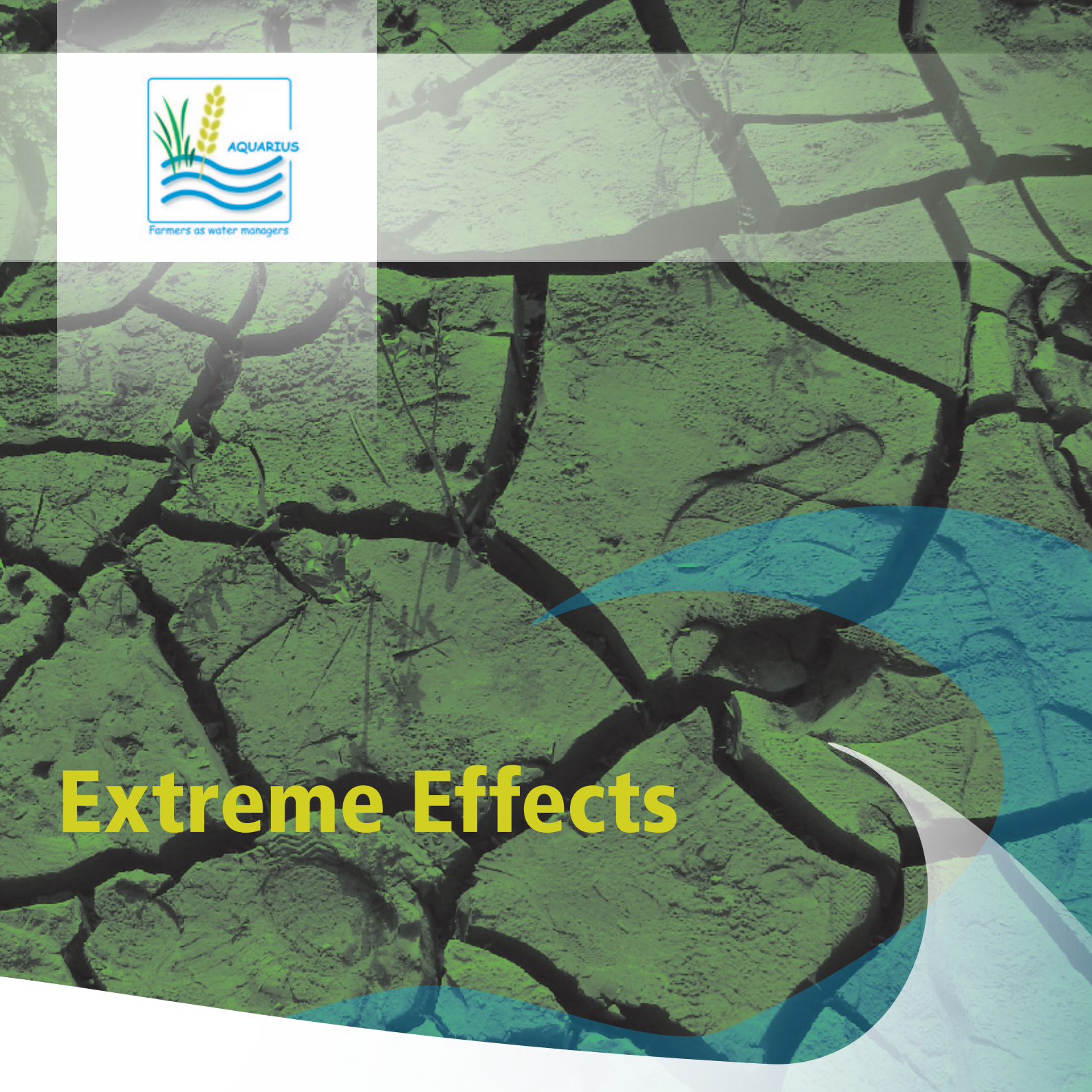

AQUARIUS
Farmers as water managers
Extreme Effects

Summary of the Phase 2 Report:
The influence of climate-related extremes on the agricultural sector and the exploration of adaptive measures

Climate and Agriculture in the North of the Netherlands

Contents

1 Introduction

1.1 Background

In 2004 the research programme 'Climate changes Spatial Planning' was initiated. Aim of this programme is to strengthen the Dutch knowledge infrastructure by increasing insights into the relationship between climate change and land use, transferring scientific knowledge to target groups in society and transferring practical know-how to scientific target groups. Within the scope of this programme the practise-based project 'Climate and Agriculture in the North of the Netherlands' officially started in 2007.

