Future of Mountain Agriculture in the Alps

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1 Introduction

In the European Alps, a total of roughly 18 % of the area is farmland and a further 18 % is covered by natural and semi-natural grassland (EEA 2005). In total, about 31.4 % of the Alps, with a surface area of 190,600 km^2 (Streifeneder 2010), are still used for agricultural purposes. Therefore, agriculture has a great responsibility for these areas and, by cultivating arable land, fields and pastures, makes an important contribution to the maintenance of a diversified cultural landscape in the Alps. However, there are marked differences between the eight Alpine states, Monaco, France, Switzerland, Italy, Germany, Liechtenstein, Austria and Slovenia: While almost half of the German Alpine area is used for agricultural purposes, in Italy only 25 % and in Slovenia less than 20 % (Tappeiner et al. 2008) is cultivated. From a proportional point of view, the largest Alpine areas are located in Austria (29 %), Italy (27 %) and France (21 %) (Streifeneder 2010).

Mountain agriculture in the European Alps has undergone considerable changes during the last 50 years. Compared to other mountain areas, such as the Andes or the Himalaya, the European Alpine area is influenced by four important factors which must be considered when analysing the development of mountain agriculture and its social significance: (1) The European Alpine regions are part of highly-

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developed countries with, from a global point of view, an above-average degree of prosperity (IMF 2012). The tertiarisation is well advanced in the Alpine countries; on a country level the agricultural sector only holds a share in overall employment of between 2.4 (Germany) and 9.1 % (Slovenia) (PSA 2007). (2) The majority of the population in the European Alpine countries lives in cities or urban areas. In addition, there is a tendency for the population to concentrate in regional centres. The urban population and the fact that rural populations exhibit an increasing social orientation towards urban life have a significant influence on future development of mountain areas. In this context Messerli et al. (2011), even contend that the urban population, with its lifestyle and leisure activities, has a stronger influence than the population living in the Alpine region. At the same time, the mountain regions and agriculture are increasingly dependent on financial transfers and thus on the economic performance of the business centres (Weiss Sanpietro et al. 2004). (3) Due to the on-going economic development, agriculture is undergoing a progressive structural change accompanied by a reduction of the production factors labour and land. According to Schermer and Kirchengast (2006, p. 43), market integration of mountain agriculture leads to a switch of agriculture from a way of life to a form of business. Although rapid progress has been made in the mechanisation and rationalisation of mountain agriculture since World War II, the sector is unable to withstand the pressure of competition from more favourable locations due to the cost disadvantages resulting from its climatic, topographic and basic structural conditions (Schermer and Kirchengast 2006). (4) In the Alpine countries, the contribution to food security generated by agricultural commodities is of limited importance and is becoming smaller and smaller (Lauber 2006). Thus, the production potential of mountain agriculture is currently not fully exploited. This is in contrast to a more global perspective, since food security is at risk for 40 % of the mountain population worldwide (SAS 2012). The relatively low importance of production in the Alpine region can be explained by the switch from production designed to ensure self-sufficiency to market-orientated production which took place in the middle of the last century (Tasser et al. 2011).

In contrast, the multifunctional services provided by mountain farming in Alpine areas are becoming more and more important (Streifeneder 2010). The concept of multifunctionality is one of the central elements for the support for mountain agriculture in the European Union (Shucksmith et al. 2005), as well as in Switzerland (FOAG 2004) and Liechtenstein. At the same time, the optimisation of multifunctional services provided by mountain farming is a major objective of the mountain agriculture protocol of the convention on the protection of the Alps (Alpine Convention), which strives to achieve comprehensive protection and sustainable development of the Alps (Alpine Convention 1991). The objective to maintain and support the cultivation of traditional farmland and a form of agriculture which is compatible with both the location and the environment is based on the conviction that "by virtue of its wealth of natural resources, water resources, agricultural potential, historical and cultural heritage, value for quality of life and for economic and leisure activities in Europe and the transport routes

crossing it, the Alpine region will continue to be of vital importance, particularly for the local population but also for the population of other regions," (Alpine Convention 1991, p. 2). In particular, the latter also covers tourism since, especially in industrialised countries, the mountain regions are important tourist destinations. In fact, die Alps are the world's second most important tourist region (SAS 2012) with over 540 million overnight stays per year.

This contribution explores the question of the development of mountain agriculture in the European Alpine region, both up till now and in the future, and the associated impact on the multifunctional services it provides. In the context of the specific situation and importance of the Alpine area, precedence is given to the ecosystem services which are incorporated into the overall concept of multifunctionality and which are linked to the utilisation and maintenance of open farmland as well as to the interaction between agriculture and the environment (Huber et al. 2012a). This contribution is designed as a meta-study and summarises the state of knowledge regarding the development and future of agriculture in the European Alps.

The answers to the questions raised are based on (a) a description of structural changes in agriculture in the Alpine area in recent years (Chap. 2); (b) a review of publications in the last few years on the subject of developments in mountain agriculture and the multifunctional services associated with land-use (Chap. 3); (c) as well as a compilation of model-based studies assessing the impact of (global) scenarios on land-use in the Alps (Chap. 4). Context-specific fields of action for mountain agriculture are identified, giving due consideration to future economic, natural and political basic conditions and the anticipated development in the Alpine area (Chap. 5).

