Chapter 2

LAND-USE CHANGE DYNAMICS AT CADASTRAL PARCEL LEVEL IN ALBANIA

an object-oriented geo-database approach to analyse spatial developments in a period of transition (1991-2003)

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Abstract: A case study in Albania is presented based on the EU Phare Land Use Policy II project results where GIS-oriented instruments and innovative methodologies were implemented to support decision-making for land-use policy and planning. The developed Land-Use Information System for Albania allows the logical and functional hierarchical arrangement of land uses and data harmonisation with other land-use description systems. It is linked to the object-oriented Land-Use Change Analyses methodology that groups changes into conversions and modifications. The preferred change patterns indicate that land users take rational decisions when changing land use, even in the absence of any regulating plan, as is the case in post-communist Albania.

Key words: land-use change dynamics, knowledge discovery in databases, object-oriented database approach, agriculture, urbanisation.

1. INTRODUCTION

In Albania, the government has distributed the land to rural households instead of restitution of most of the fertile lands to a small number of families that would have restored the highly unequal pre-reform land distribution (Swinnen, 1999; 2000). The transition from 550 large agricultural cooperatives to 467,000 smallholder farms was associated with the fragmentation of land into 1.5 million parcels that often have limited or no access to infrastructure and mechanisation. Most of the agricultural land

lies in sloping areas with soils having high erosion risk potentials. Most of the farms are subsistence ones and about 75% of farm production is for home consumption. The lack of information, inadequate extension services, almost no access to bank credits, lack of marketing channels up to difficult access to transport are the major constraints for the Albanian farmer. Since around half of the Albanian population is employed in the agricultural sector, a national development priority is a sound land-use policy allocating land to uses that prevent degradation and yield high long-term returns. The land users should ensure the long-term quality of land for human use, minimise social conflicts and protect ecosystems. All user categories should have enough land with an infrastructure balanced against environmental threats, at reasonable costs and endowed with a well-defined tenure.

The EU Phare Land Use Policy II project (LUP II) provided GIS-oriented instruments and innovative methodologies to support decision-making for land-use policy and planning to the Ministry of Agriculture and Food in Albania. These methodologies and tools have been applied in three representative pilot communes in the northwest, centre and southeast of the country. This paper illustrates the concepts adopted and results obtained for the analysis of land-use change dynamics over 1991-2003. Land-use change is one of the main driving forces of (global) environmental change and therefore central to sustainable development (Meyer and Turner, 1994; Walker *et al.*, 1997; Walker, 1998). Thus analysis of past land uses and the understanding processes and preferred pathways of change will support informed decision-making for improved, sustainable and environmentally sound land uses in future.

2. METHODOLOGY

This section gives a short description of the information system and its basic unit that were used in this study and briefly introduces the methods that were used in the analysis of the land-use changes. The methodology is described more extensively in two LUP II project documents (Agrotec S.p.A. Consortium, 2003a; 2003b).

2.1 The cadastral land parcel as basic unit

For each piece of land, individuals choose a type of use from which they expect to derive the most benefits in the context of their knowledge, the individual’s household, the community, the bio-physical environment and the political structure to which the individual may be subject. These choices vary in space and time resulting in a spatial pattern of land uses. The analysis

at the level of the spatially explicit legal parcel unit of the multi-purpose cadastre may show the variability at the level of each cadastral zone while the aggregated level of the commune may show patterns that remain invisible at the detailed scale, and vice versa (Veldkamp *et al.*, 2001). The aggregated level of the commune is important in the land-use policy and planning process while the cadastral parcel unit is a level that corresponds with the decisions made by the individual landowner or land user. It should be clear though, that such decisions may be related to the group and its size the individual belongs to (Verburg *et al.*, 2003). Individuals interact to form groups and organise collective action (e.g. farmer associations).

In general, land registration and the cadastre should be seen as part of the process of natural resources planning and management. The multi-purpose cadastre should therefore be seen as an integral part of the land management system. It is therefore important to establish linkages with a wider range of land-related data, especially those relating to the environment. In this manner, managing land and land information meet (Dale, 1995).

2.2 The Land-Use Information System for Albania

There is significant diversity of opinion about what constitutes a land use (UNEP/FAO, 1994). In the context of the project land use is defined as '*the type of human activity taking place at or near the surface*' (Cihlar and Jansen, 2001). The developed Land-Use Information System for Albania (LUISA) has adopted as guiding principles two criteria that are commonly applied in international systems (Anderson *et al.*, 1976; IGU, 1976; ECE-UN, 1989; UN, 1989; CEC, 1993; 1995; FAO, 1998; CEC, 1999; UN, 1998; APA, 1999): (1) *function* that refers to the economic purpose of the land use and can group many different land-use types in a single category; and (2) *activity* that refers to a process resulting in similar type of products and is used at the lower levels of the hierarchy (Jansen and Di Gregorio, 1998; 2002). The adopted concept builds upon and exceeds experiences gained in two case studies (Jansen and Di Gregorio, 2003; 2004). Furthermore, LUISA arranges in a logical and functional manner land uses at different levels of detail and allows data harmonisation with other land-use description systems in use in the country (e.g. statistical office, cadastre and communes).

Categories present in the current version of LUISA represent the key categories of the Albanian law on the land: 'agricultural', 'forests', 'pastures and meadows' and 'non-agricultural' land uses (Figure 2-1). The set of classes in this legend is only a proportion of what one may actually find in Albania. The cadastre in Albania contains information on 1.5 million parcel units with an average size of less than 1 ha. Because of the scale of observation selected, i.e. the cadastral parcel unit, and in order to create in a

timely manner a pragmatic land-use database of a manageable size (i.e. all records created will need to be maintained and updated at regular intervals), the decision was made that only one land-use class is attached to each parcel unit. At aggregated cadastral parcel levels, mixed classes can be introduced but they do not exist at the most detailed level of LUISA.

