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## Typology of the urban-rural dynamic for Swiss municipalities

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## Typology of the urban-rural dynamic for Swiss municipalities

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### Abstract

The decrease of open landscape areas due to urban growth is one of the most relevant land use process occurring all over the world and one of the most challenging process to manage for policy makers (Antrop 2004). Although landscape conservation is generally expressed as policy goal, in Switzerland as in other European countries three main complexity-dimensions hamper policy implementation in this domain. First, the urban growth is steered by socioeconomic trends which are persisting like population growth. Second, this process has a very regional character. The complexity of the situation is highlighted by the fact that there are more than 2600 municipalities in Switzerland and that they are very heterogeneous in terms of their techno-economic conditions, such as their knowledge and industrial base and human resources, in particular. Third, a real coordination between land-use policy and agricultural policy is missing. A municipal typology focusing on the conflict between open landscape conservation and urban growth is needed as an instrument of policy domain coordination.

Here, we developed spatial indicators for land use, land cover change, landscape functions change and urban sprawl as negative landscape quality and calculated them for the 1400 municipalities of the western part of Switzerland. Through a cluster analysis we have identified four groups of municipalities with different behaviour according to these 13 spatial indicators. One significant finding is that these groups show a differentiated picture of the region analysed. We identified municipalities characterised by high urban sprawl and municipalities where conflicts between population growth and agricultural activities can occur. For these vulnerable municipalities it is particularly important to formulate regional goals for landscape conservation and set clear priorities. This typology could be an important basis for national and regional decision-makers for formulating regional landscape

conservation goals with the consideration of both needs and views of agricultural and land use policy.

## Introduction

One of the functions of agriculture is to contribute to landscape protection by maintaining open landscapes and creating landscape diversity. Through the cultivation of areas with crops, grassland or land use for animal pastures the cultural landscape can be maintained. Since cultural landscape has important ecological, economical and social functions, its protection is very important for a sustainable land use and social development (Verburg et al. 2008). However, loss of valuable agricultural land and open landscape through urbanisation is a well known trend in Europe and overall the world (Antrop 2004, Bengston et al. 2004).

In Switzerland this phenomenon has been interpreted as one of the most challenging phenomenon to manage in order to seek sustainable land use development (ARE 2005a). 37% of the whole Swiss territory is covered by agricultural land and 7% is covered by urbanised land, 31% is covered by forests and 25% of unproductive area (water and rocks). In the last decades a decrease of 3, 1% of productive agricultural area has been observed and this means the loss of 11 ha productive agricultural land every day. The main cause of this decrease is the increase of the urbanised area, which has been 13% during the last decades (BFS 2001). The most important driving forces underlying the conflict between agricultural use land and urban land use are population growth, economic development and transformation process and political processes (Hersperger et al. 2007).

On one hand agricultural land is needed for food production and is important for leisure and landscape perception. On the other hand population increases and this asks land for new residential buildings. Often, the land suitable for residential buildings is also the most adequate for agricultural activity because flat and accessible. Development of industrial and commercial activity and the development of new roads for increasing mobility also cause building activity (Hersperger et al. 2007).

The management of land-use conflicts between urban growth and open landscape decrease need the coordination between land-use and agricultural policy. In the Swiss Agricultural Policy direct payments are conditional upon proofs of ecological performance. Furthermore, in Switzerland compensation for special performance with regards to the environment and livestock also an important measure (Bundesrat 2009). Other measures which seek to prevent

the reduction of agricultural land through built-up area expansion are formulated in the Swiss Federal Law on Spatial Planning. Cantons have to design a fixed area of agricultural soil of good quality allocated in different municipalities which has to be protected and have to deal as reserve for agricultural land-uses in crisis situations. However, the loss of agricultural land due to ineffective management of urban growth is still occurring and is partially caused by a non optimal coordination between needs, vision and policy instruments in land use and agricultural policy (Gennaio et al. 2009).