2 Development of Agriculture in the Alps Since 1980

From a historical point of view, mountain agriculture and land-use in the European Alps has been undergoing continuous change for some considerable time (Siegl and Schermer 2012). From 1850 onwards, momentous political, economic and social changes accelerated the structural development of mountain agriculture. Between the beginning of the twentieth century and the end of the 1970s, the share of the population employed in agriculture sank in most Alpine areas from 70 to under 10 %. Over the last 30 years, changes have been modest when compared to the tertiarisation of the economy during this time. However, developments over this period show clearly the difference in the development of various regions with their specific natural and socio-economic characteristics. It is precisely these developments that form an important basis for the evaluation of short- and medium-term prospects for mountain agriculture in the Alps.

In spite of a wide range of regional, agricultural and environmental policy measures, the transition in mountain regions and mountain farming in the Alps has continued since the 1980s. Low incomes, a lesser degree of innovation in

Table 1 Structural change in the Alpine part of the countries

Country	Number of farms 1980	Number of farms 2000	Change of farms 1980–2000 per year (%)
Austria	109,554	96,205	−0.7
Switzerland	37,256	24,546	−2.1
Germany	29,041	22,017	−1.4
France	52,647	28,128	−2.9
Italy	165,607	93,046	−3.2
Liechtenstein	358	191	−3.1
Slovenia	53,089	23,149	−4.3
Alps	447,552	287,282	−2.2

Source Streifeneder et al. (2007)

comparison with other economic sectors, limited flexibility, tough global competition and the unfavourable topographic conditions cause potential successors to give up agriculture and mountain farms are abandoned. In some European regions, the high rate of abandonment has practically led to a collapse of agricultural structures and land-use, while in other regions structures and utilisation are only changing slowly.

Within the Alpine region there are significant differences at both regional and community level with regard to the development of farm structures, but also more particularly with regard to land-use. Although there are numerous local and regional peculiarities which influence the small-scale development of abandoned utilised areas and reforesting in suitable locations, favourable locations are less likely to be reforested than low-yield sites which require a lot of maintenance.

Viewed as a whole, between 1980 and 2000 the number of farms in the Alpine area went down by over a third, to 287,000 farms with at least one hectare of utilised agricultural land (Streifeneder et al. 2007). In particular, a great number of farm abandonments were recorded in a large part of the Italian Alps as well as in the French and Slovenian Alpine regions. On the other hand, the lowest number of abandonments was observed in the German and in particular the Austrian Alps (Table 1).

The trend to a declining number of farms continued in the decade up to 2010. Thus, for example, the number of farms in the Swiss mountain area sank by 1.7 % (Federal Statistical Office 2011) per year between 2000 and 2010, while in Austria the number of farms in the mountain area went down by 1.2 % per year between 1999 and 2010 (Statistics Austria 2012). Based on the evaluation of Streifeneder (2010) for the period 2000–2007, the decline in the number of farms in Italy, France and Germany in the decade up until 2010 is probably higher than in Switzerland and Austria. Regions with stable agricultural structures confront regions in the western and southern Alpine area where the dynamic structural development identified in 1980 continues unabated.

The abandonment of farms and the decline in the labour-force employed in agriculture lead to changes in land-use (Table 2). According to Streifeneder

Table 2 Development of utilised agricultural land in the Alpine region

Country	Utilised agricultural land 1980	Utilised agricultural land 2000	Change in utilised agricultural land 1980–2000 (%)	Change in number of farms 1980–2000	Agro-structural type Streifeneder et al. (2007)
Austria	1835369	1734369	−5.5	−12.2	Well performing region
Switzerland	805360	791938	−1.7	−34.1	Well performing region
Germany	511996	505433	−1.3	−24.2	Well performing region
France	84,9389	858650	1.1	−46.6	Uncorrelated structural change
Italy	1502027	1254044	−16.5	−43.8	Dynamic structural change
Liechtenstein	3634	3,593	−1.1	−46.7	Average structural change
Slovenia	210751	137566	−34.7	−56.4	Dynamic structural change
Alps	5718526	5285601	−7.6	−35.8	

Source Streifeneder et al. (2007)

(2010), the utilised area in the Alps sank by 7.6 % between 1980 and 2000. Slovenia and Italy had the highest decline in utilised area. In contrast, the utilised area of agricultural land in Liechtenstein, Switzerland and Germany remains practically stable or, in the case of Austria, falls slightly. However, there has been a clear drop in the utilisation of alpine pastures and unfavourable agricultural areas, as shown by the ongoing increase in reforestation (MacDonald et al. 2000). An investigation in the Swiss Alpine region reveals that new areas of scrub and forest are situated mainly on summer grazing pastures and in the uplands whereby this applies primarily to slopes or steep locations which involve a lot of labour or to poorly or undeveloped sites (Gellrich and Zimmermann 2007). The discrepancy between the decline in the agriculturally utilised area and the number of farms is a direct result of the marked increase in the average land area utilised by the remaining farms. As the size of the farms increases, the area farmed by one worker also increases which leads to a generally more labour-extensive form of farming concentrating more on those areas which are easily accessible and can be cultivated using machines. In regions with unfavourable agricultural production conditions, as much as two thirds of the previously utilised area is no longer worked,

