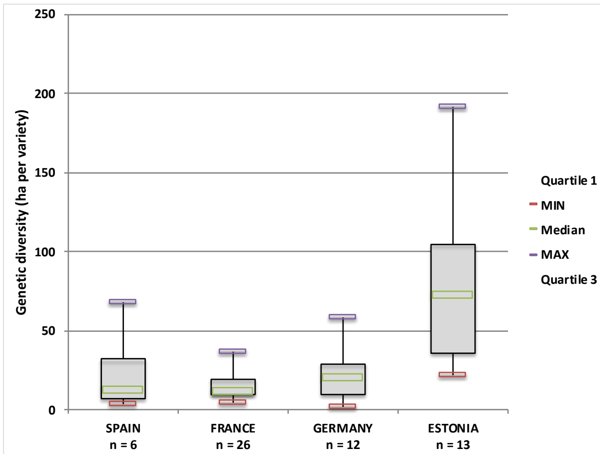

Figure 6: Genetic diversity on farm. Amount of hectares per crop variety

2.1.2 Dairy farms

The dairy pilot farms show a variation in herd size not only between the countries but also within the pilot farms of one country (Table 4).

Table 4: Number of dairy cows on the dairy pilot farms.

Number of dairy cows	Minimum	Average	Maximum
Southern (n = 6)	87	156	230
Atlantic (n=7)	32	94	240
Continental (n=8)	74	117	250
Northern (n=9)	65	448	1819

The average milk production on the pilot farms varies between 10000 litres/cow/year (Spain) and around 7,000 litres/cow/year (France) (Figure 7). The pilot farms across the different climate zones therefore cover a range of production intensities.
The median fodder autonomy is on most pilot farms at 100 %, except in the dairy farms in Spain (Southern climate zone). Here the variation in fodder autonomy is largest as well, followed by the dairy farms in France in the Southern climate zone (Figure 8).

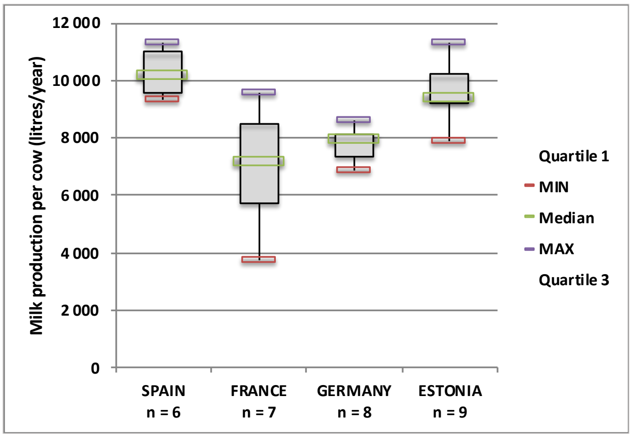

Figure 7: Average milk production (litres/cow/year) on the dairy pilot farms.

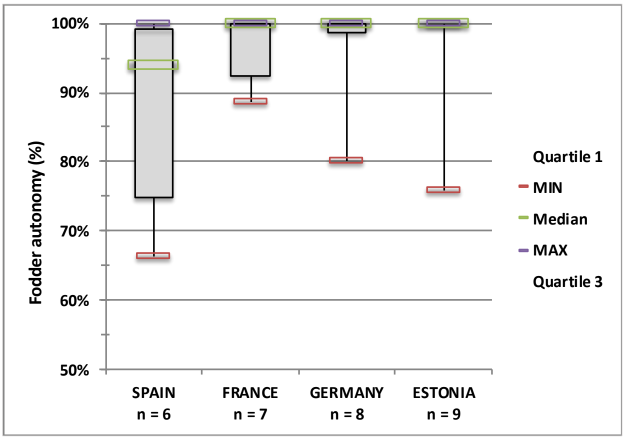

Figure 8: Fodder autonomy (%) on the different pilot farms

The thermal comfort of the dairy cows is overall highest on the pilot farms in Germany (Continental climate region). The countries more to the South have more problems when dealing with the thermal comfort in buildings and on pastures. In Estonia, four of the nine pilot farms have a high thermal comfort in buildings (Figure 9). Heat waves not only reduce thermal comfort of the dairy cows but also lead to a reduction in milk production, the pilot farmers over all countries classified the percentage of milk loss during heat periods between 10 – 20 %.