Efforts towards the coordination of different goals in land-use management have been done in different studies. One of the most promising approaches is the ecosystem goods and services approach (De Groot 2006). This approach assumes that landscape is multifunctional and defines landscape functions as the ability of the landscape to provide goods and services for humans, which attribute to them values (ecological, economical and social). Some studies have quantified at a local or regional scale landscape functions (Verburg et al. 2008, Willemen et al. 2008) goods and services and have tried to attribute them values in order to deliver a tool able to support sustainable land-use management (Grêt-Regamay and Kyzia 2007). Grêt-Regamay and Kyzia. (2007) estimated the monetary value of ecosystem services like scenic beauty, avalanche protection and habitat for the Davos landscape in the Swiss mountain region. The results show that tools trying to estimate spatially-explicitly the values of this goods and services are very useful for deciding which land-use should be promoted in order to achieve a sustainable land use development. However, because of the complexity of the valuation methods and amount of the data necessary, such studies can only be performed for a local or regional scale and cannot easily be coordinated with a national overview (Rossing et al. 2007). For the national policy coordination spatial typologies seems to be an adequate tool.

Typologies are usually built to characterise complex or multidimensional phenomena. Through a set of indicators different dimension of the phenomena can be monitored and the typology-building helps to read common trends and patterns (Tappeiner et al. 2008). Typologies dealing with multiple land uses and the multiple causes of land use changes are e.g. the Swiss Municipality Typology (Schuler and Joye 2008) or the Typology of the Alps developed by Tappeiner et al. (2008). The first is used as general basis for research and national and regional policy-decision making and the second was explicitly developed in order to monitor and manage sustainable development in the Alps. In the Swiss Municipality

Typology many socioeconomic indicators are integrated but indicators for land cover and landscape qualities are missing. Perlik et al. (2008) focused on land use change developing regional spatial scenarios for the urban development under consideration of actors' behaviour. Both typologies contribute to the policy coordination in the definition of regional development goals. However, a municipal typology putting the focus on the conflicts between agriculture, open landscape, urban growth and urban sprawl is still needed.

The aim of the paper was to assess the diversity among 1430 communes across western part of Switzerland for agricultural and socio-economic variables and to identify the vulnerable municipalities in terms of pressure on landscape quality. Land cover, agricultural and socio-economic variables characterizing land use; sector productivity and social conditions of the population have been used to answer the following questions:

Which is the urbanisation degree of the municipalities?

How large are the reserves of open landscape still present in the municipalities?

How large is the pressure on open landscape given by urban growth in the municipalities?

How is agricultural activity developing in the municipalities?

How is the landscape quality developing in the municipalities?

The characterisation of Swiss municipalities through this information is needed for sophisticated landscape management in vulnerable communes and selection of regional policy instruments to enhance sustainable rural development in these areas.

## Material and Methods

The whole Swiss territory is considered in the study. In the first step the method is applied and tested for only for the western part of Switzerland (Figure 1).

To characterise municipalities three groups of indicators were selected. With the first indicator group we aimed to describe the state and change of the built-up and agricultural areas (Table 1). For this work we extract the “built-up area”, the “open landscape” (composed by “agricultural area” and “pasture area”) from the Swiss Land-Cover GIS-Database. In order to have comparable data we normalised the data with the total municipal area and we expressed them in percentage of the municipal area. We calculated the changes subtracting the Land Cover Data of 1997 with those detected in 2004/9. We expressed those changes in the indicators “percental change in urban area”, “change in urban area  $\text{cm}^2/\text{km}^2$ ” and “percental change in agricultural area”.