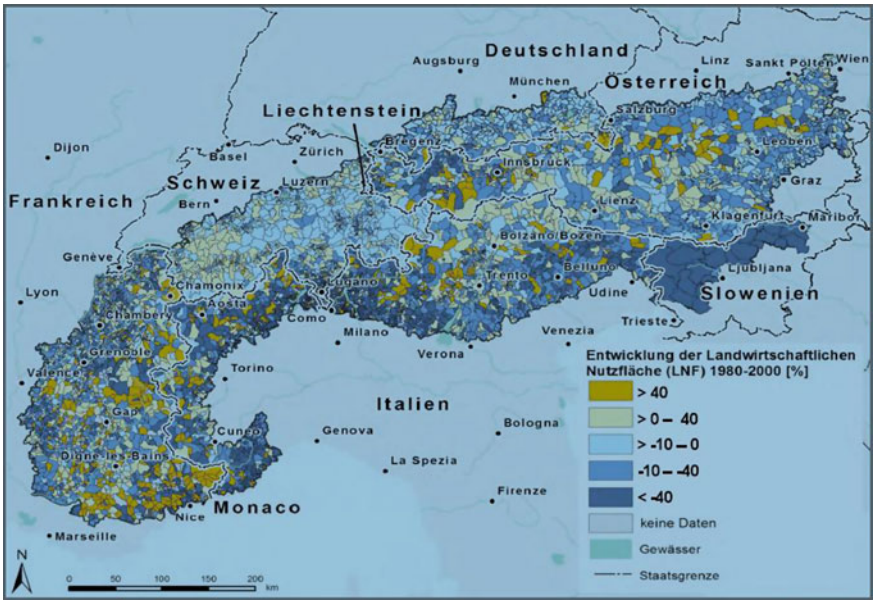

Illustration 1 Changes in agricultural utilised land in the Alpine area (1980–2000). *Source* Streifeneder 2010

while only very little land was taken out of cultivation in productive areas (Tasser et al. 2007). Insofar as land in marginal locations is not abandoned, it is only farmed extensively or used for grazing (Tasser and Tappeiner 2002; Pezzatti 2001) (Illustration 1).

The speed and pattern of changes in agricultural structures depends not only on the economic and social environment and existing farm structures, but also to a large extent on public support for mountain agriculture. While countries such as Italy (with the exception of the regions South Tyrol and Trento) and France have not attached any importance to the Alps for a long time, mountain areas and mountain farming have been receiving support in Germany, Austria and Switzerland (Bätzing 1996). Streifeneder et al. (2007) characterise these areas as "well performing regions" with moderate structural change and an assured income for mountain farms. Up till now, it has been possible to a large extent to prevent utilised agricultural land from being abandoned and left fallow in these countries. This is the result of favourable, economically viable structures and State support programs designed to offset location disadvantages plus farm income support. In spite of the fact that agricultural support in Liechtenstein is comparable to support provided in Switzerland, the structural change and decline in utilised area are both noticeably more pronounced. Streifeneder et al. (2007) typifies this development as "average structural change". By way of contrast, "dynamic structural change" can be observed in the development of mountain agriculture in Italy and Slovenia where a large number of farms have been given up and, compared to the Alpine

region as a whole, an above-average amount of land has been abandoned. France occupies a special position since, according to the data on structural development harmonised by Streifeneder (2010), there has been no decline in the agricultural utilised land in the Alpine area in spite of the high number of farms abandoned ("uncorrelated structural change").

3 Literature Review on Agricultural Land-Use Change in the Alps

The concept of multifunctionality as a central element of mountain farming in the European Alps developed against the background of structural changes in agriculture and the ongoing marginalisation of the sector. Multifunctionality in general (Helming and Pérez-Soba 2011) and in mountain farming in particular is closely linked to agricultural land-use (Flury and Huber 2007). Cultivation and the intensity of the utilisation play a central role for the provision of services which go beyond the primary function of food production.[1] The maintenance of open landscapes (preservation of landscape vs. abandonment) is a vital factor in mountainous regions (MacDonald et al. 2000; Pointereau et al. 2008; Keenleyside and Tucker 2010). This is linked to various ecosystem services, which are of great importance to both the population in the Alps and society as a whole (Lauber 2006; Bacher et al. 2012; Huber et al. 2012a). In particular, this involves ecological services such as the maintenance of open cultural landscapes (Fischer et al. 2008; Lindemann-Matthies et al. 2011; Tasser et al. 2012b), the conservation of biodiversity (Tasser and Tappeiner 2002; Rudmann-Maurer et al. 2007), the protection of fertile land (Tappeiner and Cernusca 1998) or protection from natural hazards (Newesely et al. 2000; Tasser et al. 2003).

