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**FRAGILE ECOSYSTEMS AND SCARCE RESOURCES MEET
GROWING FOOD DEMAND: IS “BUSINESS AS USUAL” LAND USE
AN APPROPRIATE LONG-TERM SOLUTION
FOR THE ALPINE COUNTRIES?**

SUMMARY

The Alpine region is exposed to two major challenges in terms of sustainable agriculture: 1) topographical conditions constrain the area, which can be used for agricultural production and 2) the Alps have suffered a dramatic loss of biodiversity in the last few decades. This loss is to great extent caused by a) intensified use of agricultural land in high-yielding areas (e. g. excessive nitrogen depositions) and b) abandonment of agricultural areas with low productivity. In the near future, these challenges are expected to amplify, as the Alpine region will have to contribute to a growing global food demand. In order to find anchor points which help to tackle these challenges a qualitative system analysis was conducted to identify and analyze the variables which influence agricultural land use in Austria, Liechtenstein and Switzerland. Results suggest that our Alpine land use system exerts an enormous pressure on the level of certain variables. If current trends of land use continue, levels of the variables “ecological quality of agricultural areas” and “attractiveness of landscapes” will most likely decline. Contrarily, the level of “land use intensity on arable land and grassland” will increase further. This shows an imminent need to substantially change land use especially if we seek for long-term food security and conservation of natural resources.

Key words: land use, food production, ecosystem services, Alpine region, qualitative system analysis

INTRODUCTION

Soil is the most sensitive and valuable natural capital of mankind (Haber and Bückmann, 2013). It is a scarce resource and the basis for growing food. In order to contribute to increasing food demand, the Alpine region is exposed to two major challenges. Firstly, topographical conditions in the Alps constrain areas, which can be used for agricultural production (Stöcklin et al., 2007).

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Secondly, the Alps have already suffered a dramatic loss of biodiversity (BAFU, 2015). This loss is to great extent caused by a) intensified use of agricultural soils in high-yielding areas (e.g. excessive nitrogen depositions) and b) abandonment of agricultural areas with low productivity (European Commission, 2008). In times of a globally growing population, which is causing increasing food demand combined with a changing climate, it is important to preserve ecosystem services especially those in ecologically fragile zones. In order to improve our knowledge of the Alpine land use system, variables which are influencing this system have to be identified and analyzed. This is described in the following paragraphs.

MATERIAL AND METHODS

In order to find anchor points which help to tackle the challenges described above, a qualitative system analysis (Scholz and Tietje, 2002) was conducted. This analysis helped to identify and examine the variables which influence land use in Austria, Liechtenstein and Switzerland. Based on a qualitative assessment 30 variables were selected. These variables were assigned to different categories (see Table 1). In a workshop, conducted in March 2014, experts from Austria and Switzerland reviewed these variables and assessed levels to which these variables impact each other. Subsequently, these variables and their interrelationships (impact matrix) were analyzed with the software SystemQ. Essential analysis routines of this software are a) the system feedback and b) the effectiveness analysis. Under a) we could estimate the level of pressure that our land use system exerts on different variables under the assumption that “business as usual” land use will continue in the Alpine Region while under b) we could define the potential of variables qualifying as a suitable starting point for policy measures fulfilling a predefined sustainability objective.

RESULTS AND DISCUSSION

Figure 1 shows the feedback of our land-use system in the Alpine countries – displaying the degree of change (bar size) and the direction of change (increase (+) or decrease (-)). It demonstrates how the level of different variables will change up to 2030, if “business as usual” land use continues. As figure 1 reveals, our Alpine land use system exerts a relatively high pressure on specific variables acting as “receivers”. If current land use practices and trends continue, levels of the variables “land use intensity on arable land” and “land use intensity on grassland” will most likely increase. Consequently, levels of the “ecological quality of agricultural areas” and “attractiveness of landscapes” can be assumed to further decrease.

In order to identify anchor points for influencing land use change, it is necessary to define an objective of sustainability. For instance soil protection is one of the main components of sustainable land use (Haber and Bückmann 2013). Therefore, a suitable sustainability objective may be defined as to improve the level of “ecological quality of agricultural areas”. The effectiveness analysis showed that such an improvement could be achieved by enhancing the variables

“self-initiative of local stakeholders” and “resource conserving agricultural land management”. For this, it is necessary to provide appropriate and specific policy measures at national and regional level.