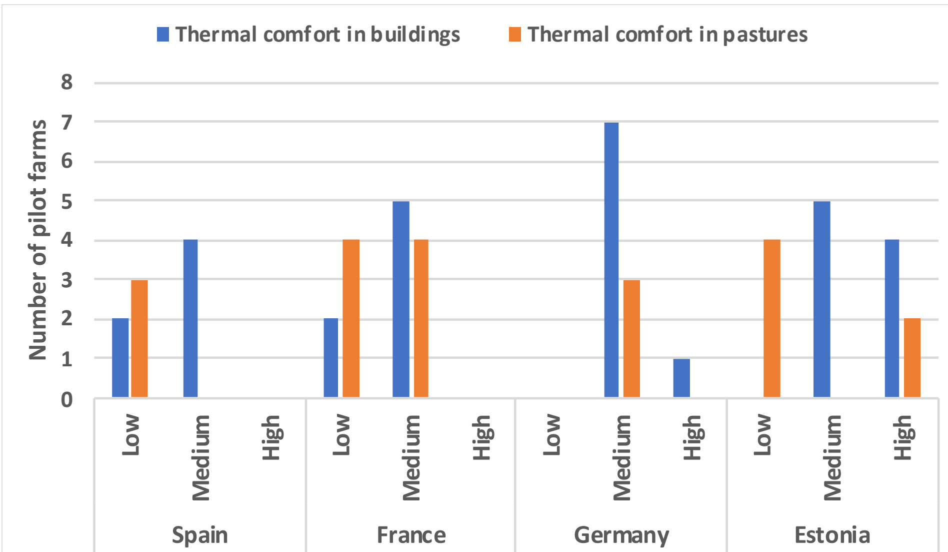

Figure 9: Thermal comfort of dairy cows on the pilot farms in buildings and on pastures

2.2 CLIMATE OBSERVATIONS

To illustrate the climate observations in the project countries of the different climate zones, representative points were taken, seen in Figure 10. The data for the climate observations was taken, like the climate data for the vulnerability assessment, from the platform Agri4Cast.

Figure 10: Transect from southern to northern Europe (red dots) to illustrate the climate observations in the four different climate zones

The observed climate data taken, is the data from the past 30 years (1987 – 2016). The average temperature decreases, as expected, from South to North within a climate zone and throughout the countries (Figure 11). The same trend is seen with the number of days > 25°C (Figure 12).

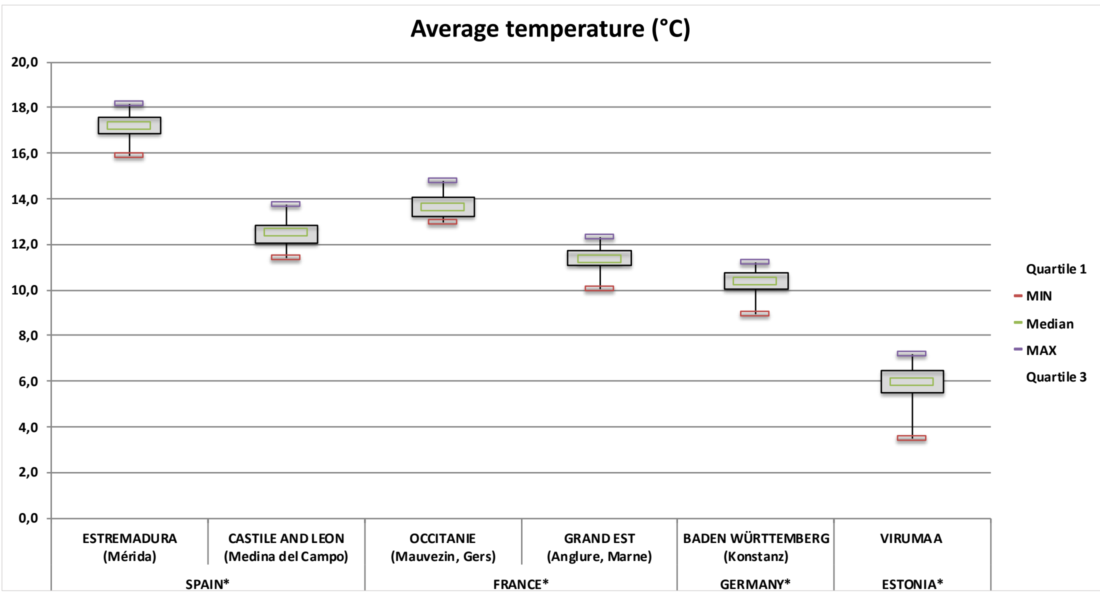

Figure 11: Observed average temperature for grid cells (25 x 25 km) in six different representative regions (Agri4Cast)

