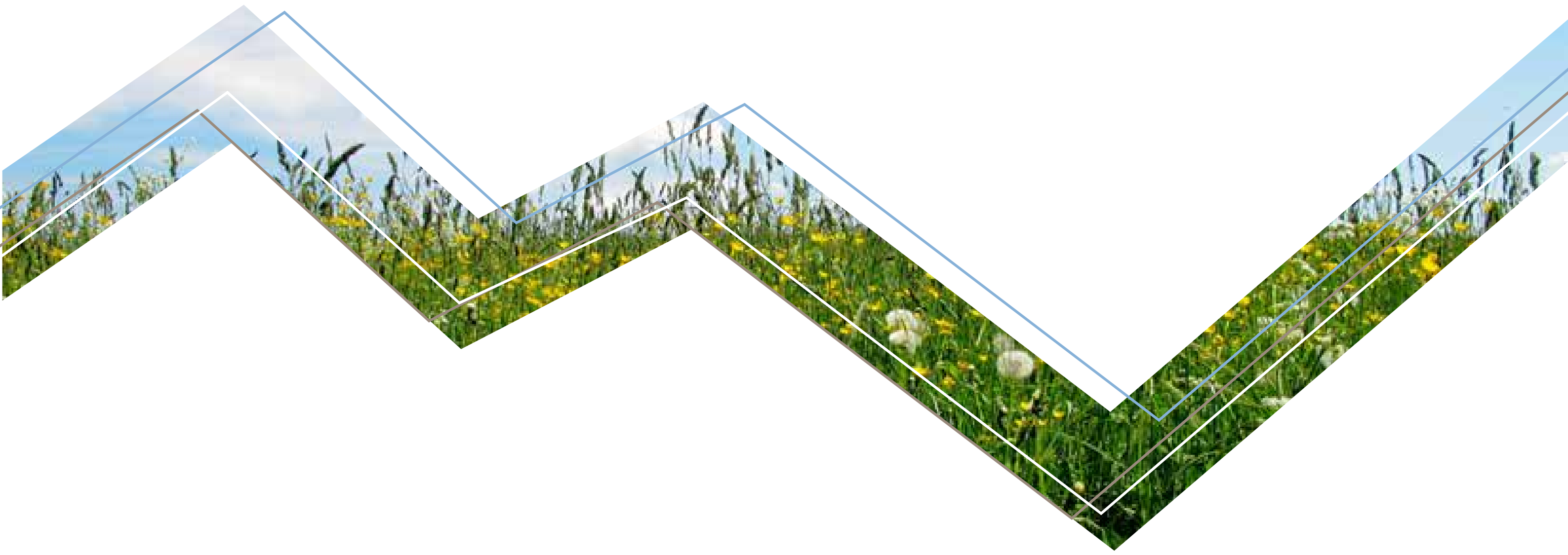
COMPACT NO 02/2011

AGRICULTURE AND CLIMATE CHANGE

A BACKGROUND REPORT BY CIPRA



CIPRA

CONTENTS

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cc.alps in a nutshell

The Project “cc.alps – climate change: thinking one step further!” is organised by CIPRA, the International Commission for the Protection of the Alps, and financed by MAVA Foundation for Nature. Through the Project, CIPRA is helping to ensure that climate response measures in the Alpine region are in harmony with the principle of sustainable development.

http://www.cipra.org/en/cc.alps/results-and-products/compacts

1 INTRODUCTION

Within the project "cc.alps – climate change: thinking one step further!" the International Commission for the Protection of the Alps (CIPRA) investigates climate response measures in the Alps. CIPRA compiles information on climate protection activities and adjustments to climate change in the Alps (hereinafter referred to as climate response measures) and analyses the impacts of these climate measures on the environment, economy and society. CIPRA's aim is to make climate response measures comply with the principles of sustainable development, to make these information accessible to a broader public, and to warn the public of those measures that have negative effects on nature, the environment, social cohesion and the economy.

The "CIPRA compact" series comprises several thematic publications that take a critical look at climate measures in the Alps. The series covers the following activities in addition to the subject of "agriculture": energy, constructing and refurbishing, energy self sufficient regions, spatial planning, transport, tourism, natural hazards, nature protection, forestry and water.

The present compact "agriculture in climate change" is dealing with climate change response measures taken or suggested for the agricultural sector in the Alps. The compact is structured as follows: Section 2 exposes statements given by CIPRA. Section 3 is the main body dealing with agriculture and climate change in the Alps. Subsections are on the characteristics of Alpine agriculture (3.1), the contribution of the agricultural sector to climate change (3.2), the impacts of climate change on the agricultural sector (3.3), and climate response measures in the agricultural sector. These are discussed with respect to adaptation (3.4.1), mitigation (3.4.2), organic agriculture (3.4.3), bioenergy (3.4.4), and consumer behavior with respect to food demand (3.4.5). Conclusions are given in section 4, good practice examples are presented in section 5.

2

CLIMATE-COMPATIBLE AGRICULTURE IS BIOLOGICAL

CC.ALPS: CIPRA'S DEMANDS FOR AGRICULTURE

The agricultural sector is directly affected by climate change impacts but it also contributes to the release of greenhouse gases (GHG) and rising concentrations of GHG in the atmosphere. A sustainable climate response strategy in the field of agriculture involves anticipating, planning and long-term thinking from farm level to transnational level. Prominent fields of activity are sustainable land and soil management, sustainable water management, managing manure and soil carbon as well as organic agriculture as an overall strategy.

As agriculture is a highly subsidized economic sector, subvention policy can be used as a lever to guide the sector to sustainability and climate neutrality.

CIPRA's proposals:

- ### GO ORGANIC – A SOLUTION FOR THE WHOLE ALPINE REGION

Given the conditions, it is inherently impossible for farms in the Alps to keep up with mass production in the lowlands. The only alternative is to go for the highest possible quality. High-quality regional products can also play an important role in sustainable tourism.

Organic agriculture combines all the principles of sustainable agriculture. It increases the CO_2 storage capacity of the soil, producing 65 % less CO_2 than conventional agriculture, and it makes an important contribution to species diversity and the prevention of soil erosion.

Therefore CIPRA proposes agricultural production throughout the Alpine region on the principles of organic agriculture. Guidelines for subventions at all levels should aim at achieving this.

- ### USE WATER INTELLIGENTLY

The increasing frequency of droughts resulting from climate change, especially in summer and autumn, will lead to a greater use of water for irrigation by agriculture. This can only be allowed to the extent that it does not conflict with the supply of drinking water and the proper functioning of wetland biotopes and ecosystems. Solutions include the creation of reservoirs, drip irrigation, increasing the organic matter content of the soil so that it can retain more water and the use of drought-resistant plants. The extensive know-how of traditional agriculture should be used to (re) introduce traditional plants and livestock adapted to dryer conditions.

