

# Agriculture

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## 1. Introduction

### Background

In Switzerland, land used for agriculture amounts to 37% of the total area. About one third of the agricultural land is located in the midlands. Pastures and meadows account for the largest part of the entire agricultural land (permanent pasture in fig. 1). Accordingly, the majority of the 65,866 farms focuses on livestock husbandry, whereby dairy cattle farming dominates. The most important land-use category in arable farming is cereals.

More than 70% of the farms are full-time enterprises. In 2003, the mean farm size was 16.2 ha. Plant products account for 47% of the output value of agricultural goods, dairy products for 27% and other animal products for 26%. In Swiss agriculture, the degree of self sufficiency is highest for proteins, with 70 to 80%, and lowest for carbohydrates, with 50 to 60%.

Agricultural policy in Switzerland is reforming agriculture step by step. Current agricultural

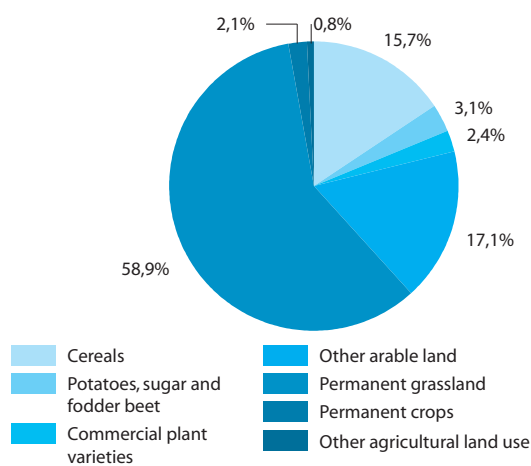


Figure 1: The most important land use categories 2003<sup>1</sup>

policy (AP 2007) focuses on the improvement of the competitiveness of domestic agriculture and food industries. In the next phase (AP 2011), this new focus will be further developed. These measures have a strong impact on the agricultural output value. Implementation of the expected commitments to the WTO will result in a reduction of the agricultural output value by about 1.5–2.5 billion Swiss Francs compared to the reference years 2001/2003.<sup>2</sup> Due to this development, the structure of Swiss agriculture

will change considerably. At the moment, it is not possible to predict the consequences for land use, crop cultivation, or farming of grass and pasture lands. This uncertainty makes it difficult to quantify the consequences of climate change, that is, the direct consequences for agricultural production in Switzerland as well as the indirect consequences due to climate change in other countries (see section 9). The following considerations largely ignore such possible changes, which are caused by political and economic forces, and which may be of much more importance in the 2020–2050 time frame than the impact of climate change.<sup>3</sup>

Climate is one of the most important limiting factors for the cultivation and yield of crops and livestock husbandry. Due to the climate in Switzerland, arable farming is limited to lower elevations, whereas fodder production covers a climatically much wider variety of elevations and dominates at higher elevations. Climate change will therefore bring about a change in an important parameter. The following remarks focus on this expected change with regard to cultivation and yield per unit of area, suitability of location and pest management, as well as possible consequences and adaptabilities of cultivation measures, livestock husbandry and farm management. A closer examination of regions and cultivation methods (e.g., conventional or organic farming) is omitted due to the lack of data.

### Overview

No threshold value for global warming can be given for the effect on agriculture. However, a moderate warming of less than 2–3 °C of the annual mean by 2050 will tend to have a generally positive effect on agriculture in Switzerland. The potential annual production of pastures will increase as a result of the longer vegetation period. The potential yield of many cultivated crops will increase as well given sufficient water and nutrients. Animal production will profit from cheaper fodder due to increased yield and from the longer grazing period. Negative effects will be related to the decrease in available water due to an increase in evaporation from plants and ground (evapotranspiration) with the decrease in summer precipitation, the increased prevalence of weeds and pests, and the increase

in climate variability and extreme events. In the case of a stronger warming of more than 2–3 °C by 2050, the disadvantages will prevail: Water shortage will occur more often due to the increase in evapotranspiration and decrease in precipitation during the vegetation period, and the accelerated plant growth of cereals and grain legumes will cause yield loss.

