Alpine agriculture – future water scarcity and options for agriculture

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Abstract

The Federal Institute of Agricultural Economics (AWI, Austria) takes part in the EU Alpine Space project "Alp Water Scarce". The subproject of AWI tackles the role of agriculture in an integrated water management system with the objective to strengthen the awareness of water consumption. It outlines the risks for agriculture and water systems in climate change scenarios and shows options for an adapted agricultural land use to avoid water scarcity and its negative consequences. Focus is on a regional scale, which enables to get an overview of priorities for adaptation strategies and measures in various alpine regions.

Keywords: Alpine agriculture, water scarcity, sustainable agriculture, climate change

1 Outline and objectives

The Federal Institute of Agricultural Economics takes part in the EU Alpine Space project "Alp Water Scarce", under coordination of Mountain Institute, University of Savoy (FR). The subproject of the Federal Institute of Agricultural Economics tackles the role of agriculture in an integrated water management system to strengthen the awareness of water consumption in agriculture, to show the risks for agriculture in climate change scenarios. In long term the subproject tends to show possibilities for an adapted land use to increase the efficiency of water usage and to avoid water scarcity and its consequences for agriculture. A general risk evaluation defines potential impacts of certain combinations of agricultural land use and regional conditions through developing corresponding indicators of the topics agricultural land use, livestock husbandry, soil conditions and climate. A concrete risk characterisation is done on the example of the Alp Water Scarce Pilot Regions in Austria, Slovenia, Italy, Switzerland and France. Including climate change scenarios this leads to potential adaptation strategies and measures for agriculture which should be integrated in overall strategies for mitigation of water scarcity (www.alpwaterscarce.eu).

2 General impacts of climate change on agriculture

Agriculture is one of the climate sensitive sectors of the national economy. It is linked to climate change in three ways: agriculture can either cause, solve or be affected by climate change. Water consumption in agriculture differs greatly, depending on the actual land use type (grassland, arable land, special crops, vineyards, or-

chards) and type of animal husbandry. Climate change will in general affect the suitability of areas for agricultural use. As a consequence of the many expected regional climate changes – such as higher temperatures, rising evapotranspiration and heat stress, more frequent extreme weather events, varying precipitation and water supplies, decreasing duration of snow cover, changing infestation patterns, higher CO_2 and O_2 concentrations and increasing UV radiation – agriculture will need to adapt to minimize the production risk. The expected changes in the climate will influence vegetation periods as well as the quantity and quality of crops, and will additionally have indirect consequences: such as for harvesting conditions, for availability of water and nutrients, and for the transport, storage and processing of products. Climate change will directly influence livestock husbandry by impacting animal health, growth and reproduction, but also indirectly by affecting the productivity of pastures and forage crops. Agriculture is furthermore linked with up- and downstream industries; as a result, the manifold interdependencies among different economic sectors should be taken into account for measuring the overall effects of climate change. Apart from the direct effects of climate change on agriculture, the different climate and weather conditions will also have consequences for natural hazards, tourism patterns and regional development, all of which may have an additional impact on agriculture, particularly in view of the regional economies.

3 Development of regional indicators for describing water scarcity risks in agriculture

Indicators for water use in agriculture already exist, from the OECD (OECD 2000), and these take into account the change in total agricultural water use as well as the intensity of agricultural water use relative to other users. In addition, the EU developed two indicators within the IRENA system (**I**ndicator **R**eporting on the Integration of **En**vironmental Concerns into **A**griculture): Indicator no. 10 "water use intensity by agriculture," which measures the irrigable area and the type of irrigated crops, and indicator no. 34.3, which measures the share of agriculture in water use. The existing indicators mainly concern irrigation and therefore do not take into account the actual total water use of agriculture, which would be of importance in the Alp Water Scarce project. To meet the project goals, a system of most relevant agricultural indicators was developed and it includes plant cultivation, livestock husbandry, and soil and climate conditions:

- water consumption for plant cultivation: proportions of specific cultivated plants on agricultural land weighted according to the crop coefficient (which comprises evapotranspiration);
- water consumption for livestock husbandry: proportions of specific livestock units weighted according to specific water demand;
- irrigation: proportion of irrigated area on agricultural land;
- soil: proportion of soils weighted according to the capacity of available water in soils;
- climate: regional and monthly aridity (in relation to temperature and precipitation).