A comprehensive review of literature was carried out in order to be able to make a statement about the prospects for mountain agriculture and, by association, the provision of the multifunctional services. This involved the consultation of all those publications registered in Scopus between 2000 and 2012, with a title, abstract or key words containing the terms "land-use change" AND agriculture (farming) AND Alps (Alpine). Publications focusing strongly on non-agricultural aspects were rejected. This process resulted in 13 publications containing statements regarding the future of mountain agriculture. Table 3 contains a list of the publications consulted. In addition to the authors and the focus of the publication, the Table also includes the case-study region(s), the type of the agricultural change

[1] To a certain extent, the reduction of the idea of multifunctionality to land-use aspects leads to an incomplete view of the complexity of the actual concept. A comprehensive examination of multifunctionality in mountain agriculture would demand due consideration of a "territorial view" (Cairol et al. 2009), sustainability aspects (Renting et al. 2009) and the dynamic, temporal transition perspective (Wilson 2007). However, this would exceed the scope and objective of this Article.

(based on Streifeneder et al. 2007) and the methodological background. The central statements of the respective articles regarding future developments are cited in the last column.

The literature consulted covers the Alpine area quite widely and its diversity is well represented by various regions in France, Switzerland, Italy and also the Eastern Alps. In addition, the principal types of structural changes in agriculture as defined by Streifeneder et al. (2007) are covered completely. As various authors were studied, the analysis of the literature is a source of insight concerning the different points of view adopted by the respective institutions as well as the national attitude towards development, the status of mountain agriculture and the related country-specific problems. Agricultural land-use and its impact on multifunctional services and future structural change are investigated using statistic methods (e.g. Tasser et al. 2007) on the one hand, as well as with normative methods and also agent based land-use models (e.g. Briner et al. 2012) or linear programming models (e.g. Marini et al. 2011) on the other hand. One important characteristic of the more recent publications with an agro-economic orientation is that they combine agro-economic methods with other models and are thus able to assess changes in structures and land-use giving due consideration to climatic, ecological and socio-economic changes [e.g. (Gibon et al. 2010; Schreinemachers and Berger 2011; Briner 2012)].

The investigation of the literature resulted in the following conclusions concerning the future development of mountain agriculture, land-use and the associated maintenance of open cultural landscapes together with the related multifunctional services. They can be summarised under three headings:

- *Trends and existing driving force for land-use*. Some of the authors conclude that a continuing trend towards the abandonment of utilised land will have a negative impact on biodiversity and the associated services in the Alps and that existing measures are insufficient to counteract this change (Albert et al. 2008; Niedrist et al. 2009). In this context, Tasser et al. (2007) show that the former land-use intensity and proximity to forested areas play an essential role in the reforestation process of previously utilised agricultural land. Regardless of climatic change, the political and market environment will still continue to be the driving force behind the development of mountain agriculture in future (Briner et al. 2012).
- *Conservation of specific forms of utilisation*. Since specific types of vegetation can be attributed to certain forms of agricultural utilisation (Tasser and Tappeiner 2002), various authors conclude that specific forms of land-use should be conserved and encouraged in order to maintain the associated multifunctional services. Thus Quétier et al. (2007) call for conservation of mown meadows (mowing), Giupponi et al. (2006) consider the support of tradition livestock husbandry to be a key factor in the struggle to maintain open landscapes and Marini et al. (2009) identify extensive production systems and the utilisation of steep meadows as forms of agriculture which should be

Table 3 Literature on agricultural land-use in mountain regions and implications for the future

Authors	Focus	Region/Country	Structural change typology[a]	Methodology	Implication for the future of mountain agriculture
Albert et al. (2008)	Land-use change and tree dynamics	French Alps	Uncorrelated structural change	Land-use scenarios, based on habitat-suitability model and landscape model	Current management regime is not intense enough to resist colonization by larch in open and species rich grasslands. Ongoing and future agri-environmental policies have to be quickly adapted to protect biodiversity and ecosystem services provided by subalpine grasslands
Briner et al. (2012)	Modelling climate and land-use change	Visp/Switzerland	Well performing region	Modular modelling framework including forest, land-use and climate sub-models	Structural and economic trends will constrain agricultural production in Alpine regions despite potential favourable production conditions
Cocca et al. (2012)	Abandonment of livestock farming	Belluno Province/Italy	Dynamic structural change	Multiple regression models	Efforts are needed to maintain a territorial network of traditional extensive farms to avoid further landscape deterioration in Alpine areas
Gellrich and Zimmermann (2007), Gellrich et al. (2008)	Land abandonment and natural reforestation	Switzerland; four case studies in Switzerland	Well performing region	Multivariate statistical models; Classification analysis and interviews	General policy measures for the whole mountain area are not suitable for the prevention of land abandonment and forest re-growth and policy measures must pay more attention to local characteristics and needs
Giupponi et al. (2006)	Climate and land-use change, biodiversity and agri-environmental measures	Belluno Province/Italy	Dynamic structural change	Simple and multiple regressions analysis	Maintenance of the livestock production system typical of mountain agriculture is shown to be the key factor for contrasting land abandonment and the consequent expansion of woodlands