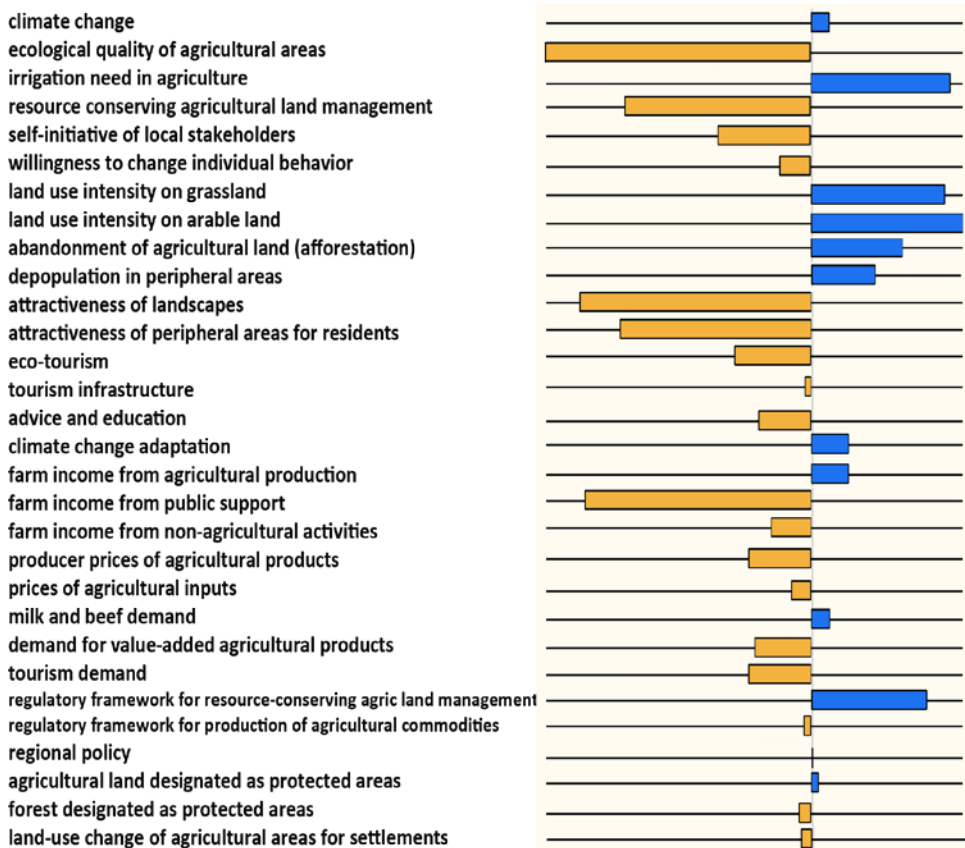


Figure 1. System Feedback

Table 1: Variables and Definitions

| | Name, High Level/Low Level, Current State | Definition |
|--------------------|---|--|
| Biophysical System | Climate Change High Level: More climate change Low Level: Less climate change Current State: Medium/High (+1) | Changes in the climate related production conditions for agriculture |
| | Ecological Quality of Agricultural Areas High Level: High quality Low Level: Low quality Current State: Medium/Low (-1) | Quality of utilised agricultural areas with respect to natural habitats and the connecting elements for flora and fauna with respect to biodiversity, ecosystem services, soils and soil condition, and resilience |
| | Irrigation Need in Agriculture High Level: Large need Low Level: Small need Current State: Medium/High (+1) | Irrigation need for the production of agricultural commodities |

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| Social System: Individual Actor | Resource Conserving Agricultural Land Management High Level: High degree of implementation Low Level: Low degree of implementation Current State: Medium/Low (-1) | Degree to which farmers implement agricultural land management strategies to support and enhance resource conservation and ecosystem services (land use) |
| | Self-initiative of Local Stakeholders High Level: Large initiative Low Level: Little initiative Current State: Medium/Low (-1) | Own and collective initiatives to try out and realize own innovations (technologies, ideas etc.) |
| | Willingness to change Individual Behavior High Level: High willingness Low Level: Low willingness Current State: Medium/Low (-1) | Value change in civil society: willingness to change personal behavior, e. g. eating habits, gentle tourism, avoidance of waste and supporting resource conserving production |
| | Land Use Intensity on Grassland High Level: High land use intensity/high livestock density Low Level: Low land use intensity/low livestock density Current State: +1 | Land use intensity of grassland use in terms of livestock density (cattle, sheep, goats) |
| | Land Use Intensity on Arable Land High Level: High land use intensity/high N and P input Low Level: Low land use intensity/low N and P input Current State: Medium/High (+1) | Land use intensity of arable land in terms of N and P input |
| | Abandonment of Agricultural Land (Afforestation) High Level: High abandonment of areas or rather dense afforestation Low Level: No abandonment of areas or rather no afforestation Current State: Medium/High (+1) | Abandonment of agricultural land is leading to afforestation |
| Social System: Society | Depopulation in Peripheral Areas High Level: High migration, particularly of the young people Low Level: Low migration Current State: Medium/High (+1) | Decrease in population in peripheral areas |
| | Attractiveness of Landscapes High Level: High attractiveness Low Level: Low attractiveness Current State: Medium/High (+1) | Attractiveness of landscapes for entire population |
| | Attractiveness of Peripheral Areas for Residents High Level: High attractiveness Low Level: Low attractiveness Current State: Medium/Low (-1) | Attractiveness of peripheral areas for residents is determined by accessibility, infrastructure, perception of landscapes/scenery and cultural identification of the residents with the mountainous areas |
| | Eco-Tourism High Level: Good balance or rather gentle tourism Low Level: Bad balance or rather non-gentle tourism Current State: Medium/Low (-1) | Balance between intervention in environment and culture for touristic use and perception of the attractiveness of the landscape |

