13 ASSESSING LAND USE INTENSITY AND DYNAMICS IN A RURAL MEDITERRANEAN LANDSCAPE: LASSITHI PLATEAU IN CRETE

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INTRODUCTION

Landscapes change rapidly today and the general trend is one of polarisation between more intensive and more extensive land use (Antrop, 2004a; 2004b; 2004c; Klijn and Vos 2000a; 2000b). The ongoing urbanisation and concentration of infrastructures is characteristic of areas of more intensive land use, such as urban metropolitan and industrial areas and many coastal zones. Extensification occurs in many rural areas, which are less well accessible, in particular in mountainous regions. Marginalisation, land abandonment and uncontrolled reforestation are characteristic processes here (Vos and Klijn, 2000; Vos and Stortelder, 1992). Furthermore, settlements are not always abandoned, but can gradually transform by functional urbanisation or by immigration of "new ruralists" (Van Eetvelde and Antrop, 2004). In addition to this, agricultural practice itself is changing profoundly. These developments are certainly taking place in the EU where the Common Agricultural Policy (CAP) Reform since June 2003 (EU, 2005) disconnects subsidies from agricultural production. The CAP Reform aims to start a new rural development policy, intended to reduce land abandonment in rural areas. For most rural areas important transformation of the land use is expected. The IRENA Indicator Report (EEA Report, Nº. 6/2005) states that between 1990 and 2000, the utilised agricultural area of EU-12 decreased by 2.5%, affecting mainly permanent grasslands and permanent crops. According to the same report, intensification seems to have levelled off during the 1990s, whereas the trend towards farm specialisation remained in the EU-15. Extensive farming systems, however, are important for maintaining the biological and landscape diversity of farmland, including Natura 2000 sites (EEA Report, No. 6/2005). "Mixed livestock" farms are often associated with high biodiversity and landscape quality and form part of "high nature value farmland". From this point of view, their decreasing proportion by about 25% from 1990 to 2000 is extremely relevant.

Despite this overall prospect, the impact of policy upon the development of landscapes remains still difficult to assess (Dramstad and Sogge, 2003; Parris, 2004; Paquette and Domon, 2001; 2003). Very often monitoring programmes are lacking to follow what is really happening (Bunce, 2005). "Land abandonment" calculated from land cover inventories, such as the CORINE database or EUROSTAT statistics (SPESP), is too

abstract and on too small a scale to express the changes that can be expected in the landscape. Also, the meaning of the concept landscape is changing and so is its significance (Claval, 2005). The European Landscape Convention (Council of Europe, 2000) stresses the importance of the perception by man. This public perception of what is going on in the landscape can be very different from the conception policy- and decision-makers have, based on abstract documents. In rural and natural areas that are additionally important for tourism and recreation, the perception and preferences of the landscape can be very different from its "administrative" status derived from statistical analysis. This is important because very often new rural development searches for new functions and services to attract new residents and tourists, who most often make decisions based upon personal preference and not on scientific analysis. The IRENA Indicator Report (EEA Report, No. 6/2005) also mentions this difficulty to capture the diversity of agricultural landscapes in indicators on the basis of current available information, as selected case studies mostly describe typical landscapes. The report concludes that the state and impact indicators relating to biodiversity and landscape are weaker than the others because they score lower on the availability of regional and time series data. Thus, the difficulty to assess landscape impact of policy relates to the availability of relevant data on the appropriate observation level.

This paper aims to explore these difficulties in a changing rural area in the mountains of Crete (Greece). The Mediterranean area consists to a large extent of traditionally multifunctional spaces, with an agricultural system based upon polyculture and transhumance. The landscape here is very vulnerable to a polarisation of land use intensity, as for example the "high nature value farmland" (Caraveli, 2000). The perception of polarisation between intensification and extensification will be very different according to the scale of observation. Table 1 situates the study area in the possible observation scale levels. The focus of this study is on the sub-regional to local scales. These scales still allow perception of the landscape and are therefore further called "landscape scales". At the regional scale and over, generalisation and abstraction result in more conceptual information about the landscape which is totally distinct from the terrain experience.

Table 1: Scales for evaluating landscape qualities and changes.