(continued)

Table 3 (continued)

Authors	Focus	Region/Country	Structural change typology[a]	Methodology	Implication for the future of mountain agriculture
Marini et al. (2009)	Impact of farm size (number of livestock units) on plant and insect diversity	Province of Trento/ Italy (tourism region)	Dynamic structural change	Multi-factorial mixed ANOVA	Regional stakeholders should consider targeted conservation schemes to prevent the ongoing substitution of small farms with large intensive farms (livestock units). (…) support farms with low production of organic fertilizers and reward the maintenance of the current management of steep meadows
Marini et al. (2011)	Mitigating the impacts of the transition from traditional to modern farming	Province of Trento/ Italy (tourism region)	Dynamic structural change	General Linear Mixed Models and Linear regression; Structured interviews with farmers	Agri-environmental schemes are positively related to both plant and insect diversity and might easily be implemented in future agri-environmental policy. However, we conclude that large and modern farms need to get more involved in biodiversity conservation as they will be the main actors in the future of Alpine farming
Monteiro et al. (2011)	Drivers behind loss of permanent meadows	Valtellina valley/ Lowlands Italy	Dynamic structural change	Land cover mapping; spatial bivariate analysis; GIS-based logistic regression model	In contrast to land use/land cover changes in other mountain regions; this study has found abandonment in the lowlands of Valtellina in addition to massive use intensification in the remaining meadows. Meadows habitat needs a well-designed landscape and farming planning (…)

(continued)

Table 3 (continued)

Authors	Focus	Region/Country	Structural change typology[a]	Methodology	Implication for the future of mountain agriculture
Niedrist et al. (2009)	Plant diversity	Bolzano/Bozen/Italy	Exceptional development	Discriminant analysis and biodiversity indices for 936 vegetation surveys	Number of plant communities along with the number of species decreases constantly and significantly with increasing land use intensity and on abandoned land. (…) Due to current trends, such as land abandonment and land use intensification, plant diversity in the Alps is decreasing considerably
Quétier et al. (2007)	Modelling ecosystem service sensitivity to land-use change	Villar d'Arène/Central French Alps	Uncorrelated structural change	Trait based modelling of plant functional types	Ecosystem services are most sensitive to changes in grassland management, supporting current agri-environmental policies aimed at maintaining mowing of subalpine grasslands in Europe
Tasser et al. (2007)	Land-use change and natural reforestation	Eastern Alps	Gradient of different dynamics	Historic photography, field work, Zero-inflated negative binomial model	Three most important driving forces of natural reforestation are the seed dispersal, the actual agricultural use and the years since abandonment. The less intensively the land was formerly used, the higher tree density in the reforested area
Zimmermann et al. (2010)	Land-use and land-cover change and biodiversity	European Alps (ecoregions)	Gradient of different dynamics	Hierarchical cluster analysis using historical maps and aerial photographs	The effect of land-use change depends on the landscape context. In other words, the same process (reforestation) has different effects in a largely agricultural area, compared with an area that already has a high proportion of forest

[a] Based on Streifeneder et al. 2007

encouraged. At the same time, larger farms should be definitely involved in the conservation of extensive forms of land-use (Marini et al. 2011).

- *More comprehensive solutions*. Basically, agricultural land-use in mountain regions is influenced primarily by a combination of local natural conditions and the basic conditions generated by economic and agricultural policy. However, comparable structural development processes or identical measures have different effects in different regions (Zimmermann et al. 2010). This leads to the realisation that if policy measures are not adapted specifically to the location, they are hardly likely to counteract the heterogeneity of abandonment of utilised land and forest encroachment in mountain areas brought about by natural and socio-economic conditions (Gellrich and Zimmermann 2007 and Gellrich et al. 2008). In addition, various authors place importance on the overall perspective. Monteiro et al. (2011) come to the conclusion that agriculture must be viewed within the context of a well-designed landscape planning. Cocca et al. (2012) reason that a territorial network is the only way of maintaining traditional land-use forms and the associated multifunctional services provided by agriculture.

On the basis of the literature studied, however, it is not possible to develop a direct causal relationship between regional differences in structural change (based on Streifeneder) and the policy implications drawn for the future of mountain agriculture. Indeed, the demand for the conservation of traditional agricultural systems is more pronounced in places where dynamic structural change is predominant. In the scientific debate, however, the same trends and policy measures are judged to be of importance, regardless of the nature of the structural changes in agriculture.

4 Scenarios for Agricultural Land-Use in the Alps

The major driving force behind changes in agricultural land-use in the Alps is of an economic and socio-cultural nature (Tappeiner et al. 2006; Briner et al. 2012). Therefore, the future of mountain agriculture depends strongly on overall economic and social developments. On an aggregated level, the future is characterised by numerous uncertainties. They can be structured consistently with the aid of scenarios to evaluate future developments. In this section, model-based studies assessing the impact of different scenarios on land-use in the Alps are summarised (Table 4).