Agriculture is an important pillar of socio-economic prosperity in the North of the Netherlands. Climate change can have an enormous impact on the farming community, not only as a result of the changing conditions but also with regard to diseases and plagues, the demand for alternative crops (e.g. for bio-energy), and the risks for farm management.

There is every reason, therefore, to take a close look at the possible effects of climate change and adaptive measures. The project 'Climate and Agriculture in the North of the Netherlands' is being implemented in three phases.

The results of phase 1 have been documented. Wageningen University and Research Centre carried out preliminary studies on the impacts of a shifting market and climate change in the European agricultural sector up to 2050. Using two climate-market scenarios and three different crops, researchers investigated which European regions had good farming perspectives for the future. Results indicated that agriculture in the North Netherlands region could adapt to the changing situation.

The second phase involved studies on the impact of extreme climatic conditions on various crops and farm animals in the North of the Netherlands (Wageningen UR) and possible measures for adaptation (Grontmij). In previous publications the most important outcomes have been summarized.

The main aim in phase 3 is to formulate adaptive strategies for each area. For this purpose the North of the Netherlands has been divided into eight 'uniform cultivation areas'. A descriptive profile was written for each of these areas so that all relevant information can be combined per area.

All three phases have been carried out in close cooperation with those working in the practical field and interim results are checked against actual situations.

2 Main Theme

Before we present the work methods and the most notable outcomes of phase 2 it is necessary to explain the main theme of this phase. Phase 2 has been focussed on a large number of crops commonly grown in the North of the Netherlands. Besides this we have taken a look at some new crops and the situation in dairy farming. The results are very diverse. Extreme weather conditions in relation to each crop were studied – these extremes are different per crop. Then, a series of measures were sought for the various extremes and crops so that cultivation and production can be adapted. The results, although varied, give a good indication of what the situation is and what can be done about it.

It seems that not only heat, drought and flooding cause damage, but also that warmer winters and periods of warm humid weather in the summer months are an equally important issue. There are great differences, depending on the crop. The following crops, studied in relation to extreme climate conditions, are described in the report, together with possible measures to be taken.

Current crops
Seed-potatoes
Grass
Winter corn
Starch potatoes
Onions
Winter carrots
Sugar beets
Lilies

Bio-energy crops
Willow
Rape

Alternative crops
Sunflowers
Artichokes
Grapes
Cherries

Greenhouse crops
Tomatoes

Produce
Dairy cows
Free-range pigs

2.1 Most notable results

Most crops are influenced by climate change and the associated extremes in weather. Not all of the outcomes are negative - there are positive results as well. The most obvious weather extremes are that there are fewer periods of continuous rainfall and less night frosts. Continuous rainfall has been defined as a period of 21 days with at least 16 days of more than 0.5 mm of rain. If these periods occur less frequently the land is easier to toil and work on. With regards to night frost, just one extra night with more than 2 degrees frost can be enough to damage crops. Thus, a less frequent occurrence of night frost will result in less damage.

There are some weather extremes that require timely adaptive measures because they have a negative effect on cultivation or crops. Heat waves and heavy rainfall are the most frequent extremes. Heat waves can lead to drought while heavy rainfall means that crops are submerged under water, causing rot. For both extremes the solution may be found in water management.

There is an increased risk of diseases and plagues as a result of the changing climate. Winters are less severe and the combination of higher temperatures and humidity mean that diseases survive the winter and can arise in the following cultivation cycle.

Fortunately many problems can be avoided if there is good farm management. Of course this does entail being able to anticipate. For example, it is worth considering the possibility of sowing potatoes in broader ridges, just as this is done in Mexico. Grass can be sown using a more heat resistant seed mix. When building new barns and cattle sheds one should make allowances for climate- regulatory measures – this is already happening on an increasing scale.