- **LIMIT THE USE OF BIOMASS AS AN ENERGY SOURCE**

  Growing crops for biofuel is inefficient, because the same area can produce many times more energy with, for example, photovoltaics. Growing crops for this purpose may also be counterproductive because some production methods consume more energy than is produced. Finally, the growing of fuel crops must be questioned from the point of view of the global food situation.

- **CONSUME LESS MEAT - AND, WHEN YOU DO, MAKE SURE IT IS FROM REGIONAL ORGANIC FARMS**

  Ultimately climate change mitigation is also a question of consumer behaviour. Livestock accounts for 37 % of global anthropogenic methane emissions, no less than 65 % of nitrogen oxide emissions, and 9 % of CO_2 emissions. So reducing the consumption of meat is an important contributing factor to climate change mitigation. Any meat that is consumed should be sourced from regional organic farms that use extensive livestock farming methods without buying in additional animal feed and without synthetic chemical fertilizers. This helps preserve the soil and bind more CO_2, unlike intensive farming methods where it is ploughed up releasing CO_2. A lower meat consumption and regional organic livestock farming not only help mitigate the effects of climate change, they also increase the regional value added and make a valuable contribution to preserving the cultural landscape of the Alps.

3

AGRICULTURE AND CLIMATE CHANGE IN THE ALPS

Agriculture is highly exposed to climate change, as farming activities directly depend on climatic conditions. The severity of the impacts of climate change on the agricultural sector varies by regions. According to the EU (EC, 2009a) mountain areas are among the most vulnerable areas to climate change in Europe.

The Alps have already undergone an exceptionally high temperature increase with temperatures rising more than twice the average warming of the Northern hemisphere, i.e. around +2 °C between the late 19th and early 21st century (EEA, 2009). As in the past, the Alps will be exposed to a stronger warming than the rest of Europe. According to the A1B scenario of the IPCC (Intergovernmental Panel on Climate Change) which assumes a balanced use of energy sources that does not rely on fossil fuels alone, a temperature rise of 3.9 °C until the end of the 21st century is projected for the Alps, compared with a warming of 3.3 °C for Europe as a whole. The warming will be particularly elevated in the high mountains (> 1500 m), with a 4.2 °C increase. However, until the mid-21st century the temperature increase will reach 1.4 °C only so that warming will be much faster in the second half of the century (EEA, 2009). Future temperature increase is projected to vary significantly between the seasons. The highest increase is expected in summer, the lowest increase is expected for spring. Plus, a regional differentiation in temperature increase applies, with the Alpine south-west exposed to the highest temperature increase and the north-east to the lowest (EEA, 2009). The variations between years might increase in the future and precipitation might decrease in summer and increase in winter, with continuously declining precipitation until the end of the century. Here again, the south-west will be most affected and the north-east least affected.

Climate change will bring about earlier snow melt, glacial recession, and reduced melt water and precipitation run-off during summertime, i.e. altered hydrological situations with consequences for slope stability, water availability and water run-off performance (EEA, 2009; OcCC, 2008, Fischlin et al., 2007), see also water compact. These impacts have consequences for the agricultural sector as a whole and for irrigation in the Southern Alps in particular. But the agricultural sector is not only affected in terms of climate change impacts. It also contributes to the release of greenhouse gases (GHG) and rising concentrations of GHG in the atmosphere. The agriculture sector is thus called to provide solutions to both climate change mitigation and adaptation.

3.1 THE STRUCTURE OF ALPINE AGRICULTURE

Many people associate Alpine agriculture with mountain farming. A closer look at Alpine regions shows that they do not only consist of steep sloped farmlands but a variety of zones with grasslands and high quality arable land. For centuries, farming has enabled the survival of the population in the Alps thereby shaping a cultural landscape. Although the significance of farming has decreased in favour of other activities such as tourism, it is still important for spatial and regional development and the maintenance of the cultural landscape. But economic and social changes, i.e. industrialization and urbanization, led to a decline in the number of Alpine farms by 43 % between 1980 and 2000 (Streifeneder et al., 2007). If current trends continue to prevail, it must be expected that the agricultural sector in the Alps is shrinking further with the risk of depopulation of areas with poor natural assets and difficult access. Support for farming in these marginal areas is justified by its multifunctional roles, i.e. agriculture not only produces foodstuff but maintains Alpine cultural landscape (Pruckner, 2005). Therefore, financial support is granted in each of the countries at varying degrees.

The structural information summarized in Table 1 show that in general Alpine farming is dominated by grassland farming, i.e. milk production and cattle rearing. Other ruminants like sheep and deer play a minor role. At high altitudes and on the northern side of the Alps, grassland farming is the most suitable form of farming. The inner-Alpine longitudinal valleys and the southern Alpine rim as well as the pre-Alpine hills show favorable climatic conditions enabling farmers to cultivate permanent crops (mainly grapes and apples). Only a small fraction of agricultural land is suited for arable farming in a few municipalities in southern Burgenland, in the environments of Vienna and in the French Western Alps (Tappeiner et al., 2008).

Table 1: Structural information on farming in Alpine regions.

Alpine region	Switzerland	Germany	Austria	France	Italy	Slovenia	Liechtenstein
Total territory, km²	24.902	10.967	54.606	39.631	51.607	7.894	160
Arable land, km²	160	562	1.960	n.a.	833	214	9
Grassland, km²	2.829	3.881	15.282	5.809	11.020	1.070	23
Agricultural land, km²	3.128	4.450	17.332	8.589	12.890	1.357	36
Agricultural land per farm, ha	13	21	19	39	28	7	19
Total number of farms 2000	24.546	22.017	96.205	28.128	91.440	22.411	127
Share of fulltime farms in %	64	54	33	57	76	46	56
Farm abandonment 1980-2000 %	-34	-24	-9	-47	-43	-56	n.a.

Source: Tasser, 2009 and Eurostat 2009, Streifeneder et al., 2007. Note that the data for structural information on Alpine regions (lower part of the table) are from years close to 2000 whereas other data are from 2005.

3.2 AGRICULTURE AS A CONTRIBUTOR TO CLIMATE CHANGE

Global agricultural systems contribute substantially to climate change, primarily via emissions of methane (CH_4) and nitrous oxides (N_2O). Globally, agricultural land use contributes about 10 % to 12 % of anthropogenic emissions of greenhouse gases (GHG) according to the common reporting scheme of the UNFCCC (United Nations Framework Convention on Climate Change) (year 2005, Smith et al., 2007). This calculation does however not include energy use for fertilizer production (which is assigned to the manufacturing sector) and for agricultural machines (ascribed to the transportation sector). Therefore, the total global GHG emissions from agricultural production are estimated to actually sum up to a much higher share (ITC and FiBL, 2007). In addition, CO_2 emissions from agricultural soils are not included in the emission balance of the agricultural sector but in the land use, land use change and forestry sector because they originate mainly from land use changes such as deforestation. Although agricultural lands generate very large fluxes of CO_2 to and from the atmosphere, the net flux of CO_2 is small (Smith et al., 2007).