Westhoek et al. (2006) developed four scenarios for rural regions in Europe. They apply to a time horizon up until 2030 and illustrate the relevant uncertainties for rural regions. At the same time, they are consistent with the climate scenarios of the IPPC (Abildtrup et al. 2006). The extent of globalisation (i.e. increasing integration of global markets vs. regional integration of markets) and regulation (little vs. high regulation) was chosen as the main driving force for future developments.

Table 4 Discussed scenarios of agricultural land-use

Source	Scale	Time horizon	Methodology	Scenarios
Van Meijl et al. (2006)	World (results focused on Europe)	2001–2030	General equilibrium modelling (GTAP) and land-use modelling (IMAGE)	Global economy (A1) Continental markets (A2) Global co-operation (B1) Regional communities (B2)
Tappeiner et al. (2006)	Stubaital (Innsbruck)	2033	Workshop; probabilistic simulation; optimization model	Status quo Environmentally friendly agriculture Support of regional economics
Nowicki et al. (2009)	Europe	2020	Macro-economic modelling on different scales (LEITAP, ESIM, CAPRI)	Reference scenario Conservative CAP scenario Liberalisation
Partidário et al. (2009)	Six case studies across Europe	Long term (not defined)	Scenario workshops with local stakeholders	Business as usual Managed change for biodiversity Liberalisation
Verburg and Overmars (2009)	Europe	2000–2030	Dyna-Clue, land use model	Global economy (A1)
Verburg et al. (2010)	Europe	2000–2030	Model linkage of GTAP, IMAGE, Dyna-Clue	Global economy (A1) Continental markets (A2) Global co-operation (B1) Regional communities (B2)
Mann et al. (2012)	Switzerland	2013–2020	SWISSLand (agent based sector supply model)	New Swiss agricultural policy 2014–2017
Renwick et al. (2013)	Europe	2020	CAPRI and Dyna-Clue	Removal of Pillar 1 and all market support WTO agreement and trade liberalisation Combination: removal of market support and trade liberalisation

- *A1 Scenario: Globalisation and little regulation*. The future is characterised by integrated global markets and relatively high economic growth. Agricultural productivity increases due to pronounced technological progress. Environmental problems are not regarded as a priority.
- *A2 Scenario: Continental markets*. In order to achieve the highest possible degree of independence in the field of food security, market solutions are sought primarily at regional level respectively with countries having the same values and standards. This is based on the maintenance of trade barriers and agricultural support. Cultural identity remains strongly anchored in the landscape and there is a minimum of State regulation.
- *B1 Scenario: Global co-operation*. Economic profits are coordinated at the international level by means of comparative cost advantages and trade in order to achieve wealth distribution, social justice and protection of the environment. This is based on far-reaching market liberalisation and State regulation to protect cultural values and the natural heritage.
- *B2 Scenario: Regional communities*. Local and regional communities become anchor points for society. The consumption of local products and self-sufficiency, responsibility for the environment and justice are the key to sustainable development. Far-reaching regulation and incentives for the conservation of small-scale farm structures are characteristics of a form of agricultural policy which is geared to self-sufficiency and ecological responsibility.

The scenarios have a range of implications for mountain agriculture. It is an accepted fact that the risk of the abandonment of utilised land is highest in mountain areas, and thus also in the Alps (Keenleyside and Tucker 2010). Utilisation of marginal land depends primarily on support for land-use generated by domestic support measures and to a lesser degree on the development of market access (Renwick et al. 2013). This is confirmed by earlier model results obtained by van Meijl et al. (2006), according to which the negative impact of liberalisation on land-use in Europe is, on the whole, low. Although results differ depending on the scenario, even in the worst case (Scenario B2) land-use does not decline much more than 10 %. In Scenario A2 (continental markets), there is even an increase in agriculturally utilised land. This is due to the fact that while the common agricultural policy (GAP) leads to an increase in extensive farming it does not result in abandonment of land. Model calculations carried out by Verburg and Overmars (2009) using the landscape model Dyna-CLUE concerning the explicit maintenance of open landscapes reveal that the abandonment of land is to be expected primarily in regions with unfavourable production conditions. Scenario A1 (global economy) shows that the decline in the Alps is comparable with that experienced by the Pyrenees, the Massif Central or the central German uplands (Mittelgebirge). While in three of the four scenarios the abandonment of utilised land continues to be the predominant change in land-use in Europe (Verburg et al. 2010), the degree to which it occurs varies from one Scenario to the other. In particular, the anticipated weaker level of economic growth in the EU15 is clearly apparent in the two B Scenarios where the abandonment of utilised agricultural land is much higher than in the two A

Scenarios with less State regulation. In fact, given high economic growth, the abandonment of utilised agricultural areas in Scenario A2 is supposed to be even lower than the expansion to new production locations. This is due to the fact that the European demand for food and energy must be satisfied from within Europe itself. Keenleyside and Tucker (2010) criticise the results of Verburg et al. (2010) and van Meijl et al. (2006) as unrealistic and, therefore, do not consider them in their conclusions. However, macro-economic effects cannot be disregarded when considering the future of mountain agriculture. Although the model Scenarios may seem unlikely, the modelled effect can nevertheless occur.