Another way of anticipating is to change over to different crops. A number of crops have been studied with this in mind. The artichoke and sunflower are good alternatives for winter carrots and onions, for example, because of their salient tolerance and drought resistance.

The following chapters will deal with work methods and notable issues per crop.

3 Approach

Phase 2 of the project 'Climate and Agriculture in the North of the Netherlands' can be described in four important steps. The first step is the selection of climatic factors. This involves defining the relevant climate extremes per crop or cultivation. The second step is aimed at determining the frequency of these extremes and the expected changes in the future. The G+ and W+ scenarios have been used to this purpose. On the basis of steps 1 and 2 it is determined which problems, damage and opportunities per crop/cultivation are observed. The fourth and last step determines and describes adaptive measures.

Practical tests

During the entire process there was constant interaction with the work field. At both bilateral and sectoral meetings the draft results have been explored and discussed together with the farmers.

Steps taken

The following four steps were taken:

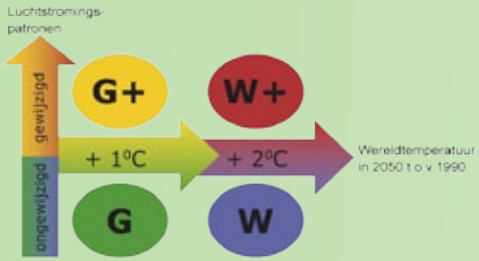
1. Determine relevant climate factors
2. Determination of climate extremes and frequency
3. Determination of problems, damage and opportunities
4. Determination of possible adaptive measures

Determination of relevant climate factors

Every plant and animal has its own sensitivities and ideal conditions – a combination determined by climate and soil. It is also true to say that the threshold values at which damage or weakness occurs are specifically related to each crop or animal. Allowances have also been made for the different growing phases of each crop – seedlings obviously have a different threshold than mature or ripened crops. Based on literature, expertise and practical experience the various growth stages and critical climate factors for each crop were identified. An estimate was made of the possible damage and this is expressed in percentage of reduced yield or diminished quality.

Determination of climate extremes and frequency

The climate in the Netherlands is changing. How it is changing is influenced by global warming and alterations in air stream patterns and the related winds in our vicinity (West Europe). These two aspects have been visualized in the following diagram. (G+ = Gradual, W+ is Warm). This



G	Gematigd	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
G+	Gematigd +	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind
W	Warm	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
W+	Warm +	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind

research project focuses on the changes in weather extremes and is based on the G+ and W+ scenario. The choice for this scenario relates to previous studies and phase 1 of our research.

Determination of problems, damage and opportunities

Effects on crops and cultivation of the various climate extremes have been determined per crop. This was done on the basis of expert judgement and input from the farming sector. By determining the average potential damage per incident it is possible to visualize failure costs. Particular attention was paid to the changing frequency: the more frequent a heat wave the more often this will lead to damage and losses. This is the point at which one must reconsider investments.

Depending on the damage measures will need to be taken. In order to select the greatest climate-risk factors for a time span up to 2040, the average annual economic damage resulting from these factors is calculated over a period of 30 years. If the average economic losses resulting from climatic impacts results in at least 10% of the annual economic gains then the impact is indicated as a risk.

Determination of possible measures

Adaptive measures are activities undertaken to contradict the negative effects of a climate-related impact. During this fourth step these measures were investigated on the basis of literature, interviews with experts and personal insights. An inventory was made of the measures that could prevent the effects of a climate factor (for example, covering crops during rainy periods) and measures that can limit the damaging effects of a climate factor (for example, improving the permeability of the soil).

An overview was made of measures that can be taken against general climate extremes such as drought, heavy rainfall, frost, wind and hail. A supplementary list was made, zooming in specifically on the relevant climate factors for the various crops and the corresponding impact. While creating this list of measures allowances were made for the 'level' of implementation or development. The following levels have been differentiated:

- Crop level: measures the farmer himself can take and that are specifically aimed at the crop (e.g. combating a disease that poses a danger for a specific crop).
- Farm level: measures the farmer can take that not only influence the crop but also influence other elements in the farming system (e.g. crop rotation).
- Regional level: measures that are implemented on a regional scale (e.g. by the water authorities, provincial administration), including adjustments in the water system.
- Sector level: measures taken by the whole sector – these must be guided and developed (e.g. development of resistant crops and technological development).