Picture 1: Methane and nitrous oxides are the most important greenhouse gases from the agricultural sector.

Methane and nitrous oxides from the agricultural sector contribute about 47 % and 58 % of total methane and nitrous oxide emissions, with a wide range of uncertainty, however. N_2O emissions from soils and CH_4 from enteric fermentation constitute the largest source, biomass burning, rice production and manure management account for the rest (Smith et al., 2007).

For the Alpine countries, agricultural emissions share of total national GHG emissions varies substantially, from 5 % in Germany to 18 % in France, see Table 2. This is inter alia due to different national energy resource mixes, i.e. France has a high share of nuclear energy resulting in a lower share of emissions from energy production and a higher share of agricultural emissions. Due to the dominance of grassland farming, GHG emissions in terms of methane from enteric fermentation must be considered a relevant source of emission in Alpine agriculture.

Table 2: Shares of greenhouse gases emissions in the Alpine countries.

	Shares 2007
Austria	9.04 %
Switzerland	10.43 %
Germany	5.38 %
France	18.02 %
Italy	6.73 %
Liechtenstein	9.27 %
Slovenia	10.05 %

Source: Eurostat, 2009.

In Western Europe GHG emissions from the agricultural sector are projected to decrease until 2020. This is due to the adoption of climate-specific and other environmentally-related policies in the European Union or to economic constraints on agriculture (Smith et al., 2007). But rising imports of agricultural products from other world regions into the EU contain embedded GHG emissions which are not accounted for in importing countries. They however induce rising agricultural emissions on a global scale. The underlying drivers are higher demands for food, shifting diets towards an elevated proportion of meat consumption, and population growth that together increase nitrogen fertilizer use and raise animal manure production.

3.3 THE IMPACTS OF CLIMATE CHANGE ON THE AGRICULTURAL SECTOR

Climate change impacts and areas of concern are summarized in Figure 1. They are largely relevant for the Alpine arc but differ in terms of occurrence, magnitude and impact between regions.

Figure 1:
Climate change impacts.

Source: Own illustration.

Soil erosion

Soil erosion is one major impact of climate change. Mountainous terrains are specifically prone to soil erosion due to their steepness. Excess water due to intense or prolonged precipitation may cause tremendous damage to soil. Erosion is projected to aggravate with increases in precipitation amount and intensity (EEA, 2008). In general, regions with open agricultural land are more prone to soil erosion than grassland while managed meadows and pastures are considered significantly less erodible than abandoned grasslands (Tasser et al., 2003, ClimChAlp, 2009). Soil erosion in the Alps is a well recognized fact, identified as a priority area for action within the soil protocol to the Alpine Convention.

- Waterrelated effects

Mountain ecosystems are strongly interlinked with the hydrological cycle that has already altered over the past several decades. The shrinking of glaciers, permafrost and snow cover, changes in precipitation patterns and increasing temperatures will increase the competition for water by different sectors, in particular during the summer months when precipitation and run-off is reduced (cf. compact water). Pronounced climatic changes and water conflicts are expected in the Southern Alps. There, groundwater levels in some regions dropped by 25 % over the past 100 years (EEA, 2009). Grassland is highly vulnerable to diminished production in regions with about or less than 600 mm annual rainfall (BMLFUW, 2009). This relates e.g. to innerAlpine areas such as the dry valley of Valais in the Swiss Alps where irrigation for meadows, vineyards and orchards has a long tradition. But it also affects the eastern Alps in Austria as the dry summer of 2003 has shown (Eitzinger et al., 2009).

Picture 2:
It may fly off the shelves:
Changes in precipitation patterns and increasing temperatures will increase the competition for water.

- Changing growing season and shifts in cultivation area

Increasing air temperatures are significantly affecting the duration of the growing season which is mainly influenced by the increase in temperatures in spring and autumn. The impact on plants is reported mainly as a clear trend towards an earlier start of growth in spring and its prolongation into autumn. The same holds for grassland. Earlier snowmelt and later snow fall may extend the period of grazing and enhance productivity. Agriculture in the Alps may as well take advantage from rising temperatures regarding the expansion of cultivation area. E.g. in the upper Vinschgau region apple culture has been introduced displacing vegetable cultures. This shift is triggered by a combination of factors, i.e. the lower risk of winter frosts together with price incentives for apples over vegetable products (Fachhochschule Laimburg).

- Extreme weather events and crop yield variability

As climatic conditions become more erratic (increase in frequency and scope of extreme events like floods, heat waves, and severe droughts) new uncertainties in the future of the agricultural sector must be considered. More frequent drought could result in decreased productivity and declining quality. In permanent grassland, drought might cause formation of gaps in the sward which can be colonized by weeds with negative implications for animal nutrition (Fuhrer et al., 2006). A series of impacts from weather anomalies have been experienced during the summer of 2003 that brought temperatures of 6 °C above longterm means and substantial precipitation deficits. The economic losses for the agricultural sector in the EU were estimated at 13 billion Euro with largest losses in France (Easterling et al., 2007).

3.4 CLIMATE RESPONSE MEASURES IN THE AGRICULTURAL SECTOR

Given the above challenges, agriculture as a sector must adapt to climate change in order to reduce its vulnerabilities and to build resilience to climate change. Mitigation measures often offer synergies with respect to adaptation and should therefore be recognized as complementary climate response measures providing synergies to each other (see Fig. 2).

3.4.1 ADAPTATION: HEDGING AGAINST RISKS AND PRODUCTION LOSSES

Adaptation consists of proactive management strategies that seek to reduce risks and potential production losses from climate change impacts (see Eitzinger et al., 2009). These involve anticipating, planning and long-term thinking, from farm level to transnational level. Adaptation measures may lead to benefits in ecosystem services by high nature value farmland that provides habitat and assists migration for numerous species.

- Sustainable soil and land management

Adaptation requires a higher soil resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). A key element to respond to both problems is to enhance soil organic matter. It improves and stabilizes the soil structure so that soils can absorb higher amounts of water without causing surface run off. Measures to counteract soil erosion should focus on maintaining sustainable farming practices such as low tillage, low manuring and maintenance of permanent soil cover. It conserves the structure of the soil for fauna and related macrospores to serve as drainage channels for excess water, e.g. surface mulch cover can reduce crop water requirements by 30 percent (FAO, 2007, p. 11).