The LUISA data together with other data sets have been structured according to the European Environmental Agency's Infrastructure for Spatial Information in Europe initiative (INSPIRE Environmental Thematic Coordination Group, 2002).

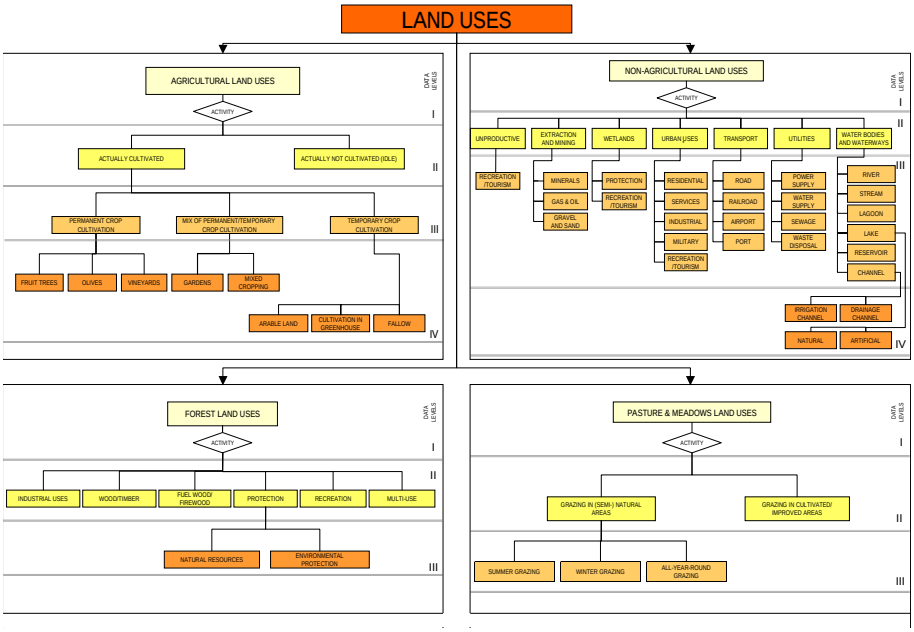

Figure 2-1. Overview of the LUISA legend with the four main categories of land use (Agrotec S.p.A. Consortium, 2003b).

2.3 The Land-Use Change Analyses methodology

LUISA contains many classes and thus will result in numerous possible land-use changes that do not facilitate a meaningful interpretation if not grouped in a functional and systematic manner. The developed object-oriented Land-Use Change Analyses (LUCA) methodology arranges the potential land-use changes in three main groups per land-use category in order to underline the change processes: (1) land-use *conversion*, i.e. where a certain land use has been changed into a land use that is very different and

the change cannot easily be reversed; (2) land-use *modification*, i.e. changes that are related to one another and where the situation can be reversed; and (3) *no change*, i.e. areas that have remained under the same land use. The parent-child relationships created facilitate the analysis of the spatio-temporal dimensions, i.e. area and perimeter over time (Booch, 1994).

In principle, land-use modifications occur within a land-use category and land-use conversion occurs between land-use categories. The exception is the 'non-agricultural' land-use category that contains a larger variety of classes than the other categories; in this category modifications occur within one group (e.g. within 'urban uses') and conversions between groups (e.g. from 'unproductive' to 'urban uses'). Unlikely changes such as a 'residential area' having changed into 'arable land' have been excluded from the change analysis.

2.4 Knowledge Discovery in Databases

The Knowledge Discovery in Databases (KDD) process is an iterative procedure of selection, exploration and modelling of large amounts of data that was used to detect *a priori* unknown relationships in the data. The KDD process comprises many elements of which the two most important in the context of this paper are (Bonchi and Pecori, 2003):

1. data-mining: the most important phase in which through the use of specific algorithms previously unknown patterns are extracted from the data that are channelled into a data model; and
2. pattern evaluation: an interpretation and evaluation of the identified patterns and data model is given in order to create new knowledge.

Some preliminary statistics on correlations between parameters were performed using the On-Line Analytical Process (OLAP) Cube for multi-dimensional analysis in order to better understand which parameters to use in the KDD process. OLAP was performed with the following variables: (1) land-use change class, (2) land-use change period, (3) slope class and (4) land suitability.

The variables used as inputs into the decision tree that belongs to the data-mining phase of KDD, have been used with the assumption that one of the variables, i.e. the land use in 2003, is dependent on other variables. The use of the variables to construct the decision tree is such that one starts at the initial node with all the available data, then at each step groups are created on the basis of an explanatory variable and in the successive step, each group created will be further subdivided by another explanatory variable and so on until the terminal node. Once a variable has been used it cannot be used in successive steps (Lombardo *et al.*, 2002). From the initial node to the terminal node a series of decision-rules can be extracted of the type IF-

THEN. Each decision-rule is characterised by a weight and a confidence level that measure the frequency and strength of the decision-rule respectively. Decision-rules that are valid for many cells have a major weight, whereas those that repeat themselves in the same manner have more significance. The method requires several runs in order to create groups that maximise the internal homogeneity and the external heterogeneity. To create the groups at each level of the procedure a function is used as efficiency index that is known as 'function segmentation criteria' (Han and Kamber, 2000).