SCALE	EXAMPLE	EVALUATION QUALITIES
International	EU	Economic production, growth, population density, growth
National	Greece	CORINE data, national statistics and surveys
Regional	Crete	NUTS II level data
	Lassithi	*Nomos* (Prefecture)-level
↕		
LANDSCAPE SCALE		
Sub-regional	Lassithi	Municipality-level
Local	e.g., Tzermiado	Communities, villages
Domestic		Individual (farm) holding

The central question of this paper is whether the assessment of land use intensity and landscape dynamics based on different data sources and made at different scales is consistent. The analysis consists of two steps. First, an assessment is made at the sub-regional scale where landscape is perceivable and tangible. Different data sources are used such as maps, statistical data and field survey data, to make assessments of the spatial variation of land use intensity on the Lassithi plateau in the perspective of polarisation and dynamics. The research question here is whether the different data sources lead to a consistent image of the Lassithi plateau.

Second, the assessment made at the sub-regional and local scales is compared to analyses and visions made for the area at regional to higher scales. This will be done by comparing the analysis made here with the profile given for the area by an OECD study and a multi-temporal satellite analysis of the changing land use patterns. Analogous to the first question, it is evaluated whether these interpretations at different scales are consistent with each other.

In the following section, the study area will be situated and described. Next, the data sources available to study of the Lassithi plateau at the sub-regional scale will be analysed. This analysis is performed separately for map data, census data and field survey. An explorative statistical analysis is used to study the relationships between variables and to detect patterns for each data source. Finally, these profiles are compared with the descriptions in the reports at the regional level.

STUDY AREA

The Lassithi plateau is a highland plateau in the Lassithi or Dikti Mountains, in the central eastern part of Crete. Covering an area of 40 km^2, it is the largest of 25 similar mountain-plains or *poljes* in Crete (Rackham and Moody, 1996). Fig. 1 locates the study area in the administrative and physical context of Crete. The name “Lassithi” refers to two administrative entities, the prefecture (*nomos*) and the municipality “Oropedio Lassithiou” (consisting of 12 communities), as well as to the geographical unit of the plateau (see Table 1). The territory of one of the 12 communities does not abut the alluvial plateau and is not considered in this paper. As relates to the variables of the three data sets, only 9 of 11 communities adjacent to the alluvial plain, consisting of 15 villages or hamlets, are studied (see Fig. 3).

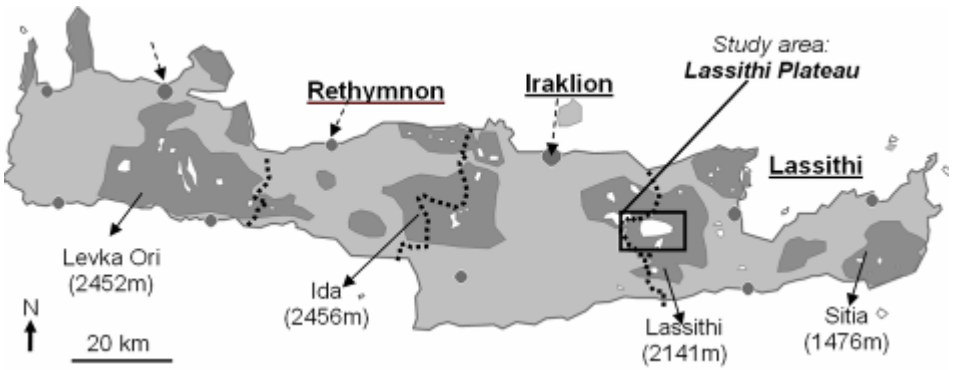

Figure 1: Localisation of the study area (box) in administrative divisions and geomorphologic entities of Crete: dotted lines between nomoi: prefectures; underlined names: name of prefecture/capital; dark grey: mountain ranges elevation >1400 m, light grey: basins, white: *poljes*. (after: Bonnefont, 1972).