Conservation agriculture[3] or organic agriculture is highly recommended. This practice increases soil organic carbon and reduces the need for mineral fertilizer use. It induces cobenefits in terms of lower GHG emissions. Nutrient-poor grasslands and unfertilized (e.g. not manured) flower meadows support higher organic material in the soil acting against soil erosion. The use of hedges, vegetative buffer strips and other farm landscaping practices have a positive influence to act against the impacts of drought, heavy rains and wind.

Barriers acting against these measures are additional labour and capital input and resulting increased production costs. Given a lower competitive position of mountainous agriculture, public programs and financial support is needed to sustain adaptive soil and land management practices in the Alps. In EU Member States, the program of rural development sets out a relevant framework (EC, 2009a), i.e. the second pillar of the Common Agricultural Policy offers subsidies for investments and incentives for agrienvironmental measures.

[3] Conservation agriculture is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment (FAO 2007).

- Sustainable water management

Freshwater-related issues such as having too much water or having too little water represent key vulnerabilities for the agricultural sector (cf. water compact). A range of management practices and technologies are available to spread and buffer production risks, e.g. multipurpose reservoirs serve for both floods and droughts, and the use of resource efficient irrigation as means of maintaining cropping intensities (IPCC, 2008; FAO, 2007, 12).

Picture 3:
One mode of water management: A school in Laimburg, South Tyrol/I is investigating in new apple varieties that better cope with water scarcity.

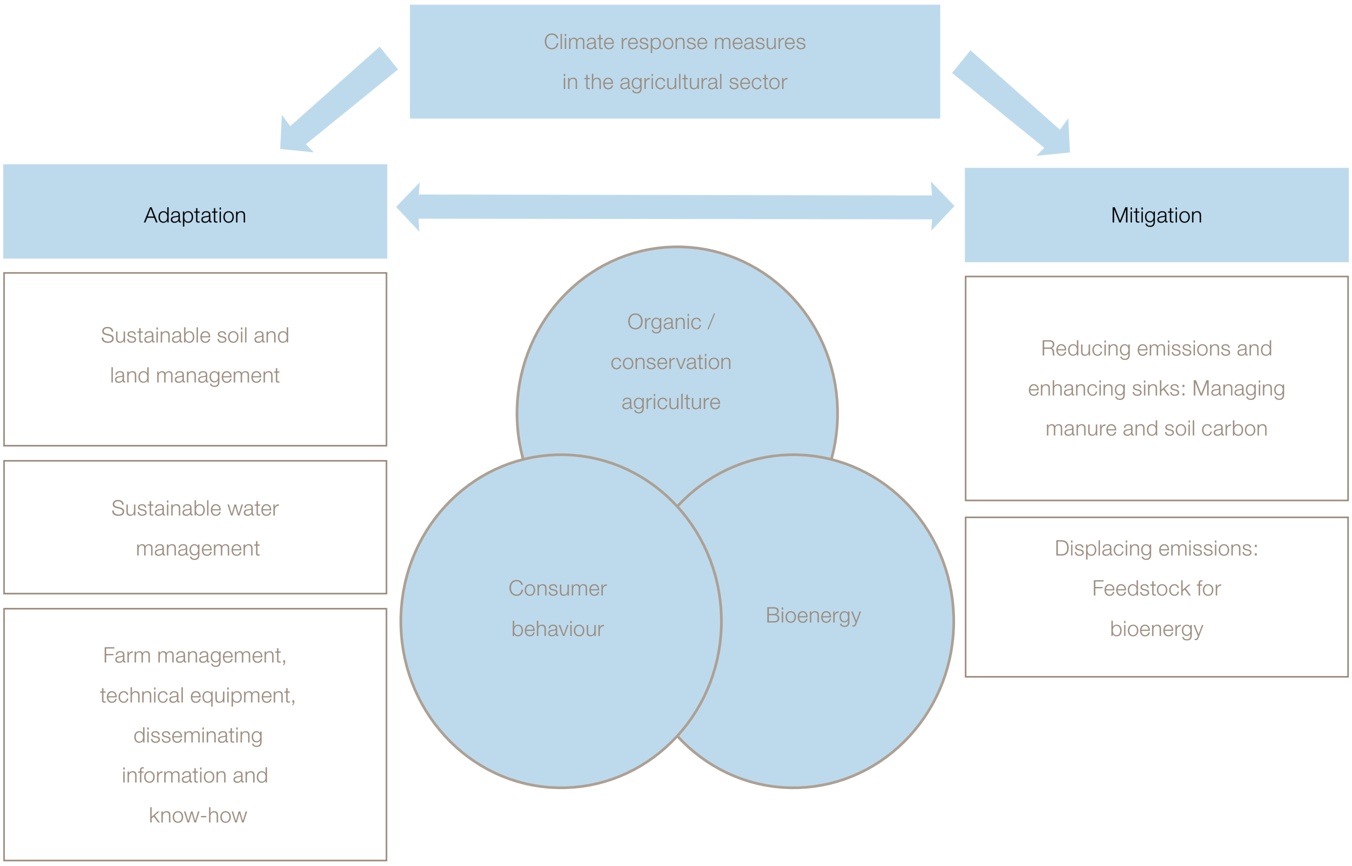
Since 2003, the Southern Alps have experienced dry summers (except for 2008). Therefore new ways of irrigation (like drip irrigation) are introduced to save water in fruit plantations (Research Centre for Agriculture and Forestry Laimburg). An increased construction of water reservoirs for storing irrigation water has been observed in the Bozen and Vinschgau areas. Water reservoirs are perceived to be a practical measure to bypass dry periods. Barriers for this measure concern construction costs, landuse rights or geological conditions (Amt für Gewässernutzung Bozen). Irrigation water demand may be reduced by selecting new crops more suitable to the changing climate, e.g. the professional school of orcharding, viniculture and horticulture in Laimburg, South Tyrol, investigates new apple varieties that better cope with water scarcity.

Grassland affected by drought and reduced water balance, in particular marginal grassland, will show higher yield variability and growing economic risk. Irrigation of grassland should only be considered in regions where abundant water reserves are available. In other cases, investments in alternative supply chains of biomass, e.g. fodder from cropland, can be taken into account with regard to the regional climatic conditions. If not adapted, vulnerable grasslands may suffer substantial economic losses, including related economic subsectors (livestock etc.). Another option could be to shift to livestock production that is less dependent on regional biomass production, i.e. poultry or pigs, together with regional crop production (Eitzinger et al., 2009). Landuse change from grassland to cropland should be avoided as it releases GHG emissions. Abandonment of livestock production and introducing short rotation woody energy crop plantations may be an alternative for grassland use. It may be favourable in terms of GHG emissions (see section 3.4.4) and be supported by general trends of structural change in the EU agricultural policy, e.g. the abandonment of the milk quota regime.