4 Notable issues per crop

The research results of the fifteen different crops in this study have been put together in this report following an established line. This chapter deals with the most notable issues for each crop, taking into account only the changes in frequency and intensity of relevant climate factors. The present day situation is used as reference. Based on the identification and quantification of these climate factors, the damage and potential adaptive measures, notable points have been made on each crop with time windows for 2040 and 2100.

Current cultivation

Winter grain

Possible climate risks for the cultivation of winter grain include long periods of drought in the summer months and changeable weather in the winter. Certain measures can be taken to limit or prevent the damage to yields. The negative effects of unsteady weather on yields are probably not that great. Yellow rust and other 'yellowing' diseases may form a bigger problem and this needs attention. Continuous wet weather is less likely in the future which means that access to the land during the harvest period (July- August) will probably improve.

Potatoes for consumption and starch potatoes

There are a few climate factors that could form a risk for the production of the different potato sorts. An increase in periods of heavy rainfall is limited and actual measures may not be necessary. The farmer can take measures to control the impact of heat waves and for storage. If farmers need to cool the potatoes with sprinkle-irrigation during a heat wave, then certain adaptive measures will probably be required in the regional water system.

Blackleg and tuber soft rot diseases (Erwinia) are likely to become a problem as there are no measures for cultivators. More research is required to be done into (biological) fungicides and/or resistant races. Lice, eelworms and the Colorado beetle also form a threat, and potato storage also needs attention. The climatic conditions for development of potato blight, (prolonged wet weather) occur less frequently and this means that control of the disease can be improved. Problems with wet fields and accessibility appear to have decreased slightly. This could mean that it becomes easier to decide when best to drive on the fields.

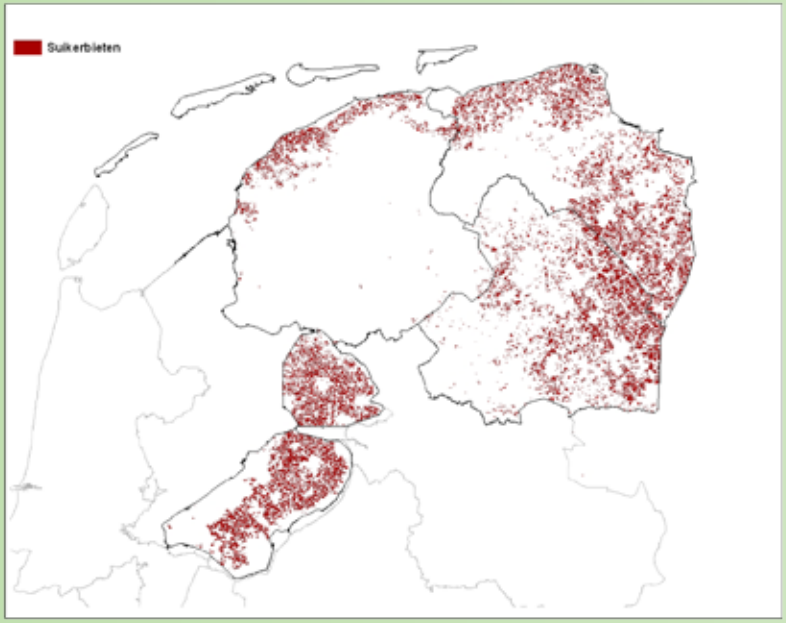
Seed potatoes

An increase in the incidents of heavy rainfall is somewhat limited and the question is if measures need to be taken. Farmers can take certain measures to limit the impact of heat waves and potato storage. If farmers need to cool the potatoes with sprinkle-irrigation during a heat wave, then certain adaptive measures will probably be required in the regional water system.

Sugar beets

Continuous warm weather in the winter period forms a possible risk factor for the cultivation of sugar beets. There are various measures which can be taken to prevent or limit the negative effects (such as a decrease in sugar content). As a result of climate change certain factors will change for the better for this crop. Extra attention may be required for the beet eelworm (Heterodera) and Cercospora leaf spot, as well as the possibility of 'new' diseases and plagues.