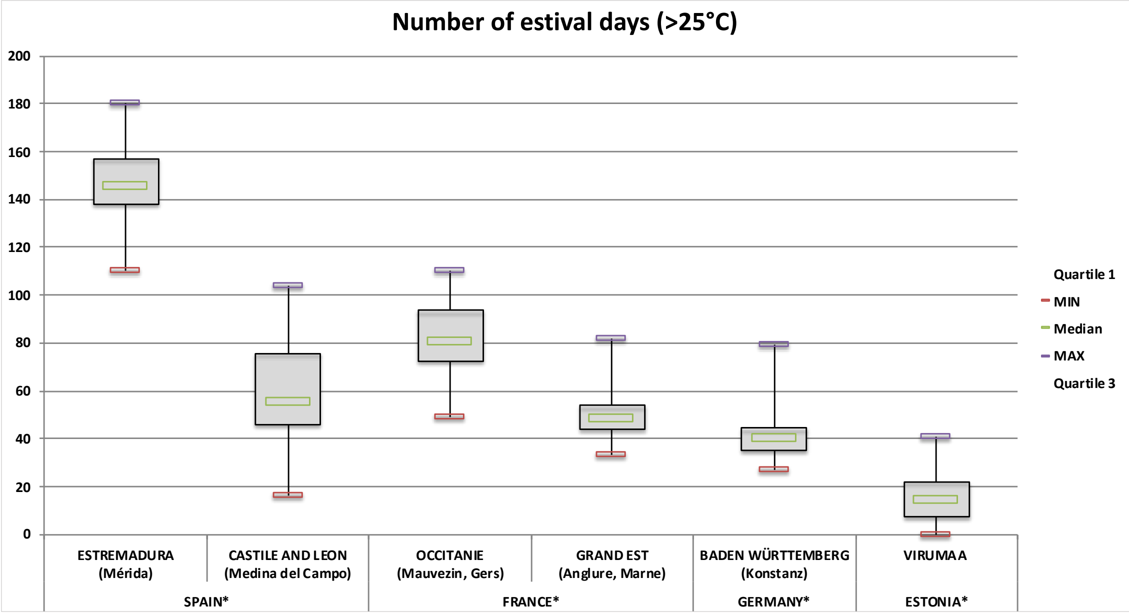

Figure 12: Observed number of days > 25°C per year, for grid cells (25 x 25 km) in six different representative regions (Agri4Cast).

2.2.1 Climate events at farm level

The most relevant climate events for the pilot farms over all climate zones are hail events and high temperatures. Hail is mainly problematic for permanent crop farms. High temperatures are a problem for all pilot farms, especially in Spain and France, but occurring more often in Germany and Estonia. Drought problems are increasing in frequency in Spain and France. In Germany early summer drought is becoming an increasing problem. Estonia is the country with the lowest frequency of occurrence of drought (27%) (Table 5).

Table 5: Frequency and impact of selected climate events on pilot farms in the Southern, Atlantic, Continental and Northern climate zones

Climate event	Southern	Atlantic	Continental	Northern
Hail	Regular for 75% of cereal farms, but impacts very variable (5%-50% yield reduction) Most problematic for permanent crops	80% of farms concerned but regular only for 25 %. Impacts very variable (5% to 100% yield reduction)	60 % of the farms concerned, mostly frequency of 10 %. Impacts very variable (10 – 80%)	Frequency (0-50%) and impact very variable (2-60%)
Intense/late frost	Regular for 75% of the cereal farms, impacts very variable (30%-70%) Permanent crops: lower frequency - variable impact	93% of the farms concerned. Low frequency but significant impacts.	23 % of the farms concerned. Low frequency but especially damaging for permanent crop farms	Low frequency 30% on average and variable impact (5-100%). On average 29%
Drought	More frequent and potential significant impacts (20-100%). Most limiting climate factor for permanent crops & dehesa	60% of the farms concerned. More frequent and potential significant impacts.	Early summer drought increasing problem: frequencies of 40 – 50%. 50 % of farms concerned with drought in general	Frequency not very high, on average 27%. Impact variable (5-35%), but on average 10%.