With the second group of indicators we aimed to describe the relevant landscape functions responsible for the pressure on and the conflicts with the open landscape (Table 1). For the approach of landscape-functions the difference between land cover/land use and landscape function is crucial. Classical Land Use and Land Cover Change data like classifications from aerial photographs or maps are generally used to determine land cover (like built-up area or agricultural area) (Kasanko et al. 2006). These data jointly with data of the protected areas can also be used as proxy for the land uses (e.g. pasture) and landscape functions (e.g. aesthetic). For one land use like crop areas it is not always automatic deducible which landscape functions are present (Verburg et al. 2008). For example the agricultural land uses can have different functions, like food production, landscape aesthetic and tourism. Further data, like the presence of recreation areas, are needed to analyse the suitability of the presence of landscape functions such as tourism for a given land cover or land use (Willemen et al. 2008). Usually the challenge is the reduced availability of these data. Therefore, in a first step, we considered only the functions which are known to be the important driving forces creating pressure on agricultural area (Hersperger et al. 2007, Gennaio et al. 2009). As functions we considered for the urban landscape (built-up area) the function of “living” which is expressed by the indicators “percental population growth”, “population growth/  $\text{km}^2$ ” and “change in residential buildings/ $\text{km}^2$ .” and the function food production since the buildings related with agriculture are considered part of the built-up area. This function of the urban landscape is expressed by the variable “change in buildings related with agriculture/ $\text{km}^2$ ”. For the open landscape we considered the function of “food production” which is expressed by the “percental change in agricultural area” and “change in agricultural area  $\text{cm}^2/\text{km}^2$ ”.

With the third group of indicators we aimed to measure the landscape qualities, which we considered the social and ecological values of the open landscape (Table 1). One of the principal goals of the Law for Spatial Planning is to delimit the building-zone from the agricultural area in order to prevent agricultural land from urban sprawl (Gennaio et al. 2009). Similarly, one goal of the Agricultural policy is to guarantee by the persistence of agricultural activities the presence of open landscape. Therefore, a proxy for urban sprawl as negative measure for landscape quality and infill development has been developed. We define urban sprawl as the dispersed built-up area which is to consider in contrast with compactness (Siedentop 2005). As proxy we use therefore an indicator of “dispersion degree” of built-up area (negative quality).

The three groups of indicators were used to build a typology of municipalities, which include all crucial information to coordinate planning activities. Similarly to Tappeiner et al. (2008) the indicators were aggregated with a cluster analysis. This statistical method is a multivariate method of analysis to bring out the structure and identify groups of objects with similar qualities or manifestations of qualities. In this study we performed a hierarchical cluster analysis (Ward’s method). As distance function we used the log-likelihood-function.

Table 1: definition of Indicators

<b>Indicator group</b>	<b>Indicator name</b>	<b>Definition</b>
State and change of land cover	Percentage of urban area	$100 * \text{Urban area} / \text{total municipal area}$
	Percentage of open landscape	$100 * [\text{agricultural area} + \text{pasture area}] / \text{total municipal area}$
	Percental change in urban area	$100 * \frac{\text{Change urban area 1997-2004}}{\text{Urban area 1997}}$
	Percental change in agricultural area	$100 * \frac{\text{Change agricultural area 1997-2004}}{\text{agricultural area 1997}}$

<b>Indicator group</b>	<b>Indicator name</b>	<b>Definition</b>
	Change in agricultural area $\text{cm}^2/\text{km}^2$	Change agricultural area in $\text{cm}^2/\text{municipal area in km}^2$
	Change in urban area $\text{cm}^2/\text{km}^2$	Change urban area in $\text{cm}^2/\text{municipal area in km}^2$
Relevant landscape functions	Percenual population growth	100*Population growth 1990-2000/population in 1990
	Population growth/ $\text{km}^2$	Population growth 1990-2000/municipal area in $\text{km}^2$
	Change in residential buildings/ $\text{km}^2$	Change residential buildings 1990-2000/municipal area in $\text{km}^2$
	Change in buildings related with agriculture/ $\text{km}^2$	Change in building related with agriculture 1997-2004/municipal area in $\text{km}^2$
	Change in the number of farms	Change in the number of farms 2001-2005
	Change in agricultural area $\text{cm}^2/\text{km}^2$	Change agricultural area in $\text{cm}^2/\text{municipal area in km}^2$
	Change in urban area $\text{cm}^2/\text{km}^2$	Change urban area in $\text{cm}^2/\text{municipal area in km}^2$
Landscape quality	Dispersion index (urban sprawl)	Change in the number of nuclei/municipal area in $\text{km}^2$

## Results



The papers will present results which constitute the basis for the formulation of regional goals for the landscape protection by agricultural activities and will facilitate the coordination of land-use planning and agricultural policy.