By taking measures involving the choice of crops, cultivation methods and farm management, agriculture will be able to adapt to a moderate increase in the mean temperature of 2–3 °C by 2050. However, the expected increase in weather variability and extreme events will be more problematic. Due to the increase in heat waves and dry spells, critical soil water conditions and droughts will occur more often in summer and the need for irrigation will rise in many places. It will be important to use the available irrigation water as effectively as possible. Conversely, an increase in heavy precipitation could intensify soil erosion. All in all, the risk of damage for special and arable crops and of yield loss in fodder production will increase. Yield security will be affected. Suitable general measures such as plant breeding and variety evaluation will play a role in mitigating the negative effects. The diversification of farms may be a useful strategy to reduce risk. In addition, the demand for insurance against yield loss due to extreme weather conditions will rise. International agricultural markets will play an important role in the future global and national

food supply. In Switzerland, the liberalisation of markets and adaptations in agricultural policy will be more important influencing factors than climate change.

## Links to other topics

### Insurance

Demand for insurance against yield losses due to extreme weather conditions

### Water management

Groundwater level; need for irrigation water; production losses due to lack of irrigation

### Land ecosystems

Conflicts over water usage; highly mechanised cultivation methods and possibly increased use of fertiliser and plant protection products; immigration of foreign species (neophytes)

### Health

Neophytes (e.g., *Ambrosia artemisiifolia*) that may cause allergies or asthma

### Energy

Increased demand for energy due to irrigation systems

### Tourism

Decreasing attractiveness of the landscape for tourists due to scrub and forest encroachment (particularly with a change in mountain agriculture)

## 2. Domestic plant production

**A moderate climate change of less than 2 to 3 °C of the annual mean will have a positive effect on agriculture in Switzerland in many respects. The potential annual yield of pasture will increase due to the longer vegetation period. Provided that the nutrient and water supply is sufficient, the potential yield from arable farming and fodder production will increase for many crops. In the event of a strong warming, however, the disadvantages will prevail. A strong increase in evaporation from plants and soils, as well as a change in precipitation, could result in water shortage at many locations.**

In the past, domestic plant production mainly depended on the suitability of the location, which is determined by the climate, soil characteristics and relief. Weather characteristics determined the course of cultivation to a large extent.

The climate change of the past years has already had a demonstrable impact on plant production. In the case of arable crops, the impact of temperature on sowing and harvest time is well documented. Today, wheat is harvested almost one month earlier than in 1970, which is partly the result of the introduction of early varieties, and the grazing of mountain pastures starts 15 days earlier than 30 years ago because mountain pastures become snow-free earlier.<sup>4</sup> The change in plant development mainly depends on the increase in temperature, in particular budding, blooming and ripeness of fruit in spring and summer. The phenological autumn phases do not correlate clearly with weather variables. Higher temperatures in winter and spring bring about an earlier start of the growing season, e.g., for dandelions. Trend analyses for the period 1951–2000 have shown that on average plants bloom 21 days earlier, foliation takes place 15 days earlier and leaves change colour 9 days earlier, while the falling of leaves takes place 3 days later.<sup>5</sup>

This trend will continue with future warming. Depending on the region, the vegetation period will be extended by about 7 to 10 days per decade,<sup>4</sup> which will result in an increase in the potential annual production of pastures.<sup>3</sup> With the decreasing number of frost days, the risk of frost damage decreases as well, although in the case of an early start of the growing season, the danger of late frost damage persists.

A moderate climate warming of less than 2 to 3 °C of the annual mean will have a positive effect on agriculture in many cases. Model calculations of potential trends in crop yield (including cereals) show that Central Europe

will tend to be in a favourable zone until 2050. Provided that all soil nutrients are sufficiently available, an increase in the atmospheric CO<sub>2</sub> concentration, in combination with slightly higher temperatures and sufficient rainfall, means an increase in the potential yield of many agricultural crops. The yield increase caused by CO<sub>2</sub> is, however, minor in comparison to long-term cultivation effects, and the positive effect on yield will be weakened by more strongly rising temperatures.<sup>6</sup> At the same time, a higher CO<sub>2</sub> concentration reduces the protein content of wheat grains, which results in a reduction of the baking quality of the flour. A slight decrease in rainfall in spring and summer will also have a positive effect on farming at many locations. The number of field work-days will increase and the decrease in soil water content will favour the use of bigger agricultural machines. In summer, periods with 2 to 3 consecutive dry days are beneficial to fodder production because insufficient drying impairs the quality of hay and aftermath.