High temperatures	High frequency. Significant impacts for animals, permanent crops and tomatoes.	78% of the farms concerned. More frequent but punctual impacts.	Only 20 % stated as a concern, but in reality nearly 100 % concerned. Frequencies of 40 %.	Frequency on average of 17% (10-20%). Impacts till now not very high (10-30%).
Storm & intense rainfall	Arable crops: storms in June and July, led to impacts between 5-30% Tomatoes: high precipitation in April and May a problem.	North of France: intense rainfall in 2016, led to yield decreases of -50% South of France: wind that strengthens drought impact	Wet springs are especially a concern for maize. Winterkill was a problem in 2012 for cereal farms	Lack of sunshine and wind damage are a problem, with a frequency of 15%, but with low impacts.

2.3 CLIMATE PROJECTIONS

To illustrate the effects of climate change on agriculture in the different climate zones, the same representative points were selected as for the climate observations. The data for the climate projections was the same data that was used for the vulnerability assessment on the pilot farms (SRES scenario A1B). For the assessment, only one climate model was used in order to show the pilot farmers the impacts of climate change in a simplified way. It is clear that this is just one illustration of the future projections. We are aware of the limitations of only using one climate model. The model used is the warmest and driest out of the models available on Agri4Cast, compared to the RCP scenarios however, the used model represents a very moderate climate change.
Following figures illustrate changes for relevant agricultural indicators from the recent past (RP) to the near future (NF). The RP being the years 1987 – 2016 and the NF the years 2017 – 2046. In order to compare the RP with the NF, the RP is not the observed climatic data but modelled data with the same assumptions as the model for the NF.

2.3.1 Cereal crops

According to the model used, the days > 25°C will increase by around 10 days in all regions in the NF, except in the region of Tartumaa (Estonia) (Figure 13). This will increase the vulnerability of cereal crops in northern and temperate regions as temperatures > 25°C during the flowering or grain-filing phase of cereal crops can lead to lower yields (grain shriveling). For the southern regions, the temperature threshold lies at 30 °C for cereal crops.
The overall average annual water balance in the period May to August will decrease significantly in all regions in the NF, except in the region of Tartumaa, in which there is a slight increase for this period (Figure 14).

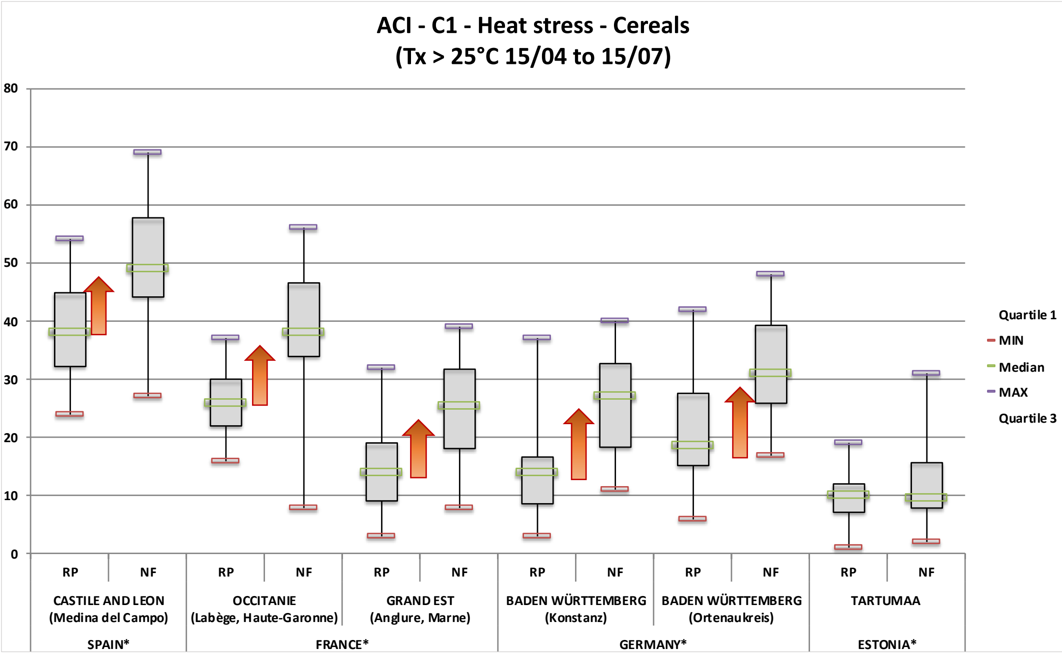

Figure 13: Development of days > 25°C in the period 15.04 – 15.07 from the RP to the NF. Relevant indicator for cereal crops (Agri4Cast)