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|------------------------|---|---|
| Social System: Economy | Tourism Infrastructure High Level: Large infrastructure (if necessary on stock) Low Level: Little infrastructure Current State: Medium/High (+1) | Infrastructure for tourism is expanded (buildings, streets, accessibility) |
| | Advice and Education High Level: Broad advice and education offers Low Level: Small advice and education offers Current State: Medium/High (+1) | Private and public advice and education for resource conserving and ecosystem service oriented agricultural land management |
| | Climate Change Adaptation High Level: Actors take more stronger actions for climate change adaptation Low Level: Actors take more weaker actions for climate change adaptation Current State: 0 | Actions taken by actors to adapt to biophysical changes in the environment as a result of climate change. The actions taken by the actors comprise of: adapted land use systems, growing of different crops, barrier woodlands maintenance, shelters etc. |
| | Farm Income from Agricultural Production In monetary terms (CHF/EURO): High Level: High income Low Level: Low income Current State: Medium/High (+1) | Farmers' income from agricultural production |
| | Farm Income from Public Support In monetary terms (CHF/EURO): High Level: High income Low Level: Low income Current State: Medium/High (+1) | Farmers' income from governmental support |
| | Farm Income from Non-Agricultural Activities In monetary terms (CHF/EURO): High Level: High income Low Level: Low income Current State: Medium/High (+1) | Farmers' income from non-agricultural activities |
| | Producer Prices of Agricultural Products High Level: High price Low Level: Low price Current State: Medium/High (+1) | Producer price for agricultural products |
| | Prices of Agricultural Inputs High Level: High price Low Level: Low price Current State: Medium/Low (-1) | Prices for agricultural inputs including feed, fertiliser, energy, plant protection. |
| | Milk and Beef Demand High Level: High demand Low Level: Low demand Current State: Medium/High (+1) | Demand for milk and beef products |
| | Demand for Agricultural Products with added-value High Level: High demand Low Level: Low demand Current State: -1 | Demand for agricultural products (food, wood) with added-value e.g. resource conservation, fairness, healthy, regional |

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| | Tourism Demand High Level: High demand from many tourists with high willingness to pay Low Level: Low demand from a few tourists with low willingness to pay Current State: Medium/High (+1) | Domestic and international demand for summer and winter tourism |
| Social System: Policy | Regulatory Framework for Resource-conserving Agricultural Land Management High Level: Regulatory framework supports resource conserving agricultural land management Low Level: Regulatory framework hampers resource conserving agricultural land management Current State: 0 | The regulatory framework set by the government (regulations, incentives) support development towards resource conserving agriculture |
| | Regulatory Framework for Production of Agricultural Commodities High Level: Regulatory Framework supports production of agricultural commodities Low Level: Regulatory Framework hampers production of agricultural commodities Current State: Medium/High (+1) | The regulatory framework (regulations, trade barriers) supports or hampers the production of agricultural commodities (e.g. in Switzerland to improve food supply security) |
| | Regional Policy High Level: High support Low Level: Low support Current State: Medium/High (+1) | Peripheral areas are supported through regional policies of the federal states or Cantons respectively in areas such as policy to housing, social infrastructure, culture, tourism, transport, employment, information exchange |
| | Agricultural Land designated as Protected Areas High Level: Large agricultural areas are designated to protected areas Low Level: Little to none agricultural areas are designated to protected areas Current State: Medium/Low (-1) | Government designates utilised agricultural areas to protected areas with restrictions for agricultural production (e.g. extensive grassland as defined by Swiss agri-environmental measures) |
| | Forest designated as Protected Areas High Level: Large forest areas are designated to protected areas Low Level: Little to none forest areas are designated to protected areas Current State: Medium/Low (-1) | Forests are designated to protected areas with restrictions in forestry use |
| | Land-Use Change of Agricultural Areas for Settlements High Level: High abandonment of agricultural areas Low Level: No abandonment of agricultural areas Current State: Medium/High (+1) | Utilised agricultural areas are abandoned and converted to areas for settlement and infrastructure |

CONCLUSIONS

This study reveals an imminent need to substantially change land use in the Alpine region especially if we want to contribute to long-term food security and conservation of natural resources. It is important to strengthen self-initiatives of local stakeholders and promote resource conserving agricultural land management such as organic agriculture. In addition, it is recommendable for the alpine region to focus on high value agricultural products, as mass scale commodity products will not pay for the higher cost of preserving ecosystems. In a forthcoming step, we will use our results of this qualitative system analysis in a global land use model (Schader et al., 2014) to quantitatively assess effects of several sustainable land use options in the Alpine region. One of these land use options will be an adoption of pure forage consuming cows which will not be fed on imported soybean meal.

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