3. RESULTS

3.1 Pilot area selection

The choice of pilot communes illustrates the diversity in landforms and (agro-)ecological conditions plus the variety in socio-economic settings. The choice of Preza Commune was also governed by the fact that it already served as a pilot area in the LUP I project. The availability of suitable digital data sets was a prime criterion for selection.

3.2 The temporal changes in the communes

Each of the three land-use data sets available represents a critical moment in time: (1) the 1991 data represent the land uses under the former centralised government; (2) the 1996 data represent the time when distribution and registration of the land to the family households took place; and (3) the 2003 data represent the actual land uses in the market-oriented economy.

Figure 2-2 shows the different types of land-use change aggregated for the three communes, i.e. Preza, Ana-e-Malit and Pirg in the centre, northwest and southeast of the country respectively, in 1991-1996 and 1996-2003. The communes comprise 2552, 3357 and 2150 ha respectively. In all three communes the intensity of changes in 1991-1996, so before the land distribution, was higher in 1996-2003. The majority of parcels were not subject to any change in either period. In Ana-e-Malit and Pirg the area not subject to change increases in the second period, but in Preza it decreases. The main change in land use in both periods concerns a land-use modification and in all three communes it is the 'medium-level-modification-in-agriculture', which means that classes in the 'agricultural' land-use category changed at level III, i.e. from permanent into temporary

Crop Cultivation or vice versa. However, the extent of this modification is diminishing in 1996-2003 in Ana-e-Malit and Pirg, whereas Preza shows a clear increase. Land-use conversions are much less important in terms of their extent but their impact may be bigger than that of land-use modifications. In Preza in 1991-1996 'agriculture-to-pasture' and 'pasture-to-agriculture' conversions are important, whereas in 1996-2003 'forest-to-agriculture' is the main conversion. In Ana-e-Malit several conversions occur in 1991-1996, whereas 'agriculture-to-nonagriculture' is predominant in 1996-2003. In Pirg in 1991-1996 'nonagriculture-to-agriculture' is the main conversion and in 1996-2003 'agriculture-to-pasture'. It seems that in 1996-2003 in particular, agricultural lands were converted, whereas overall changes were affecting less parcels. In this period land has been privatised and apparently many new owners did not want or did not have the means to continue agricultural activities.

Table 2-1. Predominant types of land-use changes (claiming over 1% of the total area) in Preza, Ana-e-Malit and Pirg in 1991-1996 and 1996-2003.

Type of land-use change	Preza		Ana-e-Malit		Pirg	
	91-96	96-03	91-96	96-03	91-96	96-03
No change	86.5	80.2	71.7	90.2	81.3	91.9
Medium level modification in Agriculture	4.9	7.6	9.8	1.9	8.2	3.9
High level modification in Non-Agriculture		1.8			1.5	
Agriculture-to-Forest			1.3			
Agriculture-to-Pasture	1.6	1.1	5.6			1.8
Agriculture-to-Nonagricultural		1.1	2.5	2.1	1.4	
Forest-to-Pasture		1.1	2.9			
Forest-to- Agriculture		3.2				
Pasture-to-Agriculture	1.2		1.5			
Nonagricultural-to-Agriculture					2.5	

Concerning the most important change, 'medium-level-modification-in-agriculture', more insight is gained when analysing what type of land-use classes result in this type of change. Selection of this change type in the three communes and grouping the class combinations of this change shows that in Preza and Ana-e-Malit in 1991-1996 the trend is to go from temporary to permanent crops, whereas in Pirg the trend in the same period is from permanent to temporary crops (Figure 2-3). In 1996-2003, the trend in Ana-e-Malit remains more or less the same. In Preza, however, the majority of changes still concerns the change from temporary to permanent crops though the rate of change is at a lower level than in the previous period, while the change from permanent to temporary crops increases clearly. In 1996-2003, the main trend in Pirg remains the change from permanent to temporary cropping but at a lower level than in the previous period and the change to

permanent crops increases. In Pirg many terraces with fruit trees, the main crop production system, were destroyed in the 1990s; in Preza and Ana-e-Malit projects are underway to plant useful trees (e.g. fruit trees, olives).

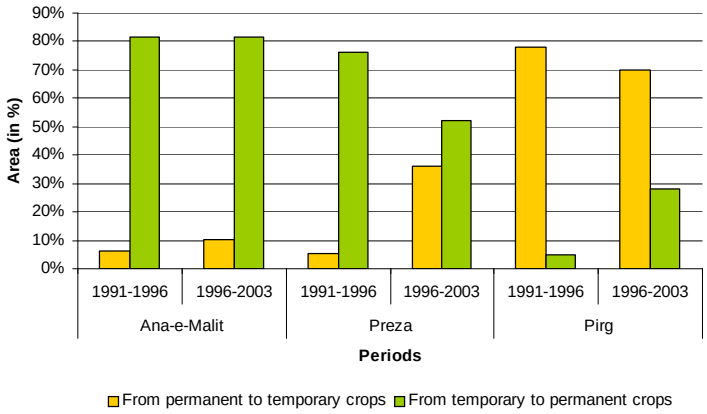

Figure 2-2. Detailed analysis of the LUCA change type 'medium-level-modification-in-agriculture'.