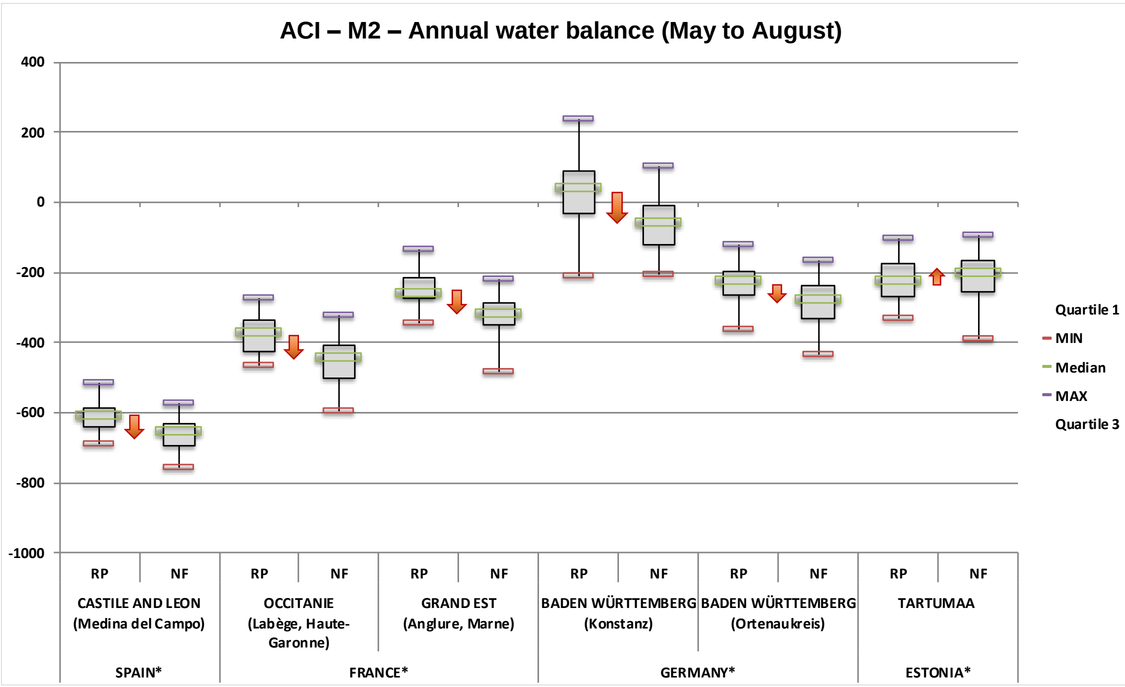

Figure 14: Development of average annual water balance from May-August from the RP to the NF. Relevant indicator for cereal crops (Agri4Cast)

2.3.2 Livestock farms

For livestock farms, a relevant indicator for cattle (both dairy cows and meat cows) is the Temperature-Humidity-Index (THI), which assesses the risk of heat stress. For the pilot farms with cattle, the amount of days with a stress factor of 73 – 80 (moderate to severe stress) was calculated. Figure 15 shows the development of the different stress thresholds. The stress for cattle will increase in all regions, but the most in Spain and the South of France.