Unstable, wet weather conditions in September seem to be on the decrease which means sugar content could increase slightly. Rhizomania may become less of a threat. Night frosts occur less



Areaal in 2008[8]

- Noord-Nederland: 32.023 ha
- Groningen: 9.764 ha
- Friesland: 2.614 ha
- Drenthe: 10.267 ha
- Flevoland: 9.378 ha

Gewaskenmerken

- Inzaai: februari - april
- Oogst: september – november
- Indicatieve opbrengst[3]:
  - Oogst: 65.000 kg/ha
  - Prijs: €0.35 per kg
  - Bedrag: €2.275 per ha
  - Suiker (16,4%): €100 per ha

Verspreidingsgebied suikerbietenteelt in de Noord-Nederland en enkele teeltkenmerken

frequently and this is favourable for the young beet plants.

A positive effect of climate change is that winters are generally warmer which means that the crop can be sown earlier, resulting in bigger yields. One must still be aware of the chances of night frost.

Seed onions

The possible climate risks for seed onions are drought in spring and summer, and warm, humid conditions during the summer period (more chance of fungus). There are known measures to prevent or limit the damage. Drought poses the greater problem and may require adaptation of the regional water system. The sector may also need to develop drought and disease-resistant races. Broad crop rotation is also necessary for disease control.

Autumn conditions may be more favourable in the future – no flooded fields - so that harvesting and storage are less problematic.

Winter carrots

Generally speaking the conditions for winter carrots will hardly change in the future. Possible risks for the crop remain drought in the growing season and heavy rainfall resulting in flooding. The crop can be irrigated during dry periods but the future of the winter carrot will depend, to a degree, on the frequency of drought periods in combination with the amount of water reserves needed for sprinkle-irrigation. Flooded fields are likely to remain a problem as there are limited possibilities for adaptation measures and the effects of such measures are inadequate. The chances of night frost in May are likely to

disappear which means this climate factor is less of a threat in the future.

Lilies

Possible climate risk-factors for the cultivation of lilies include heavy rainfall, hail and wet, humid summer weather. The latter increase the chances of Botrytis and Fusarium. In 2040 the occurrence of climate extremes will not be that much more in comparison to the current situation but these extremes could cause a lot of damage. Combating Botrytis and Fusarium are a priority at the moment since there are no adequate measures at the moment. Hail could also become a problem. No particular positive effects have been discerned as a result of climate change.

Rape

The only possible risk factor for rape is strong wind. This will not occur more often in comparison to the present situation. The impact of such an occurrence can be limited by using sturdier crops and growth regulators. Till 2040 no extra measures are required but towards 2100 something may have to be done to prevent damage by insects. With fewer severe frosts in the November –

February period there could be less damage during the crop's development phase.

Grass

Periods of continuous hot weather form a risk for grasslands in 2040. The damage can be limited with good management. There are various ways in which the dairy farmer can repair the sod. Seed mixtures with more heat-resistant races and further technological developments (including precision farming) are possible measures which can be taken to limit the problems. Less frequent and severe frost in January will be advantageous.

Greenhouse cultivation

Tomatoes

In greenhouse cultivation damages of as little as 5% can have enormous financial consequences. Heat waves cause the most damage in this sector and this demands a greater cooling capacity. Warm and humid weather increases the chances of disease, particularly fungus, demanding more intensive solutions. As a result of technological development in the greenhouse sector one can expect optimal climate control systems in the future. The possibility of an increase in heavy rainfall in August- October period means there will be more clean water available. Fewer frost periods mean that less gas is needed for heating. Warmer winters, heat waves and natural heat radiation offer opportunities for renewable energy sources.

Alternative crops

Artichokes

The type of soil in the North of the Netherlands is suitable for the cultivation of artichokes which require good drainage. Although the plant is a hardy annual it is sensitive for frost and must be packed in with straw for the winter. Artichokes are also susceptible to viruses.

The crop is relatively tolerant of salient and dry conditions so brackish land and drought will probably have little negative effect on the yield. This means that artichokes are a relatively good alternative for other more sensitive crops. Continuous wet weather conditions are expected to occur less frequently in the May to October period which could result in fewer problems with fungous diseases and damage by snails. Moreover, the risk of night frost is likely to diminish.