Figure 1 shows an overview of the pilot regions and gives information about the various current agricultural land use patterns. While in Swiss and French regions the land use is concentrated on grassland with a high share of low input grassland (alpine meadows) and cattle and sheep farming, in eastern regions (Austria, Slovenia) considerable shares of arable land and poultry and pig farming are to observe. In some south exposed regions higher proportions of land are used for vineyards and orchards (Italy, Austria, Slovenia).

The estimate of future regional climate conditions is based on climate indicators that have been assessed in the RECLIP model, http://foresight.ait.ac.at/SE/projects/reclip/ (accessed: 28/03/2010) for 2050. Future plant cultivation and livestock indicators are based on common agricultural scenarios derived from the literature and expert opinions.

4 Risk characterisation of agriculture due to water scarcity in selected Alp Water Scarce pilot regions

The developed indicator set has been analysed for selected Alp Water Scarce pilot regions to represent a broad range of present and future water-scarcity risk patterns for agriculture. The present situation shows a relatively higher risk of water scarcity due to land use and livestock in the eastern regions of Austria and Slovenia, for example within the Steirisches Randgebirge, Koralpe and Dravsko-Ptujsko. The

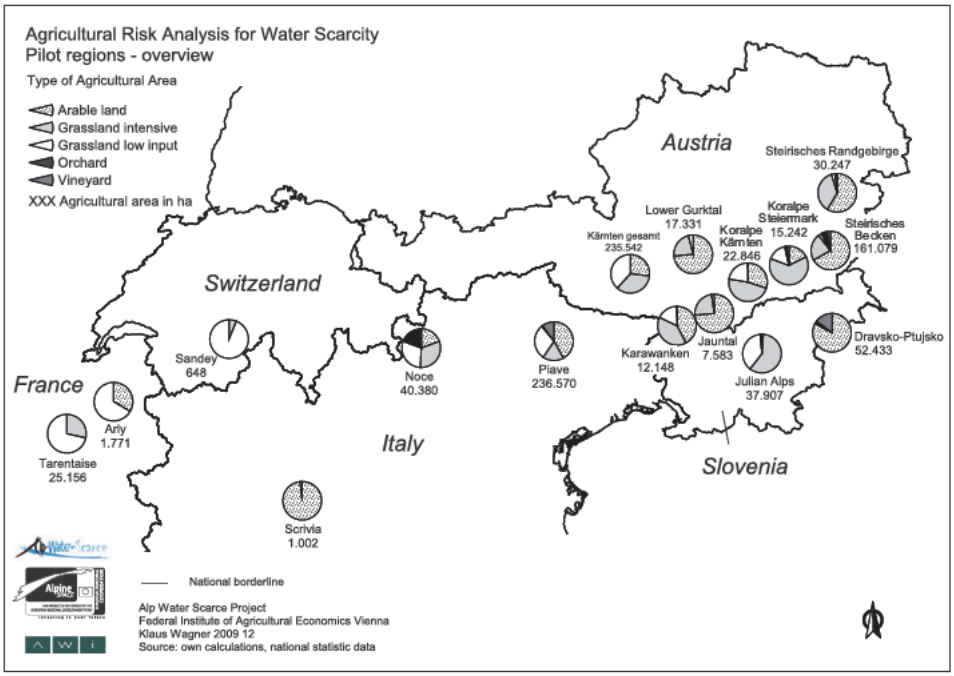

Figure 1: Current agricultural land use in selected Alp Water Scarce pilot regions.

western and southern regions of France, Slovenia and Italy, e.g. Tarentaise, Scrivia, Noce, Julian Alps, are characterised by relatively poorer soil and climate indicators. Especially the Italian regions even now greatly rely on irrigation.

The rough assessment of the future climate situation in 2050 shows that aridity in all pilot regions is expected to increase, though it will differ in extent and seasonality. The western regions (Tarentaise, Arly) will only be affected by a small increase in aridity whilst the eastern and southern regions are expected to experience higher aridity, often in summer and autumn. The most southern region, Scrivia in Italy, will face a strong increase in aridity during summer months, which implies significant worsening because summertime aridity is currently already very high.