In addition to the Scenarios based on Westhoek et al. (2006), there are other model calculations dealing with the maintenance of open utilised agricultural areas in Europe (Keenleyside and Tucker 2010). Combined calculations using Dyna-CLUE and the agricultural sector model CAPRI reveal that the aggregated effects of liberalisation efforts would result in an overall abandonment of utilised agricultural areas of less than 10 % (Renwick et al. 2013), whereby there are considerable differences depending on the various types and sizes of the farms. In particular, there is a significant decline in grassland-based animal husbandry (especially sheep and goats) in the Mediterranean countries (−25 % UAA). On average, mixed livestock holdings likewise have no further need for over 10 % of their areas. Furthermore, it is primarily the small farms (<16 ha) which are abandoned. Combinations of small farms which produce milk or meat are frequently found in the Alps. Nowicki et al. (2009) show that a complete liberalisation would lead to a marked increase in the number of farms abandoned. A large share of these abandonments would be attributable to the effect of the discontinuation of direct payments.

The results of the various calculations reveal a high degree of heterogeneity between the individual regions. Different patterns of agricultural utilisation occur depending on macro-economic conditions and local natural and socio-economic characteristics (Verburg and Overmars 2009). This becomes very clear when smaller regions are used as units of investigation (Huber et al. 2012b). Partidário et al. (2009) base their evaluation of the future of rural areas on an inter- and trans-disciplinary research design (Sheate et al. 2008) rather than on model calculations. Their qualitative evaluation of the future shows that in various case-study regions, and in particular in the Alpine regions, liberalisation scenarios have a negative impact on the fundamental indicators for sustainable development (Soliva 2007). However, a scenario which would promote the management and conservation of biodiversity is regarded as positive in all respects for sustainable land utilisation of rural regions. In addition, model calculations for Switzerland indicate that a switch from production-orientated payments for animal husbandry to area-based payments would have a favourable impact on the total utilised area in mountain areas (Mann et al. 2012). Tappeiner et al. (2006) use a variety of methods (trend analysis, stakeholder survey, agro-economic modelling) to evaluate the future of the Stubaital region near Innsbruck (Austria). Although local actors anticipate moderate changes in future, trend and modelling scenarios indicate a much more significant tendency towards the abandonment of utilised agricultural land. This

divergence reflects the importance of the values and assumptions of those directly involved when evaluating future scenarios (Soliva and Hunziker 2009).

To summarise, the analysis of various propositions for agricultural land-use shows that the macro-economic and political environment is vital for the future development of mountain agriculture, that the impact is spatially heterogeneous and that there are both winners and losers. Therefore, the aggregation level plays an important role when evaluating the future of mountain agriculture in the Alps. On the whole, rural areas in general and mountain regions in particular are rated as losers in numerous scenarios, especially in the context of the reduction of direct payments. However, liberalisation of markets for agricultural products does not result in additional abandonments in every case. On the one hand, this reflects the shortage of the factor land which will gain in importance in the event of economic growth, increasing population and the associated rise in the demand for animal products. On the other hand, from a historic point of view, the degree of agricultural land utilisation has already sunk to a low level.

5 Discussion: Future of Mountain Agriculture in the Alps

The examination of future developments in mountain agriculture outlines the area of conflict in which this future will be situated. The fundamental demographic, economic and socio-cultural driving forces which were the basis for development in the past will continue to have a decisive influence on potential development paths over the next 20 years (Keenleyside and Tucker 2010). In this context, population dynamics and general economic developments will be major factors. From a historic point of view, these have been the cardinal causes of landscape change in the past (Siegl and Schermer 2012).

On the one hand, the model simulations discussed in Sect. 4 show that aggregated economic growth and the associated increase in demand is an important driving force behind land-use not only for European agriculture as a whole, but also for Alpine and mountain farming. With regard to the abandonment of utilisable agricultural land, the simulations imply that macro-economic developments could offset impacts of regional agro-environmental policies. This exemplifies that mountain agriculture is dependent on developments which cannot be influenced by itself. This situation will be intensified by the increasing influence of the urban population and the necessity for financial transfers to ensure the upkeep of fundamental services in peripheral regions (Messerli et al. 2011).

On the other hand, regional and local case-studies summarized in Sect. 3 indicate that economic pressure generated by increasing liberalisation accelerates structural development and specific forms of land-use are lost. Given natural and socio-economic characteristics, there is a danger that specifically areas of high nature value are lost (Keenleyside and Tucker 2010). This applies especially to locations where the rationalisation and mechanisation of mountain farming have reached their limits and the agricultural labour-force is no longer available (Tasser

et al. 2012a). Consequently, the conclusion that the provision of multifunctional services by agriculture is no longer guaranteed leads to a demand for targeted support and the upkeep of the respective forms of land-use.