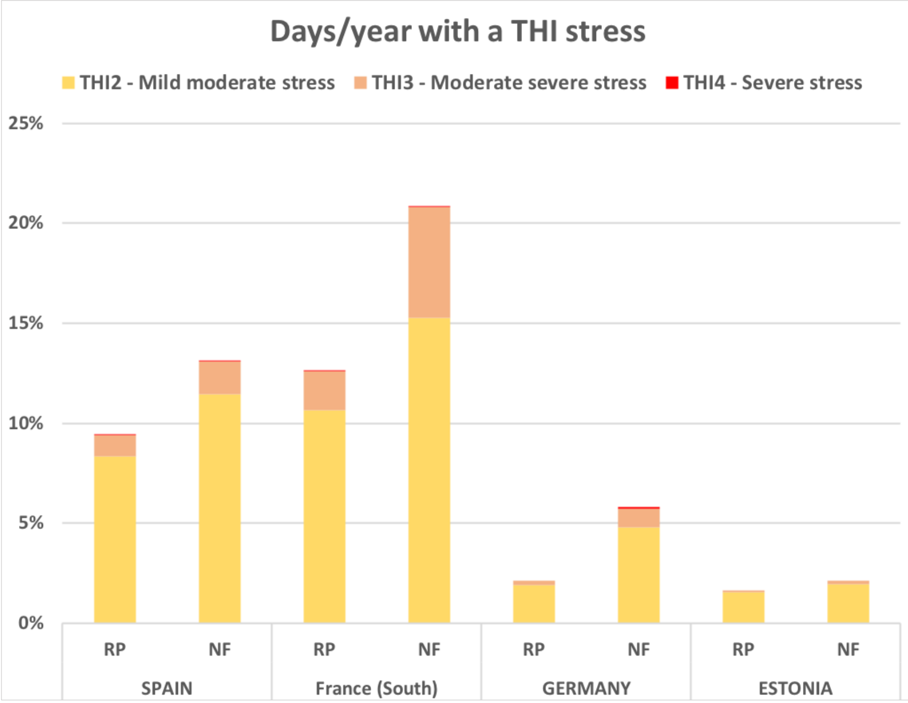

Figure 15: Number of days with different stress thresholds for cattle. Mild – moderate stress (68 - 70), moderate to severe stress (73 – 80), severe stress (80 – 89). (Agri4Cast)

With moderate to severe stress, the respiration and heart rate increase, there is a small reduction in milk production and fertility and the fodder consumption decreases.

2.3.3 Permanent crop farms

For permanent crops, especially vines, the cool night index is an important factor during the ripening of the grapes. Minimum night temperatures need to be reached in order to develop a good quality of the wine. Figure 16 shows the development of the minimum night temperature in September. There is an increase of night temperatures in all regions, especially in the South of Spain and France (region of Valencia and Occitanie). This may lead to the cultivation of other grapes varieties.

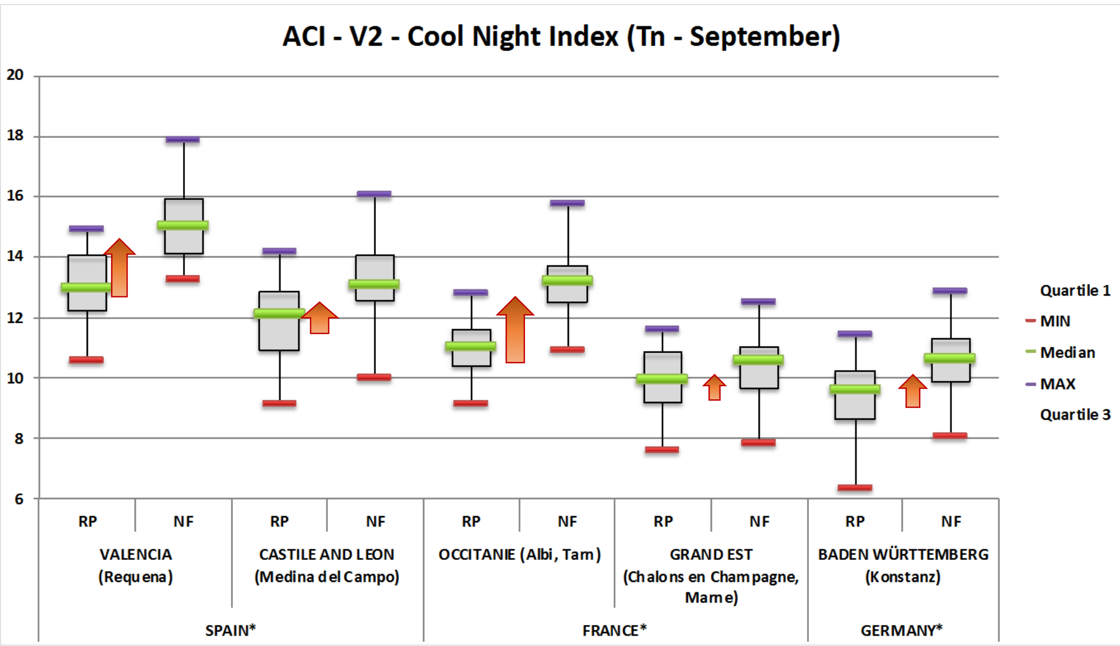

Figure 16: Cool night index. Development of minimum night temperature in September (Agri4Cast)

2.4 PILOT FARM SWOT ANALYSIS AND SUSTAINABLE ADAPTATION MEASURES

The following SWOT analysis shows the differences between the 126 pilot farms in the different climate risk regions.