The most probable long-term future scenarios for agriculture (until 2030, since a longer term would impair accuracy) indicate a decrease of agriculturally used areas. In general, this means a decrease in water consumption, but the various agricultural land use categories will develop differently. Thus, the intensively used areas in advantaged regions will decrease less than low-input farmland in disadvantaged regions. In some regions, for example in Tarentaise, Dravsko-Ptujsko, Noce, Lower Gurktal and Steirisches Becken, these circumstances will lead to an increased proportion of high water-demand categories and a slightly higher risk classification in the future as compared to the current regional situation.

In addition, livestock will decrease in absolute numbers and will drop the total water consumption for livestock in 2030. Nevertheless, water consumption per ha of agricultural area will grow due to intensified livestock husbandry and a decrease in agricultural areas. This expected development may be of importance in regions where competition for land among the different regional development sectors is high.

In summary, we were able to determine the regions that will be either more or less affected by future water scarcity in comparison to the current situation. In the French region Tarentaise, a slight increase in aridity will be accompanied by a higher risk classification for land use. In the Italian region Noce, a considerable increase in aridity will be coupled with a higher risk classification for agricultural land use. In Scrivia, the land use risk classification will drop slightly, but aridity will increase heavily and the amount of irrigation, which already now is very high, will increase accordingly. The Slovenian region Dravsko-Ptujsko will suffer from higher aridity accompanied by a higher risk classification for agricultural land use. This could be a problem for the production of silage and grain maize, especially since water scarcity appears mostly during a time when plants are most sensitive to its effects. As a result, substitute cultures that are adaptable to the changing water supply will need to be found, including crops that can replace essential cattle feed since cattle breeding is very important to the region. The Austrian regions, too, will face higher aridity, but at least the risk classification of agricultural land use in most of the regions will not increase.

5 Agricultural policy measures with impact on water consumption

The present Common Agricultural Policy (CAP) provides a basic level of income security to farmers, as well as a framework for sustainable management of the natural environment in which agricultural activity takes place. The shift from production-linked support to decoupled aid enables farmers to respond flexibly to external requirements, market signals and developments resulting from climate change. Cross-compliance links the full receipt of CAP payments – including some rural development payments – to the respective EU legislation on environment, on public, animal and plant health, including animal welfare, and on the maintenance in good agricultural and environmental condition of farmed land. Requirements governing the maintenance of permanent pastures, as well as those governing specific soil practices to avoid erosion and retain organic matter, contribute both to the sustainable use of resources and to adaptation. The Farm Advisory System ensures the availability to farmers of advice that is oriented towards the basic environmental requirements. Facilitating farmers' access to risk management tools, such as insurance schemes or mutual funds, also helps them to cope with the economic consequences of greater fluctuations in crop yields, animal diseases or weather events. In the CAP Health Check, Member States have been given the option of using part of their national financial envelopes for risk management tools within CAP support. This represents a further step in the direction of sustainable agriculture with a specific emphasis on climate change mitigation and adaptation, water and biodiversity protection, for which further rural development funding has been agreed to (Commission of the European Communities 2009).

With rural development policy gaining a more important part within the CAP, the Member States are now offered a range of measures providing targeted support for activities that also contribute to adaptation to climate change. The rural development framework can make an essential contribution to adaptation, as farm-level, local and regional adaptation requires a policy environment that strengthens the conditions for adaptation actions. Under the competitiveness axis, support for farm modernisation and the restoration of agricultural production potential can sustain adaptation to climatic change. For example, preventive mechanisms against the adverse effects of climate-related extreme events (e. g. the setting up of hail nets) and the adaptation of buildings (e. g. for housing livestock) can be supported. Improved measures and the development of infrastructure offer possibilities for addressing water management issues, thus complementing modernisation measures that provide support for water saving investments and more efficient irrigation equipment. Support for diversifying crop patterns, structures and agricultural activities, as well as for diversification into non-agricultural activities, is available under axis 2 and 3. This helps make production systems more resilient to both economic and climatic factors, as diversification is a key factor for the stability of agricultural incomes. Within the environmental and land management axis, agri-environmental schemes targeted to better management of soil, water and landscape have an important role. Investing in human capital is an EU priority for rural development, and will also be a key

Table 1: Implementation of Common Agricultural Policy measures (and comparable measures in Switzerland) with potential effects on water consumption in countries with Alp Water Scarce pilot regions.