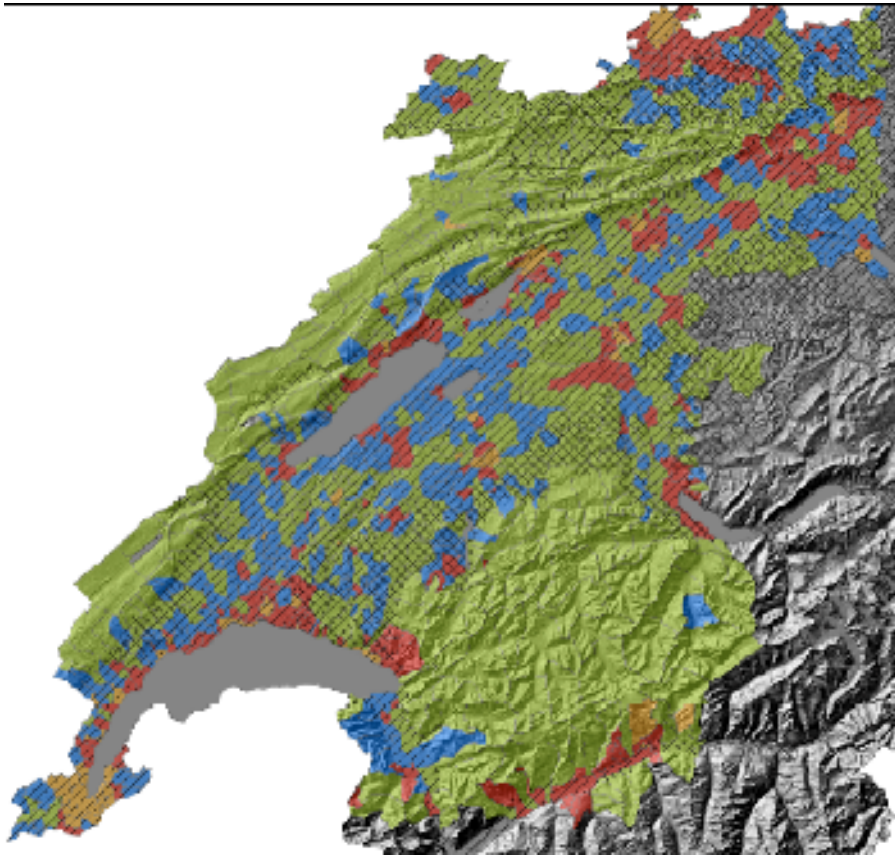
#### Description of the clusters

The municipalities are not equally distributed in the four clusters as shown in table 2. The largest cluster is Cluster 4, where almost 50% of the municipalities are present. Cluster 3 and 2 are medium clusters with more than 15% of the municipalities and Cluster 1 is a little cluster with only 72 municipalities (5%).