Fig. 2 shows the landscape characteristics on the Lassithi plateau with a digital terrain model and a geological cross section. The plateau is a *polje* of about 9 by 4.5 km, situated between 805 m and 860 m altitude and surrounded by steep pediment slopes of the limestone mountains rising up to 2141 m. According to Bonnefont (1972), the Lassithi plateau was formed by the aggregation of several depressions with a different origin. It has a flat bottom, and is divided into two parts by a small ridge of massive limestone, called a *hum*. The largest periodic river disappears into a sinkhole in the hillside at the north-western corner, with an insufficient capacity to drain the plain, causing flooding of one third of the area during winter and early spring. A layer of clay fills the plain in the west whereas in the eastern part, the stony terraces of the seasonal river form the substrate. The alternation between winter and spring flooding and the arid conditions during summer and autumn were important factors in the way the land was occupied and used throughout history (Watrous, 1982). These conditions are still reflected in the land use: more marginal agricultural area on the eastern stony soils and vast grazing fields and waste land border the fertile arable fields in the alluvial plain to the west. Here, the alluvial plain probably carries the only traditional example of a geometric grid of rectangular fields, separated by draining ditches (Watrous, 1982; Rackham and Moody, 1996: 150). The grid is confined to the lowest part of the plain, suggesting that it was introduced between 1463 and 1630 by the Venetians as a possible drainage solution (Watrous, 1982, chapter 8, note 12; Rackham and Moody 1996: 150).

Total depopulation occurred twice in history. Near the end of the thirteenth century Venetians forbade any form of settlement and agriculture to avoid rebellion activities. Subsequent depopulation continued until the late fifteenth century. During Turkish occupation (1669-1898) all villages were destroyed again and most of the inhabitants were killed. Spratt (1865) describes fifteen villages and a few hamlets and small farms in the nineteenth century. Since the Turkish period the whole plain was tilled and terraces were constructed on the slopes. The traditional Mediterranean agriculture included cereals, orchards and vineyards, as well as livestock. Olive trees are grown in

lower-lying villages at a time distance of 3 to 4 hours' mule riding (10 to max. 20 km), where most inhabitants own a field and house (Greger, 1988). Before road construction improved accessibility, 60% of inhabitants used to move there during winter time, establishing a form of transhumance to harvest the olives. Since the 1920's, the introduction of wind mills has facilitated irrigation by pumping up groundwater from a depth of 16 to 18 m. This enabled farmers to introduce the cash crop of potatoes, changing the self-subsistent agriculture into a market one.