In the case of a stronger warming of more than 2 to 3 °C of the annual mean, the negative effects will prevail. A stronger warming means accelerated plant development, which will result in yield losses for today's common varieties, in particular for cereals and grain legumes.<sup>6</sup> Rising temperatures increase the potential evaporation from plants and the soil surface. Depending on air humidity, soil moisture, short-wave radiation and the condition of the vegetation, the effective evaporation and therefore the current water consumption of crops, will also increase. Model calculations show a considerable reduction in the mean soil moisture during the vegetation period.<sup>7</sup> In view of the projected changes in seasonal precipitation patterns (more precipitation during winter and less during summer), water shortage could become much more frequent during the cultivation period at many locations (see fig. 5).

### Uncertainties

It is uncertain to what extent a change in the regional differentiation of local conditions (climatic suitability) will develop, with a change in

favourable and unfavourable locations, and to what extent the change will mean advantages of location within Switzerland and also internationally.

## 3. Extreme weather events

**Climate change will mean a change in the probability of extreme events. The expected increase in heat waves and heavy precipitation events will increase the risk of damage for special and arable crops, profit cuts in fodder production and enhanced soil erosion.**

Extreme weather events like drought, hail or heavy precipitation are of particular importance to agriculture. Hail damage for fruit, vine and vegetable cultures used to be the most common weather-related risk. After 1730, summers with drought occurred about every 50 years.<sup>8</sup> Difficulties arose particularly when two dry periods followed each other (preceding winter or summer), like for instance in 1947.

Climate change will mean an increase in the risk of extreme events and the corresponding consequences for agriculture.<sup>9</sup> Heat wave summers of the magnitude of summer 2003 will become more frequent<sup>10</sup> (see Extreme events section in the Background chapter) and the probability of drought damage will increase in the midlands and Jura. On the other hand, heavy precipitation will increase in the winter months, leading to damage of winter crops and increased soil erosion. No predictions are possible yet for hail.<sup>8</sup>

The magnitude of damage caused by extreme events is larger than the usual annual fluctuations in profit. Insurance solutions to cover the associated property damage exist. What is lacking is insurance coverage for yield loss due to extreme events like drought. How can the losses of drought years be absorbed? 2003 showed that governmental measures (e.g., a reduction in customs tariffs) can help. However, what will happen if drought years become more frequent?<sup>11</sup>

### Uncertainties

Given the presented trend, the question of insurance cover for damage in animal farming and fodder production, and of financing damage redress as a result of heavy precipitation, hail and drought also becomes increasingly pressing. The question of whether agriculture itself, governmental or other sources will cover the costs involved remains open.



Figure 2: Corn field showing drought damage 2003 (Source: Liebegg, U. Voegeli)

## 4. Yield security

**Climate change affects yield security. Suitable general measures, such as plant breeding and variety evaluation, can contribute to maintaining yield security in the future. In fodder production, the earlier start of the vegetation period could mean increased yield security.**

In agricultural plant production, the conditions influencing yield typically change irregularly. Regional fluctuations in yield are caused by the epidemic spread of disease causing organisms or pests, or by stress resulting from extreme weather events. When the magnitude is too great, this can be an economic problem not only for single farms but also for the entire agriculture of a country. Since the end of the 1960s, fluctuations in yield could be reduced for arable farming and fodder production thanks to the introduction of new means and methods of production, as well as the continual variety change. In Switzerland, this decrease is noticeable for pasture yield and wheat, and slightly less apparent for potatoes (fig. 3). Future yield security will be influenced by climate

change. The increase in extreme weather events will have a negative effect (see section 3). Plant breeding and variety evaluation are key measures for maintaining yield stability and reducing the use of production factors (pesticides, water, fertiliser, etc.). The future range of varieties will also need to include varieties that have lower yields but are more drought resistant or robust. The earlier start of the vegetation period will mean an increase in yield security for fodder production, since the first cut can already be made in spring.

### Uncertainties

It is not clear to what extent the progress in breeding and selection will be able to keep up with the trends in extreme weather events.