Table 2: Statistical distribution of the clusters

<b>Cluster</b>	<b>Number of municipalities</b>	<b>Percentage</b>
<b>1</b> Very pronounced urbanisation and loss of agricultural land	72	5.0 %
<b>2</b> Urbanised, pronounced loss of agricultural land, pronounced urban sprawl	239	16.7 %
<b>3</b> Very pronounced population increase, loss of agricultural land, low urban sprawl	437	30.6 %
<b>4</b> Status quo	682	47.7 %
Total	1430	100%

Figure 1: Spatial distribution of the four clusters



Legend	
Agricultural regions	Clusters
<div style="display: inline-block; width: 20px; height: 20px; background-color: black; border: 1px solid black; margin-right: 5px;"></div> Hill zones Mountain zones	<div style="display: inline-block; width: 20px; height: 20px; background-color: black; border: 1px solid black; margin-right: 5px;"></div>

Table 3: Summary of the variables for the four Clusters

<b>Indicator</b>	<b>Cluster 1 mean/std</b>	<b>Cluster 2 mean/std</b>	<b>Cluster 3 mean/std</b>	<b>Cluster 4 mean/std</b>
Change in residential buildings/km <sup>2</sup>	3.09/3.72	1.66/1.39	0.72/0.76	0.33/0.42
Dispersion index (urban sprawl)	-0.13/0.71	0.10/0.47	0.04/0.20	0.01/0.14
Population growth/ km <sup>2</sup>	93.3/260	40.6/54.8	28.3/26.7	4.41/11.0
Change in buildings related with agriculture/km <sup>2</sup>	-4.40/4.72	-1.48/1.63	0.30/0.92	0.20/0.72
Change in the number of farms	0.59/1.97	-0.71/1.22	-0.43/0.53	-0.31/0.39
Change in urban area cm <sup>2</sup> /km <sup>2</sup>	565/439	261/208	156/12	47.6/86.3
Percenual population growth	10.2/13.7	9.57/10.7	22.1/14.9	4.61/8.14
Percentage of open landscape	38.2/64.4	42.2/17.2	60.8/13.3	52.7/16.1
Percentage of urban area	57.2/49.3	27.6/11.9	11.1/5.13	7.73/4.70
Percental change in urban area	-17.5/27.2	-6.71/5.73	-2.90/3.65	-0.23/8.95
Percental change in agricultural area	42.9/107	12.6/13.6	20.2/20.4	8.11/14.3
Change in agricultural area cm <sup>2</sup> /km <sup>2</sup>	-490/613	-258/220	-170/214	42/217

Cluster 1: Very pronounced urbanisation and loss of agricultural land

These municipalities can be considered urban centre since in average 57% (Table 3) of the municipality territory is urbanised. Two of the largest urban centres and of the region their surrounding municipalities have been attributed through the cluster analysis to this cluster: Geneva and Basel (Figure 1).

In this cluster the trends of change in land cover and landscape functions are the most pronounced of the region considered for the analyses. First, the average urban growth is 560 cm<sup>2</sup> for each km<sup>2</sup> (Table 3) of the municipal area is the highest of all clusters. Second, also the average loss of agricultural land of 490 cm<sup>2</sup> for every km<sup>2</sup> (Table 3) of the municipal area is the highest registered. The average increase of residential buildings and the decrease of buildings related with agriculture are as well the highest registered in the analyses. Despite these clear trends give the indication of fast urban growth affecting agricultural areas, the indicator for urban sprawl show a high variance and does not give any clear evidence for landscape quality.

#### Cluster 2: Urbanised, pronounced loss of agricultural land, pronounced urban sprawl

The average urbanisation degree of 27% (Table 3) characterising these municipalities is lower than those present in the previous cluster. Although they can be considered urban centres, in these municipalities some resources of open landscapes are still available (42% of the municipal area, Table 3). These municipalities are mostly located around the urban centres belonging to cluster 1 (Figure 1).

The trends in the changes of land cover and function are less pronounced but have the same direction of those observed for the first cluster. The average of the loss of agricultural area per km<sup>2</sup> municipal area is the half of the one observed for the first cluster but is still considerable. Also the increase of residential buildings per km<sup>2</sup> and the decrease of buildings related with agriculture are lower than in the first cluster but are still pronounced (Table 3). For this cluster the indicator for urban sprawl gives evidence of bad quality landscape development (Table 3).