Measure category	Type of effect related to water scarcity	Austria	France	Italy	Slovenia	Switzerland
Decoupled direct payments	indirect, positive	X	X	X	X	X
Coupled direct payments	direct, positive	X	X	X	X	X
Market regulation measures	direct/indirect, positive/indifferent/ negative	X	X	X	X	X
Rural development – competitiveness	direct, positive	X	-	X	X	X
Rural development – environment and countryside	direct/indirect, positive/indifferent	X	X	X	X	X
Rural development – quality of life and diversification	indirect, indifferent	X	-	X	-	X
Leader	indirect/ indifferent	X	X	X	X	-

Sources: A: Federal Ministry of Agriculture, Forestry, Environment and Water Management data pool, 2010; F, I, Sl: European Union Directorate-General for Agriculture and Rural Development, 2010, information from pilot region project partners; CH Federal Office for Agriculture, 2010.

factor with a view to coping with climate risks. All Member States devote support to training, information and knowledge diffusion oriented to the improvement of farm management, methods for cropping and livestock production and environmental land management. Support can also be provided for setting up farm management and advisory services as well as for their use by farmers. Rural development furthermore plays a role in the conservation and sustainable use of genetic resources. This contributes to maintaining a broad genetic resource base, which in turn can facilitate the selection of genetic material that is resistant to changing diseases and pests, as well as the development of varieties that are more tolerant to heat and water stress.

The implementation of EU CAP measures differs among the countries with Alp Water Scarce pilot regions: Some (France, Italy) maintain a focus on the first pillar and others (Austria, Slovenia) on the second pillar. Concerning water consumption in agriculture, the analyses show there is no focus on agricultural measures which give direct incentives to higher water consumption, but there are a number of measures which are at least indifferent in their effect (on water consumption). Especially in France and Austria, measures whose effect is indifferent comprise between 2/3 and 3/4 of all subsidies; while in Italy and Slovenia the share of measures having an indifferent effect and those having a positive effect are more balanced.

6 Options for adaptation measures

Besides prevention and mitigation strategies for climate change, specific regional adaptation strategies for addressing water supply shortages must be prepared. Adaptation actions should be taken to cope with a changing climate, and these must aim at reducing the risk and damage from current and future harmful impacts. The report of the Intergovernmental Panel on Climate Change (IPCC 2007), which serves as the underlying framework of the Alp-Water-Scarce project, stresses the important role of research and development policies, institutional reforms, land tenure and reform, training and capacity building, and financial incentives, including insurance systems, in coping with climate change.

Strategies and measures may work on different levels of implementation – from general EU policy objectives down to practical farm management advisory recommendations. Early action will bring clear economic benefits by anticipating potential damages and minimizing threats. Market forces alone are unlikely to lead to efficient adaptation because of the high degree of uncertainty in climate projections. Adaptation measures will involve all actors, starting with individual citizens and through to local, regional, national and EU-level stakeholders.

Adaptation strategies must take into account socioeconomic constraints that vary widely depending on production systems, types of cultivation and the competitive situation regarding water consumption vs. other sectors, but also depending on the level of intervention. The mapping of vulnerable areas, hazard assessments, forecasting and appropriate spatial planning should serve as a basis. Especially in the case of agriculture, it makes sense to integrate adaptation goals directly into the Common Agricultural Policy (CAP). The EU paper on adapting to climate change (Commission of the European Communities 2007) formulates four pillars of EU actions:

- early action in the EU, to mean integrating adaptation when implementing and modifying existing and forthcoming legislation and policies, including into funding programmes. In the case of agriculture, climate change will add to the pressures of liberalisation and international competition. The role of agriculture as a provider of environmental and ecosystem services will gain further importance;
- integrating adaptation into EU-external actions, to mean influencing EU relations with third countries;
- reducing uncertainty by expanding the knowledge base through integrated climate research;
- involving European society, business and the public sector in the preparation of coordinated and comprehensive adaptation strategies. This could provoke significant restructuring, especially in the agriculture, renewable energy and tourism sectors.

The scientific literature offers no unanimous judgement as to whether autonomous (private sector) adaptation or planned public sector measures are most effective (Schaller & Weigel 2007). However, in every case, adapted extension services, policy options, monitoring and management plans are deemed essential. Concrete actions

Table 2: Potential water scarcity adaptation and mitigation measures in agriculture, source: own compilation.