The identified change dynamics have some important repercussions: the permanent cultivation land-use types are usually found on man-made terraces or in landscapes with slopes where the trees stabilise and protect the environment. A further analysis made, combining the land-use change data with a digital terrain model shows that one of the adverse affects of the change from permanent to temporary crops is increased erosion in hilly areas. Furthermore, there seems to be a shift in agricultural land uses because the area lost in one place and gained in another affects different parts of the commune territory. From the three-dimensional analysis of where such changes are found, it becomes clear that parts of the flat or almost flat areas favourable for agriculture are lost, whereas areas where less or even unfavourable terrain conditions (e.g. steep slopes) exist are gained. This consumption of prime agricultural lands, in the plains and river valleys of peri-urban areas, blurs the distinction between cities and countryside and hints at the 'ecological footprint' of the city (Lambin *et al.*, 2003).

3.3 The spatial distribution of changes

As physical and social characteristics of communities vary in space and time, so do land-use choices, resulting in a spatial pattern of land-use types (Cihlar and Jansen, 2001). If one shows the land-use changes not in the

format of statistics but as maps, one can easily identify in each commune areas that were more prone to land-use changes than others.

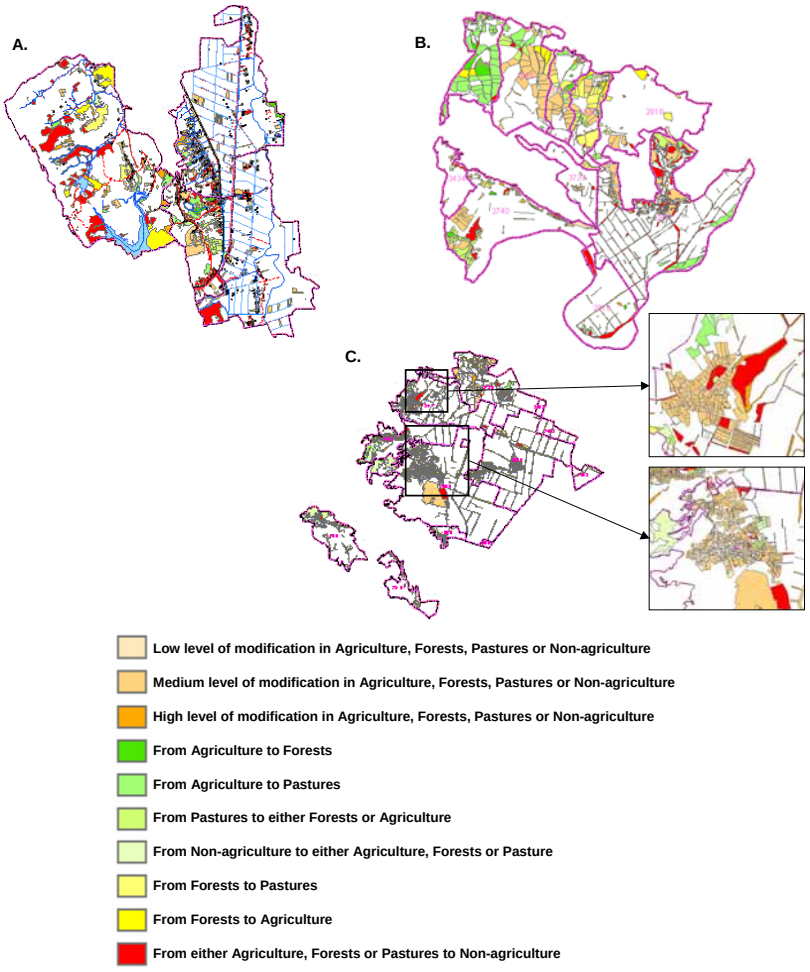

Figure 2-3. Distribution of land-use changes in the commune of Preza (A), Ana-e-Malit (B) and Pirg (C) in 1991-2003 (communes are not shown at same scale).

Figure 2-4 shows the distribution of changes over the territory of the communes ranked according to the environmental impact of the change and the fact that Albanian law protects agricultural land, forests and pastures from other uses. The changes with the strongest adverse environmental impact, occurring in protected lands are indicated at the bottom of the figure

in the darkest colours. The changes in Preza seem to be divided clearly over the territory: most conversions are found in the western part that consists mainly of hills, whereas most modifications occur in the eastern part that consists of foot slopes and a plain (indicated by the channel system). In Ana-e-Malit, modifications occur mainly on the foot slopes and close to the main village of the commune where also the frequency of conversions is highest. In the flatter areas, indicated by the channel system, few changes occur. In Pirg, modifications occur in areas where the land parcels have been divided into many very small parcels close to the villages as shown in the two detailed windows. Also conversions occur in these areas but of a type that is considered to have a positive environmental impact. Large parcels are more often subject to conversions considered to have a negative impact than small land parcels. Also in this commune the flat areas with channel systems are not subject to many changes.

The areas where land-use conversions occurred that cannot be easily reversed, are mainly in the sloping and hilly parts of the communes. In the plains, land-use modifications were dominant, whereas the residential areas grew at the cost of neighbouring land uses.

3.4 Preferred pathways of change in Preza Commune

The change dynamics can be related to the landscape position of the cadastral parcel within the terrain and the land suitability for irrigated agriculture, as the communes are predominantly agricultural ones, as well as a set of variables related to what is found in or close to the land parcel. The areas of Preza Commune that changed in 1991-1996 and/or 1996-2003 were examined more closely.

A preliminary statistical analysis using OLAP showed that:

- In 1991-1996, more stability concerning land uses exists with around 39% of the total area being classified as no land-use change or ‘medium-level-modification-in-agriculture’ land-use changes homogeneously distributed within the territory concerning the various slope and land suitability classes.
- In the same period, transformations are uniformly distributed between the different land-use classes and slope categories. Moreover there are no major conversions of land use but only some medium-level-modifications.
- In 1996-2003, contrary to the changes in the previous period, a portion of steep sloping lands has been abandoned (20%); this is probably related to abandonment of terraced areas.