- Farm management, technical equipment, disseminating information and know-how

Farm management decisions regarding adaptation must be taken on a case-by-case basis. Farm management aims at maintaining the production value of the farm and at hedging against risks and production losses. Relevant adaptation strategies mainly deal with the selection of drought and frost resistant crops and fodder plants, animal feed decisions, the choice of fertilizers and pesticide management (if any), water technical equipment, infrastructural measures and insurance to cover production losses (see Eitzinger et al., 2009). The dissemination of relevant information and know-how is a prerequisite. Research, development and knowledge dissemination, e.g. on plant breeding and variety testing, requires support through public authorities, agricultural associations etc. It is yet not clear how far advances in breeding keep pace with increasing extreme weather events.

Figure 2:
CRM in the agricultural sector.



3.4.2 MITIGATION: REDUCING AND DISPLACING EMISSIONS, ENHANCING SINKS

While agriculture's contribution to mitigation will be important, but limited, its effects on agriculture itself, in particular in terms of adaptation benefits will be significant.

- Managing manure and soil carbon

Agricultural emissions of methane and nitrous oxide can be reduced by more efficient management of these flows in agricultural ecosystems. Practices that deliver added N more efficiently to crops often reduce N_2O emissions, for instance technical equipment for precise fertilizer spreading. An overall reduction of external inputs through organic/low-energy farming systems reduces emissions by avoiding emissions intensive manufacturing of fertilizers. Instead, manure as a by-product of milk and meat production should be used as a fertilizer. Manure is a valuable resource for nutrients and an excellent soil amendment to improve soil quality and productivity. However, today manure has become mainly a waste product because farms specialized in livestock do not need manure as fertilizer for agricultural crop production. It is important to treat manure carefully in order to minimize GHG emissions caused by microbial activities during manure decomposition. Main GHG emitted by manure is methane released through anaerobic decomposition of organic matter during storage. Nitrous oxide is emitted during storage and soil application. Additional gases emitted from manure include ammonia (NH_3) and nitrogen oxides (NO_x) which contribute to odour and are indirect sources of nitrous oxide. A general management practice to mitigate methane emissions from manure is to apply it to soils as soon as possible because storing manure for long periods can increase emissions. Several problems are associated with the standard technology of spreading slurry as the emission of gaseous components is very high. Special equipment may reduce these emissions. Slurry tanks that use trailing hoses are spreading manure very precisely and considerably lower gaseous emissions escape compared to spreading jets. A similar technology goes one step further by injecting the manure directly into the top soil thus minimising emissions. This technology has been widely adopted but it is not yet the standard technology in Alpine regions due to the high price (50 % above standard jet spraying tanks). In regions with steep slopes special machines are necessary at even higher costs. Currently, the most effective alternative option of reducing emissions from manure is its energetic use, for example in the production of biogas.

Picture 4:
Manure is a valuable resource for nutrients and an excellent soil amendment to improve soil quality and productivity.

In cropland management, organic (or conservation) agriculture with reduced or no tillage have the highest mitigation potential, especially in carbon-rich soils. Organic agriculture effectively mitigates GHG emissions through efficient nutrient cycles and soil management, using green and animal manure, cover crops and composting, leading to soils that are typically enriched in carbon and soil biodiversity (section 3.4.3). Managing livestock making most efficient use of feeds often reduces amounts of CH_4 produced.

Significant amounts of carbon can be stored in vegetation and soils, e.g. in agro-forestry systems or other perennial plantings on agricultural lands. Soils are the most important reservoir of carbon in the terrestrial biosphere. To raise carbon storage in soil is a mitigation strategy. In Alpine regions grassland farming is dominating agricultural activities. Most grasslands are net carbon sinks (Eitzinger et al., 2009). Significant emissions result from conversion of grassland into arable land and from cropping of soils with high organic carbon content. Avoiding or reversing these land use changes is a highly effective mitigation strategy.

- Feedstock for bioenergy

Crops and residues from agricultural lands can be used as a source of fuel, either directly or after conversion to fuels such as ethanol, biodiesel or biogas (see section 3.4.4). These bioenergy feedstocks still release CO_2 upon combustion but the carbon is of recent atmospheric origin rather than from fossil carbon. The net benefit to the atmosphere is equal to the fossil-fuel derived emissions displaced, less emissions from bioenergy production, transport and procession. Biogas can be produced from methane trapped from covered storage of manure. It may then be used in a generator to produce heat and electricity (see section 3.4.4).

3.4.3 ORGANIC AGRICULTURE AS OVERALL STRATEGY

Organic farming is defined in the Codex Alimentarius of the FAO/WHO (1999) as "…a holistic production management system that avoids use of synthetic fertilizers, pesticides and genetically modified organisms, minimizes pollution of air, soil and water, and optimizes the health and productivity of interdependent communities of plants, animals and people". Organic agriculture has a significant potential for reducing and sequestering emissions of GHG thanks to successful soil carbon sequestration and, at the same time, reduces the vulnerability to climate change. The latter is due to the application of traditional skills and knowledge, soil fertility-building techniques and a high degree of diversity (ITC/FiBL, 2007). Organic farming is thus considered the climate response strategy of choice (see Fig. 2).

Picture 5:
Organic farming minimizes the pollution of air, soil and water, and optimizes the health and productivity of plants, animals and people!

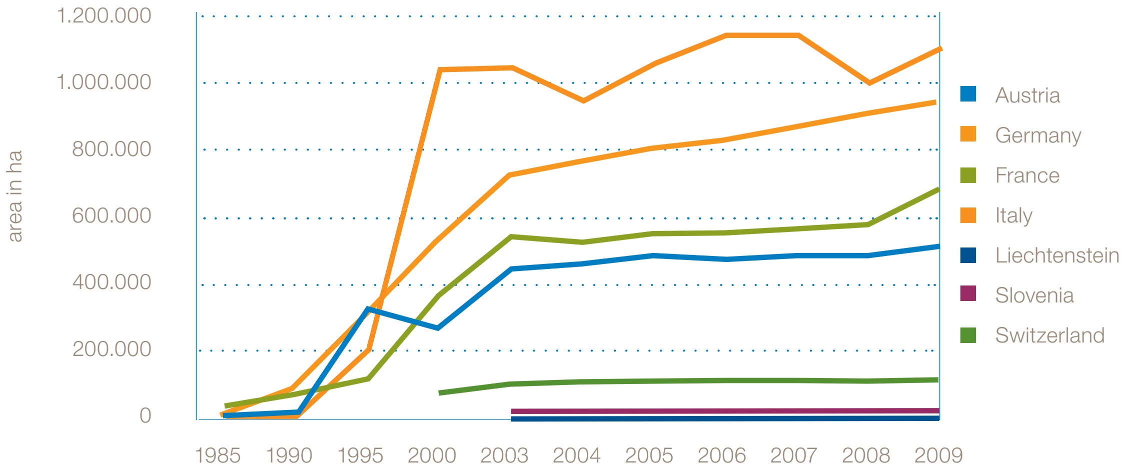
Research has shown that organic plots show higher soil carbon content than conventionally managed farmlands (Müller-Lindenlauf, 2009). In particular in the long term remarkable higher carbon contents were found in organically managed systems. The potential to sequestrate carbon is estimated to amount to 200 to 500 kg C per ha per year for arable and permanent cropping systems (Niggli et al., 2009). The dynamic and scope of carbon sequestration is high in depleted soils, i.e. converting conventionally farmed soils to organically farmed soils has a high carbon storing potential. Organic agriculture supports the integration of landscape elements leading to a further carbon sequestration in plant biomass. High carbon sequestration is given for grassland soils, i.e. the global carbon sequestration potential by improved pasture management is estimated to 220 kg C per ha per year (Müller- Lindenlauf 2009).