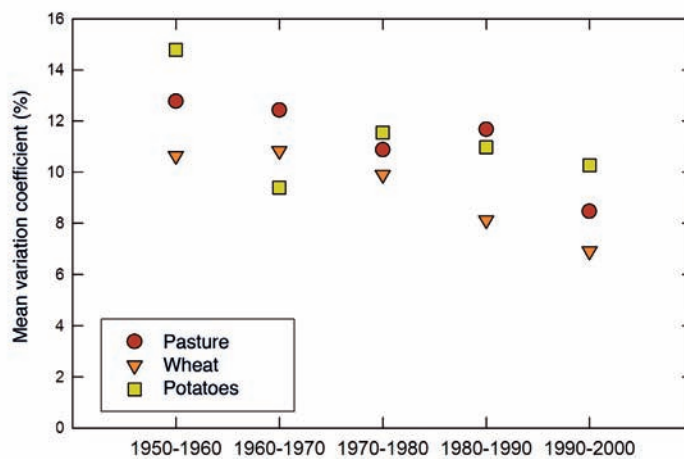


Figure 3: Temporal trend of yield stability for pasture, wheat and potatoes in Switzerland (moving average of the variation coefficient for 10-year cultivation periods). The negative trend between 1950 and 2000 shows an increasing yield stability. (Data source: Swiss Farmers' Union)

## 5. Water supply and location

**Critical soil water conditions and summer drought could become more frequent in Switzerland in the future. This would require irrigation at many locations. The extent of local water shortages not only depends on the water requirement of crops but also on local conditions.**

The water requirement of many crops (cereals, legumes, root crops, oilseed) that are grown in Switzerland today is relatively high, at 400–700 mm for the growth period.<sup>12</sup> Productivity losses occur if the water available in the soil is less than 30–50% of the useable field capacity for a longer period of time.<sup>13</sup> Optimal growth can then only be attained if the crops are irrigated. With today's precipitation volume, the need for continuous or area-wide irrigation is small. In the midlands, about 600 mm of rain falls on average between April and September (with an annual variability of 100 mm), which corresponds to a mean soil water content of about 60% of the useable field capacity. Since 1900, less than 500 mm have been measured only 15 times, less than 400 mm only five times. Total precipitation in the sub-alpine and alpine zones is larger; only the inner-alpine valleys, in particular the Valais, are confronted with the problem of water shortage.

Scenarios for the year 2050 show a slight change in spring precipitation and a considerable decrease in summer (up to 35%) and autumn (up

to 15%) precipitation. In the worst case, mean precipitation (April to September) of less than 500 mm, critical soil water conditions lasting for weeks (results are related to the year 2050<sup>6</sup>) and an increase in summer drought have to be anticipated in the midlands.<sup>9,10</sup> The need for irrigation would increase at many locations, despite the earlier vegetation start (see section 2) mitigating the situation. The extent of local water shortage will probably depend not only on the water requirement of crops but also on local conditions<sup>14</sup> (see Water management chapter).

In extreme years, water scarcity could become a problem in fodder production as well, in spite of the fact that these areas are partly situated at higher elevations.

### Uncertainties

It remains uncertain to what extent the development of irrigation plants to bridge dry periods makes sense, is feasible and possible in view of the availability of water in dry years. Avoiding risky locations and cultivating crops with lower water needs are to be preferred.

## 6. Pests and their relevance

**Climate change enhances the emergence of weeds and favours insect pests, while the population of disease-causing fungi and bacteria are enhanced, inhibited or not affected, depending on the host plant.**

Climate, weather and cultivation factors determine the type, extent and relevance of problems with weeds and pests. Climate change, in combination with increased goods and holiday traffic, has contributed to the spread of plant species that do not normally occur here (so-called "neophytes"). For example, *Ambrosia artemisiifolia* is currently being spread throughout Switzerland from Geneva and Ticino. Ambrosia is a weed that spreads quickly in fields and its pollen can cause allergies and asthma (see Health chapter).<sup>15</sup> With the increase in temperature, thermophilic spe-

cies, such as weeds of subtropical origin with little nutrient content for animals, may spread as well. Woody plant species and root weeds like field thistle, sorrel and quitch may increasingly cause problems.<sup>16</sup>

Due to mild winters, autumn germinators, such as blackgrass and goosegrass, are being favoured. Weed pressure will probably increase as a result of the faster adaptability of the weed population and their greater competitive power compared to crops, as well as the reduced ground cover caused by heat waves and erosion.