These two aspects reveal that there seems to be a contradiction between the aggregate (top-down) and the regional (bottom-up) point of view. While on the European level economic development stands in the foreground as the prime factor for full utilisation of agricultural land, the economic pressure at local level is rated as the driving force behind abandonment. The divergence in the views results from differing considerations regarding aspects of quality and quantity. In large-scale models the *quantitative* effects stand in the foreground while in individual case-studies the focus is often on *qualitative* und spatial-specific aspects.

Neither of these two aspects should be neglected when considering multifunctional agriculture. In the case of the abandonment of utilised land, the absolute area is not per se the decisive factor but rather the quality of the land abandoned, respectively of the land which is still cultivated. The provision of ecological services can be guaranteed using less land, but in spatially specific, or high-value locations. On the other hand, the promotion of traditional agriculture with small structures does not automatically guarantee the upkeep of the farms and their multifunctional services. Due also to the limited financial means available, macro-economic effects can more than offset the leverage of public support. The result is that while farmers may well remain within the sector, they earn the main part of their income in other branches and in spite of this they still abandon traditional utilisation forms. In addition, stable economic development is essential to ensure the availability of the financial resources without which it would be impossible to support peripheral regions in the first place.

Consequently, agriculture must adapt the provision of its multifunctional services to the societal demand (Lehmann 2002) and harmonise them in a spatially explicit manner (Grêt-Regamey et al. 2012). Regardless of the form of structural change which occurred in the past, maintenance and support of mountain agriculture can only be sustainable where a private or public service is provided for which there is a demand.

In addition, the fields of action for support of mountain agriculture depend on specific spatial and socio-economic characteristics. Insofar as overall economic development continues to permit utilisation of the land, targeted payments can assure the desired maintenance and support for the cultivation of traditional cultural landscapes and an environmentally-friendly form of agriculture in keeping with the location (Renwick et al. 2013). However, in the case of dynamic structural change it is possible that the same support payments will be ineffective (Huber et al. 2012b). It follows that measures to support sustainable mountain agriculture can only be effective and efficient if strategies are developed which are differentiated at a regional level (Rigling et al. 2012). Against this background, Schermer et al. (2012) developed specific options for action for various types of agriculture in the Tyrolean region.

To be able to make any use of endogenous growth potential, regional economic development is rated higher than sectoral agricultural measures in rural areas with declining employment and population (Dax 2001). On the other hand, selective

agricultural support can produce the desired results in grassland areas with a high rate abandonment of summer grazing pastures. However, in grassland areas with a low rate of abandonment, measures must be envisaged to limit, in the first instance, any increase in intensity and to support diversification of production thereby ensuring that the potential of these regions can be exploited.

Better harmonisation between agriculture, nature conservation and development planning is viewed as a central field of action for farming in valley locations. In this case too, relationships within the agricultural sector are likewise a fundamental factor, in that diversification or growth in farm size can likewise lead to negative effects such as abandonment of utilisable land (Fischer et al. 2012). This means that there is also a need for action in the field of co-ordination within the agricultural sector and the evaluation of the distributional impact of policy measures supporting mountain farming. This represents a challenge for mountain agriculture which can only be overcome through dialogue with other users and providers of services (Lehmann and Messerli 2007). A cross-border exchange of experience could aid the efficient implementation of measures and tools (Bacher et al. 2012; Schermer et al. 2012).

In addition to the distributional impact, the heterogeneity of land-use, respectively multifunctional services also plays an important role (Rigling et al. 2012). In specific cases, forests likewise provide vital ecosystem services (carbon sequestration, protection from natural hazards), which under no circumstances should be neglected. In fact, Renwick et al. (2013) even identify a generally positive environmental effect resulting from the abandonment of utilised agricultural areas. On the other hand, climatic change becomes increasingly important when viewing the future. There is a great deal of uncertainty regarding the impact of climatic change (Beniston 2003) and it is possible that its effects will be small (Vittoz et al. 2009) or far less important than the socio-economic changes (Briner 2012). Nevertheless, mountain agriculture in the Alps will be faced with new challenges in the field of availability and the distribution of water resources (Beniston et al. 2011; Beniston 2012).

6 Conclusion

Basically, mountain agriculture will continue to be at a disadvantage due to its natural and structural production conditions. At the same time, mountain farming in the Alps has a heterogeneous appearance since it is characterised by numerous contrasts; it comprises valleys and summer grazing pastures, regional centres and peripheral valleys, production oriented areas and areas with low intensities, regions with high abandonment of marginal land and others with increasing intensive utilisation in favourable locations. This in turn also leads to heterogeneous prospects for the future. Thus, the fields of action for agriculture in the Alps must be differentiated at regional level to reconcile supply and demand of agricultural products and multifunctional services. This knowledge is not new and a large number of research results identify the

need for differentiation in public support (Gotsch et al. 2004; Lehmann and Messerli 2007; Tasser et al. 2012b). However, it is of importance that macro-economic impacts should be taken into consideration when evaluating future regionally and locally beneficial measures. Otherwise there is the risk that fundamental economic developments will offset the impact of targeted measures designed to maintain and support the cultivation of traditionally utilised land and an environmentally-friendly form of agriculture which is in keeping with the respective location.

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