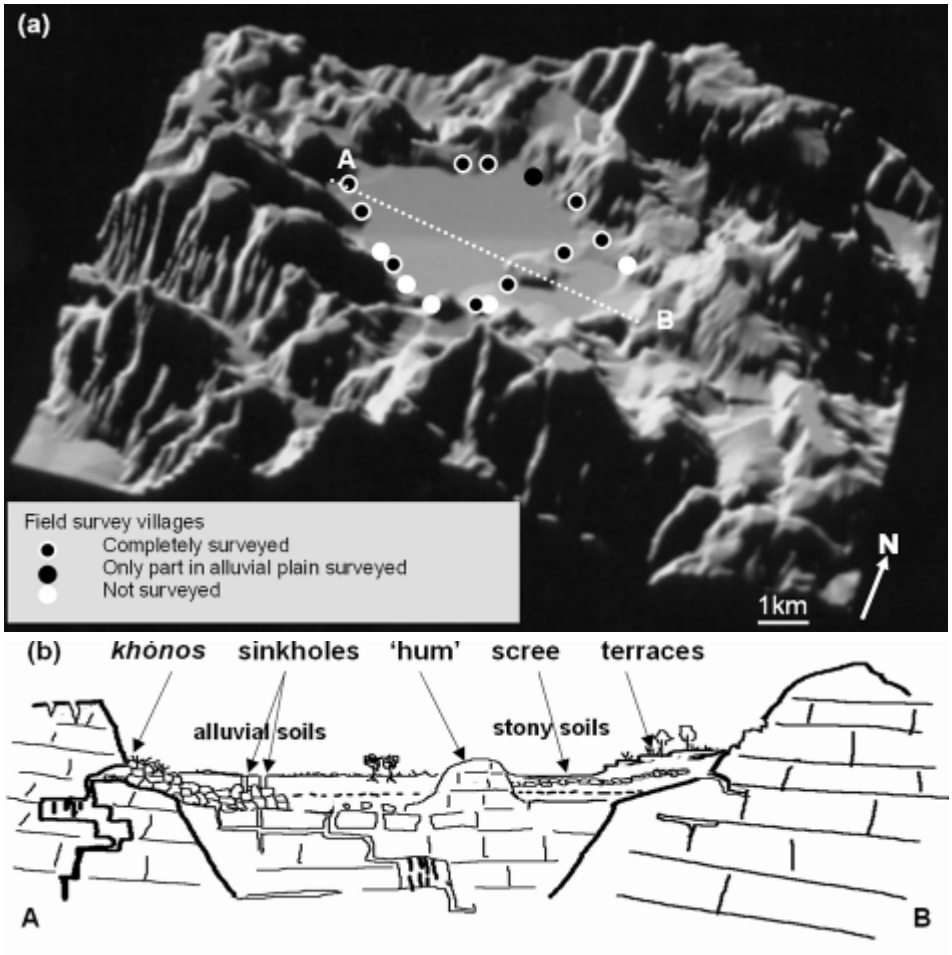

Figure 2: Physical-geographical characteristics of the Lassithi plateau: (a) Topography, Digital Elevation Model (source: Topographical map Mochos, Agios Nikolaos (1994) 1:50 000); (P1, P2: terrain photos see Figure 5); (b) section of a polje, situation of Lassithi plateau (After: Rackham and Moody, 1996: 28).

MATERIALS

Data sources for the sub-regional analysis

Three different data sets were expected to be indicative for an assessment of the village dynamics: (1) maps, (2) demographic and economic census data, and (3) a field survey of the housing quality in the villages.

Map-based variables

Maps include the topographical maps, geology and lithology, and a Land Use Map of the Municipality Oropedio Lassithiou (2002). These were used to describe the site and territory characteristics of the villages. Administrative borders of the communities defined the territories. Contour lines on the topographical map were used to create a digital terrain model, from which slope degree was calculated. Land use categories were derived from the Land Use Map of the Municipality Oropedio Lassithiou (2002). In Table 2 they are ordered according to their degrees of land use intensity. Table 3 gives the map-based variables.

Table 2: Land use categories and land use intensity classes.

LAND USE INTENSITY	CATEGORIES
Most intensively used	- Cropland (irrigated horticulture) - Cereals - Orchards - Vineyards
Less intensively used	- Semi-natural trees combined with non-tree vegetation ("savanna", Rackham *et al.*, 1996)
	- Abandoned land - Grazing fields
Not used for agriculture	- Forest - Shrubs - Barren

Table 3: Map-based variables.

NAME	DESCRIPTION	SOURCE
- Community	- (Combined) name of settlement(s)	- Topographical map 1:50.000 (Agios Nikolaos, Mochos) (*HGMS*)
- Area	- Communal territory in sq.km	
- Places	- Number of settlements in community	
Land use - Categories (9) (see Table 2) - Land use diversity	- Area in sq.km - Number of land use categories	- Land Use map, *Municipality Oropedio Lasithiou, AV Computers* (2000)
- Slopes 2-20°	- Area in sq.km	- Topographical map 1:50.000 (Agios Nikolaos, Mochos) (*HGMS*)
- Geological categories: (10) *alluvial soils*/ *talus cones and scree*/ *breccias*/ *limestones* (4)/ *flysch*/ *phyllite-quartzites* (2)	- Area in sq.km	- Geological map of Greece 1:50.000 (Agios Nikolaos, Mochos) (*Institute of Geology and Mineral Exploration*, 1981)

Census-based variables

Census data on population size were available from the National Statistical Service of Greece in 1920, 1991, and 2001. In addition, statistical data about population size and age structure, employment, schools, services, tourism and agricultural production in 1997 were at our disposal from the Municipality Oropedio Lasithiou. Employment data at the village level were also collected from the OTE phone books that list the subscribers' economic occupation. Table 4 displays the census-based variables.

Table 4: Census-based variables.