As a consequence of climate change, additional problems are expected from insect pests.<sup>17</sup> Insect species like the European corn borer, the Western corn root worm, cereal leaf beetle, plant louse and potato beetle may develop more rapidly and spread farther than before. The prolonged warm period will enable pests that used to produce 1–2 generations per season, to produce 2–3 generations in the future (e.g., European corn borer). Pests that previously caused damage every three years (e.g., ladybird grubs), will appear at shorter and more irregular intervals. Due to warmer winters, the plant louse, which overwinters in the adult phase, will migrate from its winter locations to the crops at an earlier date.<sup>18</sup>

The occurrence of disease-causing fungi and bacteria is strongly dependent on climate and weather. Climate change will have a positive, negative or neutral effect depending on the host-pathogen system.<sup>19</sup> Mild winters and springs are favourable for brown and stripe rust, mildew and helminthosporium leaf spot diseases of cereals and corn. On the other hand, warm and rather dry summers will probably result in a decrease in moisture-loving diseases, such as glume blotch and fusarium head blight in wheat. Epidemics of late blight in potatoes would also be slowed, however, overall, due to an earlier start, probably not weakened. With corn, increasing feeding damage (European corn borer) and mechanical damage of the plants caused by the weather (hail, storms) will enhance toxin-generating fusarium fungi (see fig. 4). In addition, as a result of rising ozone concentrations, facultative parasites, which do not depend on their host to proliferate and are only found there occasionally, may increasingly cause damage to crops.<sup>6</sup>

### Uncertainties

Due to the complex interactions between pests, beneficial organisms, host plants and cultivation methods, as well as the different effects of abiotic factors, such as heat, CO<sub>2</sub> and O<sub>3</sub>, predictions regarding long-term trends are difficult. The only thing that is certain is that climate change will force us to face new problems at increasingly shorter intervals. Simplified crop rotation and focus on a small number of cultivated plant species also encourages problems with pests.



Figure 4: Infestation of a corn cob by toxic fusarium fungi. The occurrence of fusaria is caused through injury of the corn by insects, hail and growth cracks. It is enhanced by strongly changing climatic conditions.

(Source: H.R. Forrer, Agroscope ART Reckenholz-Tänikon)

## 7. Food production from livestock

**Fodder production productivity will increase as a result of climate change at locations with sufficient water supply, and as a result, livestock farming will profit from cheaper, increasingly domestically produced feed. The longer grazing period, as well as new, adapted fodder plant mixtures may increase the potential of animal production. However, negative effects are also to be expected: The increase in heat days will cause problems for livestock husbandry. Furthermore, feed quality may decline and yield security decrease due to more frequent extreme events.**

Switzerland is a “fodder-production country”: The prerequisites regarding precipitation volume and distribution are very favourable for fodder production (pasture). What’s more, the topography of a large part of the area only allows for fodder production. The significance of hydroponic production is comparably small but increasing.

Traditionally, livestock husbandry was shaped by the effort to become more independent of climate variation (e.g., with climate control in barns, closed systems and conserved feed). In recent years, however, the use of grazing land has increased again. This is due to economic considerations (cost savings), and the effort to improve the well-being of the animals and to create more natural production. As a result, livestock husbandry has become more dependent on climate. However, strategies to deal with extreme climate situations are still only required in exceptional cases. Sporadically, conflicts may arise with particular housing systems, for instance with free-range systems during summer heat.

The expected future increase in the number of heat days will cause problems for animal husbandry: Water demand will increase and animals will increasingly need to be protected from high temperatures by adequate air conditioning in barns or by shading. In general, animal illnesses and parasites will probably not increase but shifts in the spectrum of pests cannot be ruled out. Already today, there are animal breeds that are better able to deal with these conditions, as well as with the previously mentioned changes. The breeding goals for breeds common in Switzerland need to be adapted.