The integration of landscape elements and higher soil organic matter contents increase the water capturing capacity of the agricultural system. This lowers the risk of soil erosion and yield losses by extreme weather events. Under dry conditions or water constraints, organic agriculture has shown to be a more robust farming strategy against climate impacts than conventional systems (ITC and FiBL, 2007).

A limited livestock density to prevent overgrazing together with ecological grassland management represents an option for organic livestock production. This is an opportunity for profitable Alpine grassland management as the growing demand for organically produced foodstuff in industrialized countries could offer access to premium prices and thereby higher incomes. Higher prices for organic products can be realized via organic certification schemes addressing consumer's awareness. The development of the organically managed agricultural area in the Alpine countries is depicted in Figure 3 with Italy having the vastest area under organic plough and Germany showing continuous growth in that area.

Figure 3:

Organic (including in-conversion) area in Europe.



Picture 6:

Extensive meat production at an Alpine meadow: Grauvieh cattle in the Stubai-Valley in Tyrol in Austria.

Organic agriculture is, however, often being associated with decreased yields. According to various studies (Niggli et al., 2009) yield reduction could be 30 % to 40 % with respect to intensively farmed regions and tend to zero with regard to less favorable regions like relevant areas in the Alps. Hence the concern of decreasing yields seems irrelevant for marginal Alpine regions.

Organic agriculture does not necessarily result in income loss. First, financial support for organic farming is offered by grants under the EU rural development programs, by legal protection under the recently revised EU regulation on organic farming (since 1992) and by the European Action Plan on Organic Food and Farming in June 2004. Second, there are several business opportunities associated with organic farming. For instance, the economic viability of organic farming may be enhanced continuously by societal trends towards more healthy foodstuffs. It might also be promoted by combining organic farming with eco-tourism. This link offers regional market opportunities maintaining the cultural and ecological landscape in the Alpine region (BfN, 2010). Such a strategy is possibly most successful if promoted vigorously, e.g. by quality campaigns and labeling in the tourist and food sector.

3.4.4 FEEDSTOCK FOR BIOENERGY PRODUCTION

One strategy of the agricultural sector to mitigate climate change lies in the supply of feedstock for bioenergy applications. Currently, this concerns primarily the cultivation of energy crops such as maize, wheat, sugar beets, rapeseeds, sunflowers and soybeans for biofuel production (cf. compact forestry) for heat and electricity. It also concerns the use of biogenic wastes and residues. The use of bioenergy may in certain cases contribute to mitigating climate change by replacing fossil fuels (cf. compact energy). But the promotion of bioenergy use is driven by different underlying aims, e.g. reducing dependence on imported oil and gas to secure energy supply and by creating economic opportunities in rural areas (see European policy frameworks on the promotion of renewable energies (2009/28/EC) and biofuels (2003/30/EC)).

Picture 7:
An uncontrolled expansion of energy crop cultivation could lead to further loss of biodiversity and to rising food prices.

Bioenergy as mitigation measure needs to be treated with care. General propositions about the GHG reduction potential are difficult to derive because the emissions balance of bioenergy production and waste collection depends inter alia on the feedstock, the region, the method of production and on the specific application (transport, heat) and may not in any case exhibit a positive result with respect to the fossil fuel application. For instance, the collection, transport and transformation of biogenic wastes and residues may be too energy intense in Alpine regions due to the scattered distribution of farms.

Whether and to what extent GHG emissions can be reduced by using bioenergy from energy crops depends to a large extent on the land-use change involved. Emissions from converting ecosystems that contain a high proportion of carbon such as forests or natural grasslands, generally negate climate change mitigation effects. In such cases the use of energy crops may even enhance emission release. Direct and indirect land-use changes must be taken into account when assessing the GHG balance. Potential environmental impacts of widespread cultivation of bioenergy crops and feedstocks on water use and nutrients as well as pesticide applications must be considered with care.

Agricultural crops producing sugar, starch and oil are used in both human food and farm animal feed as well as in the bioenergy industry. This raises several concerns about land-use conflicts for food and fuel production, which holds for the limited suitable land in the Alps as well.

The use of non-food materials containing lignocellulose for second generation biofuels is a way to an ecologically benign feedstock supply. Lignocellulose exists in biomass from agricultural co-products and residues such as cereal straw and waste from different sectors such as agriculture, horticulture, forestry etc. Second-generation biofuels are based on the utilization of the whole plant and not only on the oil or starch-containing grains thereby having a higher energy potential and employing less land. They are supposed to be a promising technology for climate protection (Worldwatch Institute, 2007). Further research is yet needed in order to develop this technology ready for the market and to determine what fraction of residue can be removed from the fields. Agricultural residues are important for soil protection and contain nutrients thus serving soil fertility, in particular in organic agriculture. The energetic use of animal and food wastes is suggested to relieve land use competition. Processing animal waste under anaerobic conditions, e.g. in digesters or tanks, to produce methane gas (biogas) is an option to generate heat and electricity, thus to contribute to emissions reduction.

Taking into account that biofuels are liquid sunlight, i.e. plants are used to convert raw solar energy into liquid (ethanol or biodiesel) another trade-off comes into play. One of this is the question whether there is a more efficient way to energy yield per available land, e.g. by photovoltaic (Nelson, 2010; cf. compact energy). Using more efficient forms of converting sunlight as plants such as photovoltaic can release pressure on scarce land resources.

Ensuring the sustainability of bioenergy is important. Comprehensive evaluation schemes to secure an ecologically, socially and economically sound feedstock production must be applied. The EU Directive on renewables establishes criteria for biofuels, i.e. GHG emissions from biofuel use must generate a reduction in GHG emissions of at least 35 % with respect to the relevant fossil fuel alternative (50 % from the year 2017). They shall not be made from raw material obtained from land with high biodiversity value such as primary forest, land with nature protection status or highly biodiverse grassland.