#### Cluster 3: Very pronounced population increase, loss of agricultural land, low urban sprawl

This cluster shows quite different trends relatively to the first two clusters. On one hand, the population increase very considerably in percent (22%, Table 3) and the agricultural area decreases 170 cm<sup>2</sup> per km<sup>2</sup> municipal area. On the other hand, the number of buildings related with agriculture increases slightly. This is the cluster with the largest reserves (60%, Table 3) of open landscape and the lower degree of urbanised land (8%, Table 3). The indicator

indicates that urban sprawl is very low. Mostly of these municipalities borders the municipalities contained in Cluster 3.

#### Cluster 4: Status quo

This Cluster comprises almost the half of all municipalities studied. These municipalities have very large reserves of open landscapes (52%, Table 3) and only 8% of the municipal area is urbanized. The indicators show that almost no change is occurring in land cover and landscape functions. The population is slightly increasing (4%, Table 3).

#### Discussion

The presented typology can potentially be used as instrument for setting regional goals for landscape conservation. In order to coordinate these needs they need to be clearly formulated and priorities need to be clearly set. For each cluster it is possible to read clear trends and to address specific questions which should be answered by policy makers.

##### 1) Very pronounced urbanisation and loss of agricultural land

The municipalities in the first cluster are much urbanised. Most of these municipalities are classed in the Swiss Municipality Typology (Schuler and Joye 2008) among the large- and mid-centres which are part of a metropolitan area and which are characterised by a population greater than 7000 inhabitants. Our analysis shows that for those municipalities open landscape and agriculture are exposed to a high pressure through the very fast development of the residential and economic functions of the urban area. The opportunity costs of maintaining the agricultural activity for most of the farmers can be very high (Mann 2009). Therefore, the questions to be answered for these municipalities is how much landscape is needed for the agricultural production function but also for the recreational function of the urban population. Primarily, the role of periurban agriculture should be cleared.

One solution could be to guarantee the presence of high quality green areas for recreation and do not explicitly protect agriculture production in these municipalities. Some countries

developed for “urban areas” and “rural areas” a planning system with different rules. In England e.g. zones where urban growth can occur have different rules than green belt areas where agricultural land is strictly protected and villages or little urban centres can grow only moderately (Carruthers 2002).

2) Urbanised, pronounced loss of agricultural land, pronounced urban sprawl

The municipalities in this cluster are vulnerable. The development trends show that large amount of agricultural land get lost while urban residential area increase. This cluster has the larger decrease of the number of farms per area. The decrease of the importance of the food production function of the agricultural area can be observed also from the decrease of buildings related with agriculture. The vulnerability of these municipalities can be argued considering three elements: first, the clear trend of decrease of agricultural area; second, the large reserves (average of 42 % of the municipal area) still present in these municipalities and third the pronounced urban sprawl indicated by the indicator. These municipalities are usually located close to the urban centres that which spread out. The geographical location of such municipalities is generally called urban fringe (Antrop 2004) and the phenomenon of urbanisation with consequent changing function and loss of importance of agriculture production is well known and has been described in many studies (e.g. Busk et al. 2008). Busk et al. (2008) speak about rural transformation because in these municipalities traditionally rural characteristics (and function) are mixed with typical urban characteristics (and function) and can compete. This transformation process needs to be steered by an active management.

Urban sprawl and pronounced agricultural land decrease are not caused purely by socioeconomically factors. In fact, such vulnerable municipalities belong to different clusters in the Swiss Municipality Typology: the great- and mid-centres, the commuters' municipalities and municipalities part of an agglomeration which can or not be part of a metropolitan area (Schuler and Joye 2008). Geographical factors like the availability of large amount of agricultural areas or the current urban structure can explain why vulnerable municipality in terms of landscape quality do not correspond to municipalities with precise socioeconomic characteristics (Mann 2009). Tappeiner et al. (2008) found by the development of a typology of the Alps that regions with the largest land consuming are not

necessarily the most accessible regions from the centres where work-places are located. For Tappeiner et al. (2008) the cause of land consuming is rather political.