- Moreover in the same period, privatisation of agricultural lands led to encroachment of fields at the costs of forests. Conversion from forests into pastures and meadows is around 10%.
- It is interesting to note that there is a strong relation between slope class and land-use class, i.e. steep lands are always related to land uses like forestry and pastures and meadows.

The data of 1996-2003 for Preza Commune has been used as input into the KDD process in order to identify what variables in the extracted decision-rules are important and lead to specific pathways of change. The decision-rules with major weights have been chosen first, followed by those with high significance. The whole territory of Preza Commune has been divided in cells of 50 by 50 metres to which a series of attributes are linked from the available data sets. The analysis aims at explaining what factors in or near the cells are important in a specific type of change. Application of the set of decision rules for 1996-2003 to the original data of 1996 resulted in a predicted land use for 2003 with a correlation coefficient of 0.75 with the collected 2003 data. The difference between the average square root of classification (0.149) and average absolute error (0.0444) is low, which means the absence of classification outliers. In addition, the accuracy of prediction for each land-use class is above 0.70 with the exceptions of services and industrial areas because the first class is little present in 1996 and the second absent at that date. Low values for these two classes, however, do not imply that the extracted decision-rules involving these classes are erroneous, but they do indicate that these rules are not easily tested and evaluated. The overall accuracy is 79.9%.

The analysis concerns in particular the 'medium-level-modification-in-agriculture' land-use change and focuses on areas that are either not cultivated or fallow, regrouped under uncultivated, as (temporary) abandonment of cultivated -especially terraced- areas is a problem. The complete set of rules for 1996-2003 is almost twice the number of the previous period (719 versus 366 rules), though there are less changes in that period. Two types of rules are extracted, i.e. *transformation* and *inertial rules*, with the description of their conditions (e.g. IF LU_1 and [conditions 1, 2, ...] THEN LU_2). Transformation rules describe a land-use change ($LU_1 \neq LU_2$), whereas inertial rules describe a land use not subject to change ($LU_1 = LU_2$). The extracted rules show that in 1996-2003, the vicinity -or neighbourhood- of the examined cell does not influence the land-use change dynamics in particular. In 1991-1996 one finds the opposite, i.e. the vicinity of the cell is very important for the change dynamics. One should also note that in 1991-1996 the extracted rules are essentially inertial rules and transformation rules are few and related to only a few cells, whereas in 1996-2003 there are much more transformation rules than inertial rules.

Furthermore, the transformation rules for 1991-1996 contain one principal condition that leads to a certain land-use change. In 1996-2003, a principal condition accompanied by more than one set of sub-conditions leads to the same land-use change. So the preferred pathways of change are much more complex in the second period.

Tables 2-1 to 2-4 show only those rules related to permanent cropping, temporary cropping and uncultivated areas. A change that becomes more evident is that remote areas with either permanent or temporary cropping, often on steeper terrain, and with a lack of infrastructure tend to become uncultivated. So in these areas the agricultural intensity has decreased dramatically.

Table 2-2. Transformation rules for land-use groups in 1991-1996.

1991	Principal Conditions	1996	Cells
Permanent cropping	High level of Uncultivated in vicinity	Uncultivated areas	167
Temporary cropping	High level of Olive trees in vicinity	Permanent cropping	28
	Medium level of Uncultivated in vicinity AND Original parcel medium-to-low in size AND No Water in vicinity	Uncultivated areas	15
	Low number of buildings in 500m AND High level of Residence in vicinity	Urban areas	68

Table 2-3. Inertial rules for 1991-1996.

Land use	Principal Conditions		Cells
Permanent Crops	Near to urban secondary road AND No Pastures/meadows in vicinity AND No Residence in vicinity AND No Water in vicinity AND No Uncultivated in vicinity AND No Transport in vicinity		173
	Medium-to-high level of Olive trees in vicinity		54
	Low level of Uncultivated in vicinity AND Medium level of Olive trees in vicinity AND No Forests in vicinity		40
Temporary Crops	High level of crops in vicinity	AND No Olive trees in vicinity AND No Uncultivated in vicinity AND No Water in vicinity AND No Fruit trees in vicinity AND No Pastures/meadows in vicinity	2245
		AND Low number of buildings in 500m	223
		AND Low level of Fruit trees in vicinity	137
		AND No Fruit trees in vicinity	125
	Medium-to-high level of crops in vicinity AND No buildings within 500m AND Poor road condition	AND No Water in vicinity	283
		AND No distance from the edge of cell AND No Olive trees in vicinity AND No Uncultivated in vicinity	103
		No Residence in vicinity AND Small distance to the edge of cell	93
	Medium-to-high level of crops in vicinity	AND No buildings within 500m AND Low erosion risk AND No Olive trees in vicinity AND No Forests in vicinity AND No Fruit trees in vicinity AND Original parcel low in size AND Small distance to artificial watering canal	150
		AND No Residence in vicinity AND Fair road condition	96
	Medium level of crops in vicinity AND No buildings within 500m AND No Olive trees in vicinity AND No Uncultivated in vicinity AND No Water in vicinity		264

Table 2-4. Transformation rules for land-use groups in 1996-2003.