3.4.5 CONSUMER CHOICE AND DEMAND FOR FOODSTUFF

Picture 8:
The change of consumer behaviour can contribute to climate protection.

Different assessments emphasize that merely a combination of innovative technologies and behavioral change in terms of consumer choice will be able to achieve GHG emissions reductions needed for climate protection (Dietz et al, 2009; Meyer, 2009; Reusswig und Greisberger, 2008). Addressing consumer choice as climate response strategy is still an unconventional but potential approach. Buying climate-friendly products, e.g. organic foodstuff may – in the middle to long term – trigger a change of energy-relevant infrastructural and political framework conditions. By changing their choice behaviour, consumers are even able to reduce GHG emissions in a relatively short term.

The diet of consumers and the corresponding demand for food is a central issue of concern for the agricultural sector. Meat and dairy products are more energy intense in production than crops. They are hence considered critical with respect to climate change. Globally, livestock emits 37 % of anthropogenic methane, mostly from enteric fermentation by ruminants, and 65 % of anthropogenic nitrous oxide, mainly from manure. The growing global demand for meat, in particular in emerging and developing countries, is aggravating GHG emissions and the competition for scarce land - the main input to livestock rearing. Feed for livestock is directly competing with crops for humans. Experts have claimed that consuming cereals directly would be more efficient than the conversion from plant to

Picture 9:
Campaigning on a diet that is conscious about the quality of meat and animal treatment could be part of the strategy of greenhouse gas emissions mitigation.

animal nutrients where energy value is lost, i.e. eating vegetarian or eating less meat therefore is advantageous for climate protection. This holds above all for intensive meat production. In contrast, extensive livestock production without external feed and fertilizer input such as in organic farming generates economic value to grasslands and prevents ploughing for arable land or construction thus keeping the carbon stored in soils.

In Western societies, a public debate about the climate consequences of diets heavy on meat has begun. This trend, inter alia triggered by repeated food scandals, also raises issues of the dignity of living beings when handling animals. Eating less meat or eating vegetarian has become a lifestyle in mainly urban-situated and economically well-off social groups. This social development should be enhanced and spread to the whole society in light of substantial amounts of emissions that could be mitigated if both (intense) livestock production and consumption of meat is reduced. Campaigning on the advantages of a diet less heavy on meat or on a diet that is conscious about the quality of meat and animal treatment, i.e. quality products from organic farming in Alpine regions, must be considered a promising low-cost strategy of GHG emissions mitigation.

4 CONCLUSIONS

The Alps are facing a continuous warming. Until the mid-21st century the temperature increase will reach 1.4 °C. But warming will be much faster in the second half of the century (EEA, 2009). Magnitudes vary between Alpine regions with the south-west most affected and the north-east least affected.

For the agricultural sector climate change implies growing concerns for soil erosion and water-related effects such as excess water due to intense or prolonged precipitation or lack of water due to drought. These impacts may cause substantial damage to soils by increasing soil erosion. They reduce soil moisture content and water retention capacity. This causes negative impacts for agricultural and livestock productivity and subsequent production losses.

Adaptation strategies like sustainable soil, land and water management and an adaptive selection of crops represent viable hedging strategies against growing climatic risks and production loss. The Southern Alps are expected to suffer from aridity. This is the region with intense vegetable and fruit production. Here irrigation techniques and water tanks can save water and buffer risks. Enhancing soil organic matter in order to improve the water absorption capacity is recommended as well as selecting crops more suitable to the changing climate. Changed farming practices with regard to low tillage methods reduce the vulnerability of soil.

A key response measure serving both adaptation and mitigation is organic agriculture. It has a considerable potential for sequestering emissions of GHG. Soils under organic agriculture capture and store more carbon than conventionally treated soils. This also holds for grasslands and related organic livestock production. As organically managed soils also store more water than under conventional cultivation, organic farming is making agricultural production more robust against climate impacts. Lower productivity, particularly as substitute for intensive agriculture, renders organic foodstuff less competitive. In order to be profitable, organic agriculture thus needs to obtain a higher price by marketing of quality and climate protection aspects. Financial support for Alpine organic agriculture may be supportive in the transition from conventional to organic agriculture but professional marketing is a more suitable strategy to harness a growing consumer demand for high-quality foodstuff. Linking organic agriculture with eco-tourism offers another promising strategy for the Alpine agricultural sector to hedge against climate change and economic losses.

The production and supply of feedstock for bioenergy production may – under certain conditions – support mitigation strategies. It must, however, be judged critically if land of high carbon stocks is dedicated to feedstock production or if energy use for production is high. Therefore this strategy is recommended only for regions of favorable farmland where land-use conflicts are small and acceptable.

In order to make adaptation and mitigation strategies viable, the dissemination of knowledge, education and advice to farmers is imperative. Awareness towards climate-related impacts of agricultural production, in particular with respect to meat and dairy products, must be triggered on the consumer's side, e.g. through quality initiatives, labeling schemes or information campaigns. A comprehensive political scheme that emphasizes possible synergies of combining mitigation and adaptation strategies and sets equivalent financial incentives can support a transition towards a sustainable Alpine agriculture.

5 EXAMPLES OF GOOD PRACTICE

5.1 ORGANIC FARMING IN THE CANTON GRAUBÜNDEN

In the Swiss canton Graubünden 56 % of the agricultural farms practice organic farming comprising in total 50 % of the agricultural farmland. With these shares, Graubünden ranges top in Swiss, European and even international comparative rankings. Most of the organic farms are situated in higher mountain regions thereby concentrating on grassland management. The organic farms in Graubünden substantially contribute to the regional employment and value creation. Almost 50 % of the workforce employed in the farming sector work on organic farms (about 3,600 persons) and about 1.2 % of the whole economy in Graubünden is generated by organic farmers including direct payments. With 1,250 members "Bio Grischun" is the association of organic farmers in Graubünden. It represents the biggest section of "Bio Suisse". A growing trend towards an increasing market potential for organic products has been recognized, according to a survey among organic farmers in Graubünden. They expect a growth in sales of organic products during the coming five years. The market potential for organic products must, however, be actively exploited by innovative product and marketing strategies. Thus "Bio Grischun" and other associations of organic farming need to advance their PR-activities in this field.

Contact: BioGrischun, www.bio-suisse.ch/de/biogrischun (de),
Bio Suisse www.bio-suisse.ch (de/it/fr/en/es)

Picture 10:
BioGrischun advertises its products with the slogan "Nature heroes. Fresh from the organic farm".

5.2 BACK TO THE ROOTS – A NEW CONCEPT OF ORGANIC LABELLING

Werner Lampert initiated an organic label called "Zurück zum Ursprung" (back to the roots) which is available at the retailer Hofer KG (www.zu-rueckzumursprung.at). He aims at providing high-quality and climate friendly foodstuffs as well as maintaining and supporting traditional Austrian agricultural structures. The label offers a range of products, including dairy products, fruits, vegetables and wheat breads.