Strategy	Arable land measures	Grassland measures	Livestock measures
1. Land / stable management, soil cultivation	Adapted nutrient, weed and pest management; adapted growth regulators; technologies for conservation of soil moisture (conservation tillage, mulching, organic); landscaping measures; adapted crop calendar (earlier sowing of spring crops, later sowing of winter crops, early ripening varieties).	Adapted nutrient, weed and pest management; mowing times and grazing systems; landscaping measures.	Adapted grazing system; adapted stable systems.
2. Intensity	Adapted nutrient management; plant density; reduced yield levels.	Adapted nutrient management; reduced mowing frequency.	Reduced livestock density; extensive grazing management; nutrient management.
3. Varieties, species	Adapted varieties or species; enhancement of seed banks.	Adapted varieties or species with higher drought tolerance; enhancement of seed banks.	Less water intensive species.
4. Commodity	Adapted crop rotation (increased use of winter crops, perennial plants and C4 crops); reduction of bare fallow; abandonment.	Adapted production system; temporary grassland; transformation of land use.	Replacing high water demand species (hog, poultry) with less demanding (cattle).
5. Farm management	On farm water collection facilities and reservoirs; Terracing, land contouring and furrow diking; hedge planting; farmers education and advice; weather risk management (e. g. insurance systems).		
6. Water management	Irrigation and its efficiency; water pricing.		
7. Policy and administration	Ecolabels for efficient water use; Integration of adaptation goals into CAP; improvement of knowledge and data on water scarcity and forecasting, promotion of technological innovation; contingency planning for droughts, elaboration of risk mitigation plans; user-pays-principle and efficient water pricing schemes; legal restrictions of water use and rationing of water; appropriate planning and dimensioning of agricultural infrastructure; establishment of technical standards; river basin planning and coordination; awareness raising, education; voluntary compliance, information and participation of stakeholders in order to develop a "water-saving culture"; evaluation and monitoring of measures.		

could include soft and inexpensive measures, for example drought tolerant crop varieties, land use planning, awareness raising, direct seeding during winter planting and measures to change farmers' attitudes and provide them with advice. Several recent research results give hints to options for farmers. Of course, important determinants are land-use systems (conventional, integrated or organic), plant cultivation measures, the selection of species in crop rotations, plant and livestock density, yield

and fertilising levels, and management and soil cultivation (WIFO 2004). In detail, measures need to ensure irrigation efficiency (reduced water losses, recycling and better storing of water) and water-efficient techniques to conserve soil moisture, as well as modification of crop calendars with respect to timing, location and cropping activities (Bates et al. 2008; Commission Of The European Communities 2009). Also important are nutrient, weed and pest management methods (Schönberger 2008; Kromp-Kolb 2004) as well as mowing times and grazing systems (Schaumberger & Buchgraber 2008). Landscaping measures can provide better protection against wind and water erosion, and evapotranspiration (Eitzinger 2007; ADAGIO 2009), while implementing buffer zones can reduce water run-off (European Environment Agency 2009). In addition to their water saving potential, these measures would help farmers save working steps and money. Adaptation can also bring about new economic opportunities, such as adapting local agricultural management practices to longer growing seasons (Commission of the European Communities 2007). At the same time, costly climate defence and relocation measures may also be necessary. Changes in crop rotations may have wide consequences on the farm system, animal production and, in the long term, on the regional economy and landscape. Table 2 provides a structure of possible agricultural measures.

7 Conclusions

The project results outline the importance to take the specific regional situation into account when adaptation measures in agriculture to climate change should be drafted. The natural conditions as well as the man-made land use show a lot of variations and the prognosticated effects of climate change differ accordingly. In general the impacts seem to be more serious in southern and eastern alpine regions where agriculture already now depends on irrigation to a considerable amount. A lot of agricultural policy measures take influence on the land use, some of them have explicit negative effects on water saving in agriculture like export refunds, levies, market interventions but it is not possible to assign them directly and regional specific. Only few of the measures have explicit positive effects. Up to now mostly erosion, water quality, landscape and economic measures are in the focus of agricultural policy. Water saving objectives and measures should be increasingly implemented in future. Some measures are easy to achieve in terms of their management and economic impacts especially in combination with existing agro-environmental measures.

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