1996	Principal Conditions		2003	Cells
Permanent cropping	Medium-to-high level of Fruit trees in vicinity	AND Original parcel medium in size	Unculti-vated	48
		AND No additional condition		23
Temporary cropping	100%>slope>75% AND Near to urban main road AND No Pastures/meadows in vicinity		Permanent cropping	21
	100%>slope>75% AND Low number of buildings in 500m AND No Transport in vicinity AND Medium-to-low erosion risk	AND Original parcel low in size AND Small distance to nearest road	Unculti-vated	45
		AND Original parcel high in size AND No Pastures/meadows in vicinity		36
	100%>slope>75% AND Gravel loose road in vicinity AND Medium-to-low erosion risk	AND Low number of buildings in 500m AND No Transport in vicinity AND Original parcel medium in size AND No Residence in vicinity		71
		AND Very low drainage value AND Medium-to-small distance to natural watering canal		19
	Gravel loose road in vicinity AND No Residence in vicinity	AND Low number of buildings in 500m AND No Transport in vicinity AND Original parcel low in size AND No Pastures/meadows in vicinity AND Low level of Olive trees in vicinity		48
		AND 75%>slope >50% AND Original parcel medium in size		26
	Slope < 25% AND Low number of buildings in 500m AND No Forests in vicinity AND Near to urban secondary road AND No Transport in vicinity AND No Residence in vicinity AND Low drainage value AND No Water in vicinity			53
	Medium-to-high distance from artificial watering canal AND Medium distance from nearest road			21
Unculti-vated	Paved road in vicinity AND Original parcel medium in size	AND No crops in vicinity	Permanent cropping	49
		AND No Pastures/meadows in vicinity AND No Forests in vicinity		28

Table 2-5. Inertial rules for 1996-2003.

Land use	Principal Conditions		Cells
Permanent cropping	No Fruit trees in vicinity AND Paved road in vicinity AND Medium-to-high distance from artificial watering canal AND Medium-to-low number of buildings in 500m		87
	No Fruit trees in vicinity AND No Transport in vicinity AND No Water in vicinity AND No Forests in vicinity AND No crops in vicinity AND Medium distance from artificial watering canal		54
Temporary cropping	Slope < 25% AND Original parcel low in size AND No buildings inside	AND Small distance to nearest road AND No Water in vicinity AND Low number of buildings in 500m AND No Residence in vicinity AND Unpaved road in vicinity	133
		AND Paved road in vicinity AND Medium distance from	59
Uncultivated	Unpaved road in vicinity AND Low number of buildings in 500m AND Medium distance from nearest road		64

3.5 Factors in the decision-making process that drive land management

The land-use change dynamics discussed previously, are related to changes in land management that, in turn, are driven by changes in decision-making processes. This decision-making is influenced by factors at different levels with direct or indirect causes (Lombardo *et al.*, 2002). A number of such factors, relevant for our case, are discussed below. This inventory is based on the findings of the LUP II project inventories and workshops.

The change in economic system in Albania has forced changes at all levels of organisation. Many land users have a sceptical approach to any form of collective action and at receiving advice from government related services. Farmers, for example, are reluctant to organise themselves on a voluntary basis in farmer associations and they hardly use the free agricultural extension services. The general lack of information hampers informed and strategic decision making by the rural households. Economic factors and policies, such as taxes, subsidies, credit access, technology, production and transportation costs, define a range of variables that have a direct impact on the decision making by land users. Market access is largely conditioned by government investments in transportation infrastructure and is identified as one of the major problems and constraints in the communes (Table 2-5). The lack of market access in certain areas has greatly influenced the agricultural production, identified as another major problem and constraint. With mainly semi-subsistence farming and no external demand (or the impossibility to respond to any external demand), the agricultural

intensity has decreased dramatically. In the pilot areas, results from the socio-economic study report that the production of most crops has declined drastically (e.g. wheat by 50%; tobacco, sunflower, sugar beet and soya by 25-33%), whereas the area of forage crops (e.g. alfalfa) increased with 17% and so did livestock production. The only crops experiencing an increase in area and production are vegetables, though mainly used for self-sufficiency purposes. Another result of the land distribution was the changed access to non-land assets such as agricultural equipment. If farmers have no or little access to machinery and labour needs to be executed manually the agricultural production will suffer. Thus, the tendency of rural households active in farming is to go towards a mixture of livestock and forage production. Crop types that are in competition with imports from especially EU countries in the internal market lose out in this competition and, as a result of their low quality and the lack of facilities, cannot be exported to an external market (e.g. CIS countries). It should therefore not come as a surprise that because of the many difficulties, 47% of the rural households in the pilot communes decided to be active in agriculture only part-time. The low agricultural productivity levels can be seen as an indicator of the non-ability of the land users to adapt to changed circumstances as described by Lambin *et al.* (2000).

Erosion and land degradation, flooding and sedimentation (especially in the floodplain of Ana-e-Malit) and pollution and solid waste problems mentioned in Table 2-5 can be seen as other indicators of the fact that, in the pilot communes the ability to adapt to changed circumstances is very limited.

Table 2-6. Main problems and constraints in the pilot areas as identified by the communes and LUP II project.