In contrary to other organic labels, "Zurück zum Ursprung" goes one step further and, as the sole certificate in Austria, accounts the CO_2-emissions of the products according to international standards. As a world novelty, the assessment is carried out as "life cycle assessment" along the entire supply chain, from the agricultural production, over the processing, packaging, storage to the retail of the product. In particular, the international dimension of land-use change was taken into account. Since July 2009 every "Zurück zum Ursprung" product is labeled with a CO_2-footprint. It was found out that "Zurück zum Ursprung" dairy products save 10 % to 21 %, wheat bread 25 % and vegetables 10 % to 30 % of CO_2-emissions compared to conventional products.

The label won the Austrian award of climate protection (Klimaschutzpreis) from the Federal Ministry of Agriculture, Forestry, Environment and Water Management and the ORF (Austrian Broadcasting) in the category industry and large companies in 2009. The project was first nominated by a jury and then elected by public choice. "The success of the project and the feedback we get makes me very proud", admits Werner Lampert.

Contact: www.zurueckzumursprung.at/co2-und-klimaschutz/klimaschutzpreis-20090/ (de)

Picture 11:
As a world novelty "Back to the roots" is carried out as "life cycle assessment" along the entire supply chain, from the agricultural production, over the processing, packaging, storage to the retail of the product.

5.3 "ZERO KILOMETRES" AGRICULTURAL PRODUCTS

"Zero kilometres"-agricultural products is an Italian initiative having a lot of success among farmers and consumers since it supports the short-distance distribution of local and seasonal fruits and vegetables.

By reducing the distances between the food production sites and the market "the zero km" project assures lower costs of transportation and competitive final selling prices. Coldiretti is the Italian trade union of the small farmers and it supports the project with actions in favour of farmers markets, direct sales to consumers, milk distributors, catering and canteens suppliers placed in the Piedmont and Veneto regions.

To give some examples:

The City of Turin welcomes 41 local markets with over three hundred local farmers that sell their products directly to the consumers;

The Turin Polytechnic is the first large structure that guarantees the traceability of the manufacturers delivering the food to its 1,500 daily users through a short chain network;

Thanks to the "zero km agricultural products" law the Veneto region has authorised the local authorities to promote the consumption of regional products in public canteens, in restaurants and in all the supermarkets; In the Veneto region currently operate 100 "Zero km" agricultural markets, a "zero km" hospital canteen and 30 "zero km" restaurants offering a short distance menu of local products.

Through these activities "Zero kilometres" agricultural products contribute to the reduction of green house gas emissions in the transport sector.

Source: www.veneto.coldiretti.it/km-zero.aspx?KeyPub=GP_CD_VENETO_ATTIVITA|PAGINA_CD_VENETO_KZ (it)

km zero

EXTENSIVE FARMING IN SLOVENIA

The Škerlj farm in the Karst village of Tomaj has an agricultural tradition since the early 17th century. Until 20 years ago, the farm made its living only from winegrowing, fruit and vegetable production as well as bee-keeping. Globalisation of food production on the one hand and a lack of land for intensive farming on the other hand forced the farmer to extend his offer as tourist farm. Milojka and Izidor Škerlj envisioned selling a great variety of their products from the fields and orchards, just beside their house, "packed" as an exquisitely prepared traditional food, accompanied by wine from their own vineyard. Another important ingredient of their offer is the domestic atmosphere, which you can feel at the moment you enter the front door.

Milojka and Izidor Škerlj are aware that extensive farming is friendly to nature. They also know that their bees play an important role for the local ecosystems. But the crown jewel of their contribution to mitigation and adaptation to climate change is the fact that vegetables and fruits are brought home in most cases by a wheelbarrow or simply in a basket. The menu on their farm consists of seasonal crops and products so that most of the food on their table didn't make more than a few hundred meters.

Pictures 12+13:
The crown jewel of Milojka and Izidor Škerlj's contribution to mitigation of climate change is bringing home the vegetables and fruits in a wheelbarrow or simply in a basket.

They are very proud of their home-produced air-dried meat products (pancetta, sausages, salami and of course air dried prosciutto) and seasonal dishes that are homemade (jota, soups from various vegetables, fruit desserts …). And of course typical for the Karst area guests on the farm can enjoy a glass of excellent wine like Teran, Sauvignon, Cabernet Sauvignon or Muscat.

Source: http://travel.nytimes.com/2009/07/05/travel/05explorer.html (en)
Contact: skerlj.tomaj@gmail.com

5.5 FARMING WITH RENEWABLE ENERGIES: LA FERME DU CLOS DE L´ORME

This farm, situated in the Departement of Drôme, 30 km East from Montelimar, is specialized in ovine and carprin breeding (400 ewes, almost as many lambs, 120 goats). The goat milk is sold to the cooperative which transforms it into cheese; a part of the sheep meat is transformed into pastries and pies.

All the ovine breeding respects the requirements of organic farming since 2001 (at that time, the Territorial Contract of Exploitation helped the conversion towards organic farming and the local cooperatives claimed for a larger production of organic meat and milk. These elements have motivated the farmers to change their mode of production), whereas the goat milk production respects the ones of the AOC Picodon. More recently, the cooperative has stopped their organic supply which has motivated the farmers to develop direct farming. Today, all the ovine production (pastries and fresh meat) is directly sold to local consumers.

Pictures 14+15:
Edmond and Fabienne Tardieu favour sustainable agriculture and living.

Renewable energies fully take part in the farm productivity. In 1998, Edmond Tardieu, who has always been interested in renewable energies, decided to implement a "jagged wood" boiler on his farm. Then, he decided to implement a solar forage dryer in order to limit the energy consumption and the greenhouse gases rejections of the farm. An Italian model which recycles the air warmed by the sun on the roof was installed on the farm; this installation even received an award.

The farm also produces "jagged wood" which is sold to private individuals in order to supply for wood boilers. Next, a photovoltaic installation will be installed on the roof of the buildings which will aim at producing 40 kW/h. If its first vocation was the animal breeding, the farm wants now to sensitize a large public to these environmentally friendly practices. Exploring visits of the farm and pedagogical visits with educational activities are provided for families and children groups. Edmond and Fabienne Tardieu also plan to open a rest house for four or six persons in the coming months.

Contact: M. Jamot, Chambre d'Agriculture de la Drôme : +33 4 75 26 99 43
Source: www.fermeduclosdelorme.fr/fr/ (fr)

6 BACKGROUND INFORMATION

- **A current listing of links, further examples, and compacts on other topics is available on www.cipra.org/cc.alps (de/en/fr/it/sl)**

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