In the future, due to climate change, fodder production productivity will tend to increase at higher elevations in locations where water supply is not a limiting factor. Animal production will profit from a better choice of cheaper domestic fodder. By breeding adapted fodder

plant varieties (including new species) and developing suitable mixtures, this advantage can be enhanced. The lengthening of the grazing period (see section 2) results in additional grazing days and raises the production potential. In addition, the increase in suitable drying days could improve the quality of the conserved fodder. However, there are also negative effects to be expected: Due to the increase in weather extremes, the supply of fodder will become more irregular during the vegetation period and the dependency on fodder preserves will grow (see section 3). Fodder plants that are adapted to warmer growing conditions often have a lower fodder value. Furthermore, parasites (primarily fungal) develop more often in plants from temperate zones, affecting the fodder value and representing a risk to human and animal health. All these factors will have a varying impact depending on elevation and region. Production relocations are to be expected; alternatively the proportion of hydroponic or climate-independent production could increase.

### Uncertainties

It is unclear to what extent the decrease in the demand for fodder preserves as a result of the extended vegetation period and the increase in demand in order to bridge scarcity during growth periods will compensate each other. The area of conflict between controlled (intensive) and natural production will add another dimension. Although the number of potential grazing days will tend to increase, the number of optimal grazing days will probably decrease due to more days with high temperatures and drought. Regarding trampling damage in the case of over-wet pastures, the situation is likely to improve.

## 8. Measures for crops, cultivation methods and farm management

**Agriculture should be sufficiently adaptable to adjust to an average temperature increase of 2 to 3 °C by 2050, by taking suitable measures in the areas of species and variety selection, cultivation methods and farm management. However, the increase in weather variability and extreme events will be a challenge.**

The current trend towards warmer and drier summers with more frequent extreme events requires an examination of the common crops, standard cultivation methods and the type of farm management.

### Crops

The yield stability of many crops will probably decrease due to summer heat and drought. Therefore, the potential of existing and alternative crops needs to be evaluated. Today's varieties might possibly be replaced by more robust varieties or species that do not need to be newly bred but may already be available in corresponding climates. In the case of perennial, special crops (e.g., in fruit growing and viticulture), adaptation is less simple.

For the importation of new plant varieties, domestic competence in variety evaluation is important in order to achieve targeted selection (acquisition of know-how). Variety evaluation, with increased consideration of change in climate and pests, also serves to select competitive and broadly resistant varieties that are also distinguished by a greater weather, yield and quality tolerance.

In order to better distribute the risk of bad harvests, there should be a multifaceted mixture of crops without returning to small-scale cultivation (see Farm management section). At the farm level, in addition to fodder production, a higher yield stability can also be attained by combining varieties in the cultivation of cereals. Crops that cannot be adapted to the changing climate (e.g., oats) need to be replaced by new ones (e.g., soy, old rice). For special crops, a high added value may be achieved, for example, by cultivating more melons, grapes or citrus fruits.

### Cultivation methods

Modern agricultural technology has already reduced the dependency of agriculture on the weather, leading to increased feed quality. In fodder production, cutting can be carried out at an earlier date (with smaller biomass or leaf area index), thereby attaining a higher quality. Further

adaptation is possible in particular for intensive pasture management with maintenance measures, while this is less likely for extensive pasture management.<sup>20</sup> Crop losses in arable farming can also be reduced by adapting the sowing date to warmer temperatures. Thereby, new possibilities for the design of crop rotation arise.

The expected increase in summer drought will force farmers to economise water usage. Possible measures include early sowing, foliar fertilising in spring and preferably continuous soil cover consisting of living or dead plant material, as well as foregoing soil tillage operations in summer. At the same time, these measures impede soil erosion by heavy precipitation. The most consistent form of tillage to conserve soil texture is direct sowing (no-till). However, this requires accompanying measures against the spread of weeds, snails or fungi, particularly in wet weather, and in general against too strong competition from the soil-covering crops.

At locations with sufficient water supply for irrigation, the irrigation water needs to be used as effectively as possible. Measures include among others the consistent use of drip irrigation in row crops and the turning off of sprinkler systems during sunshine. In the end, plants should not be spoiled by irrigating too early or too often, so that they develop an efficient root system. The relevant know-how for Switzerland needs to be acquired and incorporated into training in the future.