Constraints and problems	Preza	Ana-e-Malit	Pirg
Agricultural production	xxx	xx	xxx
Marketing	xx	xxx	xxx
Land tenure (security and size)	xx	xx	xx
Settlement and peri-urban development	xxx	x	xx
Erosion and land degradation	xx	x	xxx
Flooding and sedimentation	x	xxx	x
Pollution and solid waste	xxx	xx	xx

xxx - very serious; xx - serious problem; x - moderate

Another factor influencing the decision making of the land users is land tenure. The farm sizes in the pilot communes are very small: 78% of households have a farm smaller than 1 Ha distributed over 3 to 5 land parcels. Correcting land fragmentation is therefore considered important in Albania, as in many other parts of central Europe (van Dijk, 2003). Graefen (2002) confirms that land fragmentation is putting an additional burden on

farm management. But the question is if land consolidation is meaningful considering the average farm size of a rural household, i.e. if four parcels of less than 1 ha farm are re-allocated one can still not make a decent living. In such cases, off-farm income can supplement the revenues from the farm, thus overcoming the farm size restriction. Small farms may make sense in some labour-abundant agricultural economies in the short run, in the longer run the transition to a modern state means that farm size must be sufficiently large (Rozelle and Swinnen, 2005).

4. CONCLUSIONS AND DISCUSSION

For the first time in Albania, the temporal and spatial magnitude of change dynamics at cadastral level was studied in three pilot areas.

Modification is the predominant land-use change type and concerns agricultural lands where temporary crops are replaced by permanent crops or vice versa. In the understanding of the change processes of modification, the decision-making processes of the land users play a key role. Development of future trajectories that include intensification of agriculture should consequently include the decision-making processes of these farmers though policies usually address more aggregated levels (e.g. district or national levels). A study carried out at national and district levels may obscure the existing local variability of spatially explicit land-use changes, whereas it may show patterns that at more detailed data levels remain invisible (Jansen *et al.*, 2005). Understanding land-use change dynamics is foremost concerned with the quantities of changes, i.e. the amount of area changed and the amounts of inputs used and/or production per unit area gained or lost as a function of management level.

In 1991-1996, the observed changes were still influenced by a central planning policy, most likely due to the persisting influence of former officials, technicians and experts still considered to be a reference in land use. With the collapse of central government, the absence of any planning authority and without any improvement in the land market, land uses were mainly preserved where environmental conditions were more favourable, and degradation occurred where environmental conditions were less favourable. With the beginning of a land market and corresponding lack of regulation and legislation in 1996-2003, land-use changes were more dynamic. The greater number of pathways of change for 1996-2003 seems to confirm that the new landowners of the cadastral parcels each went their own way without any level of governmental land-use planning involved.

The analysis of preferred pathways of change in Preza Commune indicates that the land users take rational decisions when they change land

use because of, for example, low suitability or unsuitable soils for a particular use and they seem to abandon steep lands where erosion phenomena manifest themselves. The socio-economic evolution confirms that before 1991 agricultural output is mainly increased by bringing more (terraced) land into production followed by the intensification of production through fertilizer use and/or irrigation. After 1996, the costs of maintenance of these terraced areas and, more important, the division of this area not according to contour lines but perpendicular to the terracing led to the prevalent use of these areas for pasture. Furthermore, the areas most suitable to agriculture, well served with infrastructure and close to urban centres have in general maintained their production characteristics. In case of urbanisation, green areas around buildings have been maintained for production of fruit and vegetables for self-sufficiency purposes of the family household. These developments are especially surprising in the absence of any regulating plan.

Trajectories of land-use change involve both positive and negative human-environment relationships. The extracted rules, i.e. the pathways of change, for Preza Commune could be particularly critical when both types of rules indicate negative developments at national level such as the trend confirming that individuals tend to exploit better environmental conditions for their own benefit while a planning policy should distribute resources and exploitations over the area in a well-balanced manner. Indirectly, these results should stimulate the Albanian government to develop a land-use policy and strongly invest in land-use planning to prevent the permanent deterioration of the environment with non-reversible transformations.

Land-use change analyses assist the Government in defining those areas where certain land-use processes and patterns are undesired or cause negative environmental impacts that need to be mitigated. It will assist in prioritising areas for the definition of land-use planning interventions in the three pilot communes and development of sustainable future land-use trajectories. Spatial analysis can thus be instrumental in land-use planning and informed decision-making. In addition, an analysis of change may not only help to identify vulnerable places but also vulnerable (groups of) people that on their own are incapable to respond in the face of environmental change.

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REFERENCES

S.p.A. Consortium (2003a) LUP geo-database model - version 1.0, LUP II Technical report No. 1. EU Phare Project 98-0502 Land Use Policy II (author: G. Carrai).

Agrotec S.p.A. Consortium (2003b*)* A standard methodology for land-use description and harmonisation between data sets, Technical report No. 2. EU Phare Project 98-0502 Land Use Policy II (author: L.J.M. Jansen).

Anderson, J.R., Hardy, E.E., Roach J.T. and Witmer, R.E., (1976) A land use and land cover classification system for use with remote sensor data, U.S. Geological Survey Professional Paper 964. USGS, Washington, D.C.

APA (1999) *Land-based Classification Standard, Second Draft,* American Planning Association, Research Department, Chicago.

Bonchi, F. and Pecori, S. (2003) Data Mining ed estrazione della conoscenza da grandi database territoriali. in Santini L.G. and Zotta, D. (Eds.), *Atti della Terza Conferenza Nazionale su Informatica e Pianificazione Territoriale - Input 2003*, 5-7 June 2003, Pisa. Alinea, Firenze (on CDROM).

Booch, G. (1994) *Object-oriented Analysis and Design with Applications*, Second edition, Benjamin/ Cummings Publishing Company, Redwood City, MA.

CEC (1993) *Nomenclature des activités de la communauté européenne (NACE). Première révision*. Règlement 761/93 du Conseil, Commission of the European Communities, Brussels.

CEC (1995) *CORINE – Guide Technique,* Commission of the European Communities, Brussels.

CEC (1999) *CORINE Land Cover, C*ommission of the European Communities, Brussels.