For the municipalities in this cluster, policy makers need to set priorities and design landscape quality parameters specifically for these municipalities. First of all, it would be important to decide how much the urban land can expand and how much landscape and agricultural activity should be conserved there. Second, quality parameters for the landscape have to be set in order to control urban sprawl.

### 3) Very pronounced population increase, loss of agricultural land, low urban sprawl

These municipalities can be described as municipalities changing character. The population increase of 20% and the increase of the urban area of 20% indicate that the municipalities are moving from pure rural municipalities towards more urban municipalities. Although there is no urban sprawl observed, the population increase in this cluster is causing proportionally more urban growth than in the other cluster. This is an indication that the urban growth is not occurring in a compact way. This phenomenon means that urban growth and population growth are decoupled and gives advices that urban sprawl will occur in the future (Schulz and Dosch 2005).

The indicators give indication of potential conflicts. The space for residential buildings is growing considerably and the agricultural land is decreasing. Although the number of farms is decreasing, the slight increase of the number of buildings related with agriculture could indicate that the importance of agriculture activity is not decreasing and that some farms are expanding their activities. These two trends show existing or potential conflicts between the interests of farmers and of the population moving to live to these municipalities. In fact trends can be mostly observed in agrarian municipalities, agro-industrial municipalities and commuter municipalities (Schuler and Joye 2008), where people employed in the first sector is higher than 9% (and higher than 23% in the agrarian municipalities).

These municipalities can also be considered vulnerable and policy measures need to be implemented to steer development. First of all, policy decision makers have to decide whether to focus on the promotion of agricultural activities and how much urbanization should be tolerated. To well manage development is particularly important here because there are



indications of new conflicts arising which would involve many actors like farmers, land owners, municipal decision makers and population. Priorities have to be set clearly because of the high decrease potential of the reserves of open landscape which are still relatively large. One possibility is to consider all these municipalities in a sort of green belt (Millward 2006) and to treat them as green open landscape compensating the urban promotion spaces. At a regional level it is suitable that all actors participate for deciding about the plan of future development.

#### 4) Status quo

In this cluster very little changes are happening. The spatial distribution of the four Clusters depicted in Figure 1 show that Cluster 1 is mostly located in the centre surrounded by Cluster 2 and then by Cluster 3. This can be interpreted as progressive spatial expansion of a process. Since these municipalities could become vulnerable in the future it is important to plan development. Status quo municipalities cover agrarian, commuter and touristic municipalities (Schuler and Joye 2008). This means that these municipalities have different functions (e.g. food production and tourism). Therefore, policy makers and local actors should look for the potentialities and future functional role of such municipalities relatively to the other clusters. One important question to be answer is the future role of mountain agriculture.

#### Conclusion

Our typology is able to detect specific trends characterizing on the conflict between urban growth and landscape conservation. While other typologies focus on socioeconomic factors (e.g. the Swiss Municipality Typology, Schuler and Joye 2008) or consider a wide range of indicators for monitoring sustainable development (Tappeiner et al. 2008), this typology focus on a specific problem and gives background information for understanding the spatial patterns and trends of such problem.

This problem-oriented typology permits to elaborate specific key questions which helps decision makers at national and regional level to set priorities and to formulate specific regional measures. The presence of information about (a) evaluative elements for landscape quality like urban sprawl and loss of agricultural land and information about (b) landscape

functions like “built-up area for living or working” and “agricultural land for agricultural production” helps linking the needs and views of both decision makers in the agricultural policy domain and those in the land use planning domain. How agricultural policy can contribute with regional specific instruments to specifically steer towards these regional goals remains unclear in this study and need further studies and discussions among the policy-makers. In a second step of this study, regional/local detailed information about landscape functions, their values and conflicts among them should be analysed. This more detailed information could then be used for the local implementation.

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