	Strengths	Weaknesses
Southern	• Agricultural insurance • Varieties well adapted to climate change • Farming systems with diverse crops, extensive agroforestry systems	• Increasing dependence on monocultures • Insufficient management of grasslands
Atlantic	• Diversified cropping systems • Good fodder management • Irrigation	• Inadequate crops cultivated and/or low genetic diversity • Irrigation dependent on restrictions • Insufficient thermal comfort for animals
Continental	• Use of catch crops before spring crops • Income from various pillars • High fodder autonomy of dairy farms	• High share of one specific crop • Inadequate use of plough as main soil tillage management • Only 3 crops in crop rotation (especially dairy farms)
Northern	• High crop diversity and suitable soils for permanent crops • Range of varieties grown • High fodder autonomy	• No irrigation used in permanent crops • Availability of suitable fallow fields for arable farms low • Poor soil drainage on livestock farms
	Opportunities	**Threats**
Southern	• Higher productivity in temperature-limited areas if water is ensured • Increased pasture production in autumn/winter due to increased temperature • Possibility for new crops through warmer winters	• Increase in heat waves in spring & summer: increase in yield variations and heat stress for animals • Less rainfall in winter-spring • Increase of hydric deficit in spring and summer
Atlantic	• Better climatic conditions in autumn • Significant decline of the number of frost days/year • Possibility for new crops through the increase in GDD	• Increase in yield variations due to climate stress in May/June • Increase of hydric deficit in spring and summer • Increase in heat stress for animals
Continental	• Opportunity for new crops or varieties • Longer vegetation period positive for grassland & tuber crops • Reduction of moisture loving pathogens	• Higher variability in yields • Increase in heat stress for dairy cows • Risk of more and new pests/diseases/weeds due to higher temperatures & longer vegetation period
Northern	• Longer growing period, potential increase of yields and quality • Diversity of crops and varieties increased • Need of energy for heating livestock buildings is reduced	• More climatic extremes expected, higher risk for permanent crops • Increasing risk of new pests and diseases with new cultivars • Lower performance of livestock due to heat stress, especially outdoors

Although the SWOT analysis showed differences in the four climate risk regions, sustainable adaptation options were very similar in all the climate risk regions. This demonstrates that there is the possibility of suggesting certain adaptation measures that can be implemented over the whole of Europe.

For arable farming the focus of the sustainable adaptation options is on the improvement of soil structure and fertility. With improved soil fertility, water can be taken up more easily and stored for a longer period of time. Sustainable adaptation measures recommended in all climate risk regions are:

- Wider crop rotations and higher crop diversification
- Use of catch crops, cover crops and undersowing to reduce the amount of bare soil
- Cultivation of new crops for the region (e.g. soy, sunflower)
- Efficient irrigation systems or substitution of irrigated crops

For permanent crops sustainable adaptation options recommended in all regions are:

- Improvement of soils through biodiverse ground covers
- Use of adapted varieties
- Focus on quality and not quantity (especially in wine production)
- Prune in green to balance leaf surface and number of bunches (Vineyards)
- Hail and frost protection (mainly for central and Northern Europe)

Sustainable adaptation options for livestock farms focus mainly on the reduction of heat stress:

- Appropriate density of animals in buildings
- Improved cooling systems (open barns with passive ventilation, installation of ventilators, shelter for animals outdoors, shading of barns)
- Increase fodder storing capacity
- Increase fodder autonomy and diversification
- High number of drinking troughs
- Grazing management plans to increase quantity and quality of pasture in extensive livestock systems

3 How to Integrate Sustainable Adaptation Measures into Political Decisions/Policies?

The past two years have shown very clearly which adverse effects climate change can have on European agriculture. Especially the summer of 2018, with extremely warm temperatures and little to no precipitation in Central and Northern Europe. Extreme weather conditions have caused crop losses throughout Europe. The existence of thousands of farms has been extremely threatened. Due to yield losses and crop failures, retail businesses had problems with their supplies and the usual quality of the agricultural products. European farms will have to adapt to a changing climate through measures that must be sustainable and go beyond mere adjustments in current agricultural practices.

EU-wide mandatory sustainable adaptation actions to improve soil fertility

Although 40 % of the overall budget of the future CAP will contribute to climate action, some measures for climate mitigation and adaptation need to be made mandatory at EU level. The future CAP foresees a greater subsidiarity of Member States. Each Member State can decide which measures will be most effective in their country. This is certainly beneficial in some cases, but when dealing with climate change, we have seen in our project that certain sustainable adaptation options can be recommended in all climate risk regions. These are measures which underline the good agricultural practice and spread the risk on farms, the main element being the improvement of soil fertility and structure.