Cihlar, J. and Jansen, L.J.M. (2001) From land cover to land use: a methodology for efficient land-use mapping over large areas, *The Professional Geographer*, 53 (2): 275-289.

Dale, P.F. (1995) *Land reform, land registration and the cadastre – a comparative analysis between Bulgaria, Hungary and Rumania* (downloadable from OICRF website).

ECE-UN (1989) Proposed ECE Standard International Classification of Land Use, Economic Commission for Europe of the United Nations, Geneva.

FAO (1998) FAO Statistical Databases (FAOSTAT), FAO, Rome (www.fao.org).

Graefen, C. (2002) Land reform and land fragmentation and consequences for rural development in the CEE/CIS countries, Paper prepared for the International Symposium by FAO, GTZ, FIG, ARGE Landentwicklung und Technische Universität München, 25-28 February 2002, Munich.

Han, J. and Kamber, M. (2000) *Data Mining: Concepts and Techniques*, Morgan Kaufmann Publishers, San Mateo, CA.

IGU (1976) World land use survey. Report of the Commission to the General Assembly of the International Geographic Union, *Geographica Helvetica*, 1: 1-28.

INSPIRE Environmental Thematic Coordination Group, (2002) Environmental thematic user needs – position paper, version 2, European Environmental Agency, Copenhagen.

Jansen, L.J.M., Carrai, G., Morandini, L., Cerutti, P.O .and Spisni, A. (2005) Analysis of the spatio-temporal and semantic aspects of land-cover/use change dynamics 1991-2001 in Albania at national and district levels, *Environmental Monitoring and Assessment*, in press.

Jansen, L.J.M. and Di Gregorio, A. (1998) Land-use and land cover characterisation and classification: the need for baseline data sets to assess future planning, in *Proceedings of the IGBP-DIS and IGBP/IHDP-LUCC Data Gathering and Compilation Workshop*, 18-20 November 1998, Institute for Geography of Catalonia, Barcelona, Spain.

Jansen, L.J.M. and Di Gregorio, A. (2002) Parametric land cover and land-use classifications as tools for environmental change detection, *Agriculture, Ecosystems & Environment*, 91(1-3): 89-100.

Jansen, L.J.M. and Di Gregorio, A. (2003) Land-use data collection using the "Land Cover Classification System" (LCCS): results from a case study in Kenya, *Land Use Policy*, 20(2): 131-148.

Jansen, L.J.M. and Di Gregorio, A. (2004) Obtaining land-use information from a remotely sensed land cover map: results from a case study in Lebanon, *International Journal of Applied Earth Observation & Geoinformation*, 5: 141-157.

Lambin, E.F., Rounsevell, M.D.A. and Geist, H.J. (2000) Are agricultural land-use models able to predict changes in land-use intensity?, *Agriculture, Ecosystems & Environment*, 82: 321-331.

Lambin, E.F., Geist, H.J. and Lepers, E. (2003) Dynamics of land-use and land-cover change in tropical regions, *Annual Reviews of Environmental Resources*, 28: 205-241.

Lombardo, S., Pecori, S. and Santucci, A. (2002) The competition for land between urban and rural systems investigated by G.I.S. and data-mining techniques, *Decision Making in Urban and Civil Engineering*, Vol. 1 and 3, London.

Meyer, W.B. and Turner, B.L. (Eds.) (1994) *Changes in Land Use and Land Cover: A Global Perspective*, Cambridge University Press, Cambridge, UK.

Rozelle, S. and Swinnen, J.F.M. (2005) Success and failure of reform: insights from the transition of agriculture, *Journal of Economic Literature*, in press.

Swinnen, J.F.M. (1999) The political economy of land reform choices in Central and Eastern Europe, *Economics of Transition*, 7(3): 637-664.

Swinnen, J.F.M. (2000) Political and economic aspects of land reform and privatization in Central and Eastern Europe, Paper prepared for the UDMS Conference on Land markets and Land Consolidation in Central Europe, UDMS, Delft.

UN (1989) *International Standard Classification of All Economic Activities (ISIC)*, Third revision, United Nations Statistics Division, Statistical Classifications Section, New York.

UN (1998) *Central Product Classification (CPC). Version 1.0*, United Nations Statistics Division, Statistical Classifications Section, New York.

UNEP/FAO (1994) Report of the UNEP/FAO expert meeting on harmonizing land cover and land use classifications, 23-25 November 1993, Geneva. *GEMS Report Series* No. 25.

van Dijk, T. (2003) Scenarios of Central European land fragmentation, *Land Use Policy*, 20(2): 149-158.

Veldkamp, A., Kok, K., De Koning, G.H.J., Verburg, P.H. and Bergsma, A.R. (2001) The need for multi-scale approaches in spatial specific land-use change modeling, *Environmental Modeling & Assessment*, 6: 111-121.

Verburg, P.H., De Groot, W.T. and Veldkamp, A. (2003) Methodology for multi-scale land-use change modelling - concepts and challenges, in Dolman, A.J., Verhagen, A., Rovers,

C.A. (Eds.), *Global Environmental Change and Land-use*, Kluwer Academic Publishers, Dordrecht. pp. 17-51.

Walker, B., Steffen, W., Canadell, J. and Ingram, J. (Eds.) (1997) *The Terrestrial Biosphere and Global Change: Implications for Natural and Managed Ecosystems*, Synthesis volume. IGBP Book Series 4, Cambridge University Press, Cambridge.

Walker, B. (1998) GCTE and LUCC – a natural and timely partnership, *LUCC Newsletter*, 3: 3-4.