### Farm management

Global warming will extend the vegetation period and raise the number of available field workdays. These changes will affect farm management in the following ways:

Highly-mechanised cultivation methods with specific requirements for driving or cultivating soil become increasingly of interest. Expensive and efficient machines can better be used to capacity and – in the case of silage harvesting – be increasingly utilised with a time lag in mountainous areas (see fig. 5). Additionally, scheduling

labour on short-notice becomes easier with more frequent fair weather periods. All in all, labour productivity will increase and production costs will drop. These advantages could, however, be nullified by more frequent storm damage or increasing insurance costs.

In mountainous areas, global warming will bring about a welcome shortening of the long winter feeding period. Thus, the demand for conserved fodder decreases, which not only makes the hay harvest easier but also reduces the building costs for fodder and fertiliser depots.

With decreasing summer precipitation, the risk of water logging and soil compaction will also decrease in mountainous areas. In particular, heavy soils are thereby less affected by soil compaction caused by heavy machines. The risk that soil water storage and holding capacity continue to decline and that susceptibility to erosion increases is also reduced.

Foresighted planning and risk assessment become more important. To reduce risk, prophylactic measures need to be taken, such as

the inclusion of maps of natural hazards in the planning of land use, or the implementation of the natural hazards strategy of PLANAT.<sup>21</sup> A stronger diversification of farms should gain in importance again as a strategy to avoid risk. With arable crops as well as fodder production, the loss of one crop may be compensated for by another one. Due to job rationalisation, it makes sense to achieve a more multifaceted mix of crops within larger producer associations. Regarding foresighted planning, there is a great demand by practical agriculture for the improvement of the reliability of monthly and seasonal weather forecasts, as, for example, is currently being developed at MeteoSwiss.<sup>22</sup>

### Uncertainties

It would be particularly useful in practice to have a seasonal forecast at hand for annual planning. This would support farm management, which will need to have a broader palette of measures available in the event that climate is more strongly influenced by extreme events.



Figure 5: In the harvesting of round bale silage, additional harvesting possibilities in early and late summer arise due to global warming. Expensive special machines may therefore be better used to capacity. (Source: Agroscope ART Reckenholz-Tänikon)

## 9. National and global food supply

**International agricultural markets play an important role in the estimation of the future national and global food supply. By 2050, the liberalisation of the markets and the adaptation of agricultural policy, in combination with the increasing demand of emerging nations on the world market will affect food supply more strongly than global climate change.**

The effects of climate change on food supply in Switzerland have to be considered against the background of the foreseeable market liberalisation in agriculture in the coming decades. Due to the increasing interconnectedness of international agricultural markets, local markets will be less shaped by local conditions because the consequences are spread within a larger system. On the other hand, effects caused elsewhere will be felt at the local level. As a result of the complete opening of agricultural markets, production with comparative cost disadvantages will decline. Certain plant products may be more affected by this than livestock husbandry.<sup>23</sup>

On a global level, it can be assumed that agricultural production will be shifted to locations that become relatively more favourable from an agronomic perspective. For instance, Central and Northern Europe will be climatically more favourable locations, whereas semi-arid regions will be climatically disadvantaged. This may cause supply uncertainty at specific locations.

Global cereal production will generally decline and will move geographically. Due to the shift, and reinforced by trade liberalisation, agricultural markets and the international trade will become more important. Due to expected shortages, world market prices will rise. However, the effects on agricultural markets will largely depend on the general economic and global political situation, and will vary spatially. The global

distribution problems will intensify. In addition, larger price fluctuations are to be anticipated due to the expected increasing intensity of meteorological extreme events. In particular, African countries will suffer from the consequences of climate change. The solidarity of northern countries with those in the south in terms of food supply will become more important.

In Switzerland, the contribution of agriculture to the GDP is marginal. The consequences – both positive and negative – of climate change on agriculture are therefore macroeconomically insignificant. Food demand in Switzerland can be covered by imports and supply problems are not expected.

As Switzerland is located in a climate zone that tends to be favourable, the comparative advantages of the location will increase. Generally, an increased risk is anticipated, which will be amplified by the structural changes that result in larger, more capital intensive farms with a higher degree of specialisation. However, structural change will also result in improved agility, professionalism and adaptability of the farms.

### Uncertainties

The significance of the direct effects of climate change on domestic agriculture by 2050 remains uncertain in the context of other changes, mainly caused by alterations in international trade.

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