Sunflowers

There are no direct climate-related risks to the cultivation of sunflowers, although hail damage remains a possible problem. The sunflower is heat resistant and is relatively tolerant of dry, salient conditions. This makes the plant a good alternative for other more sensitive crops. Sunflowers grow well in practically all soils, as long as the soil is moist and drainage is good. The sunflower is also a good alternative because it can also be cultivated on land parcels that suffer sporadic flooding – the crop reacts positively to temporary wetness.

Grapes

When cultivating grapes fungous diseases require the most attention. With fewer chances of frost-damage this crop has become more attractive to cultivate. Requisites for successful cultivation are a light, well drained soil, plenty of sun and an open growth; the wind must be able to blow through to avoid dampness.

Climate change will probably lead to less frost in Spring which means that one of the main causes of damage diminishes notably. In the W+ scenario one can see that, around 2100, the chance of continuous wet weather conditions in the blossom period decreases. This has a positive effect on pollination.

Cherries

Sweet cherries require moisture-retentive and light clay in where the roots can grow deeply. The higher sandy soils in the North of the Netherlands (arid and infertile) are, therefore, unsuitable for cultivation. Cherries are also very sensitive to wind, particularly during the blossoming period. This means that a sheltered micro-climate is needed for successful cultivation. The loamy, light clay soils of the North of the Netherlands can be found relatively close to the sea where hard winds make it unsuitable for cherry-growing. Mild winters, a warm spring season and hail form possible climate-related risks, although there are certain measures available to control or prevent damage. The cultivation of cherries would seem

to be, for as yet, an unattractive alternative crop for the North of the Netherlands. Fewer periods of continuous wet weather from June to August would be advantageous, as would the possibility of a diminished frequency of night frosts in the spring season.

Stockbreeding

Dairy cattle

Dairy cattle can be housed indoors (in cattle sheds) or let out to graze. Possible climate-related factors that effect cattle-farm management are heat stress, water damage, warmer weather and milder winters. Heat stress can be prevented by technically adapting the sheds and/or letting the animals graze in the mornings and evenings. Excessively wet conditions form the source of higher risk of disease. This can be alleviated by improving drainage and soil structure. Warmer weather could mean an increase in worm infections but the animals can be treated for this. However, milder winters could result in even more sickness and the required measures will depend strongly on the disease.

Free-range pigs

There are two sorts of 'outdoor held' pigs. The so-called'eco' pigs represent approx 80-90 % of those held outdoors. The remaining 10 – 20% of 'outdoor' pigs can be branded as 'free-range' pigs.. There are very few free-range pig farms in the Netherlands. The most important climate threat for pig-farmers is higher temperatures. During hot weather free-range pigs can be let outdoors to cool off, which means that they have less heat stress than the animals kept in stalls. Viruses thrive in humid conditions and if climate change brings dryer air and more UV then the risks of cross-infection should decrease. The necessary measures are mainly related to disease and illness. By improving their natural resistance the pigs will become less susceptible to the higher risk of disease resulting from climate change.

5 Research – the next step

The first two research phases were of a general character and covered all of the North of the Netherlands. The next phase focuses strongly on regional 'cultivation areas'. 'Climate' workshops are being held in the region at which researchers and local farmers exchange ideas and knowledge regarding the problems and opportunities that climate change can bring. Awareness of the threats and opportunities forms the basis for these discussions.

Ultimately implementation plans are to be drawn up for each area. In these plans adaptive strategies are worked out and cohesive implementation plans for sub-regions are formulated. These areas will probably have to actively take adaptive measures before 2050, as stated in Phase 2 of the research. The development of market and climate durability strategies in the North of the Netherlands can be used as a good example for other areas in the Netherlands, particularly the West. There climate change forms an extreme challenge for the agricultural sector due to the extensive coastline the fact that the land lies below sea-level.

It is obvious that this research will not find all the answers. Some of the proposed measures need more practical testing and experience. Currently follow-up research (Phase 4) is being considered whereby farmers can test the cultivation of alternative crops, technical adaptations and water management.

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