Crop diversification as important as crop rotation

Crop diversification is as important as crop rotation. Although crop diversification is mandatory under greening, the diversification is not enough. The requirement of farms with up to 30 ha only needing a minimum of two crops and the main crop covering up to 75 % of the land, does not spread the risk of the farm enough. Through our work on the pilot farms, we have seen that a practicable adaptation measure is a further diversification of crops.

- At least 3 crops in the rotation (farms < 30 ha), at least 4 crops in the rotation (farms > 30 ha)

Reduction of bare soil

The reduction of the amount of bare soil is a further adaptation measures that is not difficult to implement. Bare soil can be reduced through the use of catch crops in arable farming or the use of green covers for permanent crop farms. Both these measures reduce soil erosion, increase the organic matter content of the soil and increase the water storing capacity (positive in droughts and heavy precipitation events).

- Use of catch crops to reduce the amount of bare soil
- Green covers in permanent crops

Better thermal comfort for animals
For livestock farms, the main adaptation measures is increasing the thermal comfort of the animals. This can be achieved through the installation of cooling systems, sprinklers and by decreasing the animal density in buildings.

- Well ventilated barns

Link sustainable climate adaptation to mitigation and biodiversity
All these adaptation measures have environmental synergies, such as promoting biodiversity and mitigating climate change. There should therefore be a stronger link between, for example, measures for promoting biodiversity on farm level and measures to adapt to climate change. Although greening has not been a very effective measure to increase the biodiversity at farm level, some of the measures (e.g. catch crops or the cultivation of protein crops) are effective measures for adapting to climate change.

Farmers need adaptation support from the training, food business, insurance and policy sector
At the current stage of the project, it seems important that the farms are sensitised about the topic of climate change and supported in their efforts to adapt. The extreme weather events of 2017 (droughts in southern Europe and late frost in April in central Europe) and 2018 (lack of precipitation and drought from April to August in central and northern Europe) greatly increased the awareness of farmers and they therefore are more open to adopt further measures and strategies for adapting to climate change. Implementing further sustainable adaptation options will also require the involvement of the whole agricultural sector such as training institutions, the processing and food industry, insurance companies and the political level.

During 2019, the last year of the project, the pilot farms will be visited and the sustainable adaptation options will be further discussed with the farmers to agree on a set of adaptation measures that are necessary to become more resilient. Events for the dissemination of the project and sensitisation on the topic will be conducted on national and EU level. These dissemination actions target a wide audience: farmers and farmers associations, as well as the stakeholders in the food industry and in politics.

4 Summary

Climate change is one of the greatest environmental, social and economic challenges of our time and agriculture is one of the most affected economic sectors. By the end of the century, it is predicted that climate change will mainly have negative effects on agriculture, exacerbating existing environmental problems (soil erosion, pest pressure etc.) and threatening the quality and quantity of yields. It is therefore important that the agriculture in the EU adapts to this changing climate in a sustainable way. Let´s use climate change as a lever for a more sustainable agriculture.

With the LIFE AgriAdapt project, the project partners illustrate the state of agriculture in Europe in terms of current vulnerability to the effects of climate change, how the climate will develop over the next 30 years, and how farms can reduce their future vulnerability through sustainable adaptation measures.

To this end, a vulnerability assessment has been developed and is conducted on 120 pilot farms (30 farms in each of the four EU climate risk regions). With the help of a SWOT analysis, the current state and possible developments on the pilot farms can be discussed. A catalogue of sustainable adaptation measures for each of the three main farming systems (arable, livestock and permanent crops) enables farmers to reduce their vulnerability in the near future.

The most relevant climate events for the pilot farms over all climate zones are hail events and high temperatures. Hail is mainly problematic for permanent crop farms. High temperatures are a problem for all pilot farms, with drought increasing in frequency. In the near future, the days over 25°C in May-June will increase, as well as the number of days with heat stress for cattle and the minimum night temperature. Through our analysis on the pilot farms we have identified several sustainable adaptation measures that are applicable to farms in all climate risk regions. These are measures for reducing the amount of bare soil, increasing the on-farm biodiversity by increasing the crop diversification and rotation and measures for increasing the thermal comfort of livestock.

Agri Adapt