NAME	DESCRIPTION	SOURCE
Population - Population 1920, 1991, 2001 - Population evolution 1920-2001	Number of inhabitants	National Statistical Service of Greece
- Population 1997	Number of inhabitants	Municipality Oropedio Lasithiou
- Population between 15 and 39 years 1997	% proportion	
- Population plus 65 years 1997		
Employment 1997 - Total employment	Number of inhabitants	
- Active population / -25 years 1997 - Employment primary, secondary, tertiary sector	% proportion	
Schools 1997 - Nursery / Primary schools /Gymnasia / Lyceums	Number of children and teachers	Municipality Oropedio Lasithiou
Services 1997: - Administrative, juridical, public services / health, cultural, sports services / other services	Number	Municipality Oropedio Lasithiou
Annual agricultural production 1997 - Meat / dairy / potato / horticulture production	Production in tons	Municipality Oropedio Lasithiou
Hotelbeds 1997	Number	Municipality Oropedio Lasithiou
Employment subscribers OTE: - In catering / agriculture / construction / as technicians / liberal professions / traders / as clerks / in services	Number of subscribers	OTE Phone books

Survey-based variables

During a field survey in 1997 of 10 villages (9 communities), housing types, age, maintenance and function of the buildings were mapped (see Fig. 3). These variables were not available from any other source. The condition of the buildings was evaluated in ordinal classes "very good", "good", "moderate", "bad", and "very bad". As relates to the building age, the houses under construction, the most recently built houses and the oldest houses were inventoried as well. A detailed mapping of the village plan was related to the physical site conditions, in particular to the central alluvial plain and the mountain slopes. Survey-based variables are displayed in Table 5.

Table 5: Survey-based variables.

NAME	DESCRIPTION	SOURCE
Buildings	Total number of buildings	Field survey 1997
Condition - Very good / good / moderate / maintenance / very bad	% proportion	Field survey 1997
Age - Oldest / recent / under construction	% proportion	Field survey 1997
Function - dwellings / stables / storage accommodation / popular cafes ("cafeneia") / restaurants / hotels / stores / services / bancs / buildings without any obvious function	% proportion	Field survey 1997

Data sources for the regional analysis

The regional scale against which the results from the three sub-regional data are evaluated, is exemplified by the conclusions reported in two recent studies: (1) a case study on the Region of Crete in Greece, made by the OECD in 2005, which gives a profile of the Cretan rural areas and of agriculture, tourism and innovation to embed place-based policies for rural development; and (2) a study of changing land use patterns based on the interpretation of multi-temporal Landsat images, reported by the Institute for Mediterranean Studies, Foundation for Research and Technology (Rethymno, Crete) and the University of Crete (Heraklion, Crete) (Sarris *et al.*, 2005).

Methods

For the sub-regional scale, the variables derived from these three data sources are considered to be possibly indicative to evaluate dynamics of the places. Because of the rather restricted data set, the analysis was explorative, applying principal components analysis and cluster analysis (hierarchical and k-means). In a first stage, the villages were classified per data set. Thus, intensively and more extensively used areas and highly to less dynamic communities were identified per data set. In this stage, a correlation analysis was used to compare variables that were derived from different data sets but expected to measure the same. The data set derived from the field survey contained spatial information, which permitted to zoom in beyond the observation scale of the village as a whole and to conclude about differences between village districts. In a second stage, the typologies of the communities that resulted from the three data sets were compared to see whether they revealed comparable patterns. All statistical analyses were done in SPSS 12.0.

The results yielded by the sub-regional analysis were qualitatively compared with the regional scale, based on the conclusions pointed out both in the OECD Report and in the study on land use change.

LANDSCAPE AT THE SUB-REGIONAL SCALE

Map data

From the available maps, land qualities, such as geology and slope degree, as well as land use can be derived.

The geology shows a variation of 10 different lithological categories (see Fig. 3). The surrounding mountains rise up to 2141 m and have slope gradients up to 77%. They consist mainly of Triassic-Jurassic limestones and cover half of the study area. The Pleistocene-Holocene alluvial deposits appear in the flat bottom of the *polje*, accounting for 17% of the total area. The hum in the *polje* and a large part of the mountains to the south are covered by Cretaceous limestones, accounting for 14% of the area. The foot slopes show gradients of 2-20% and consist of phyllite-quartzites and flysch. Some small spots of Holocene talus cones and scree appear, mostly river deposits.

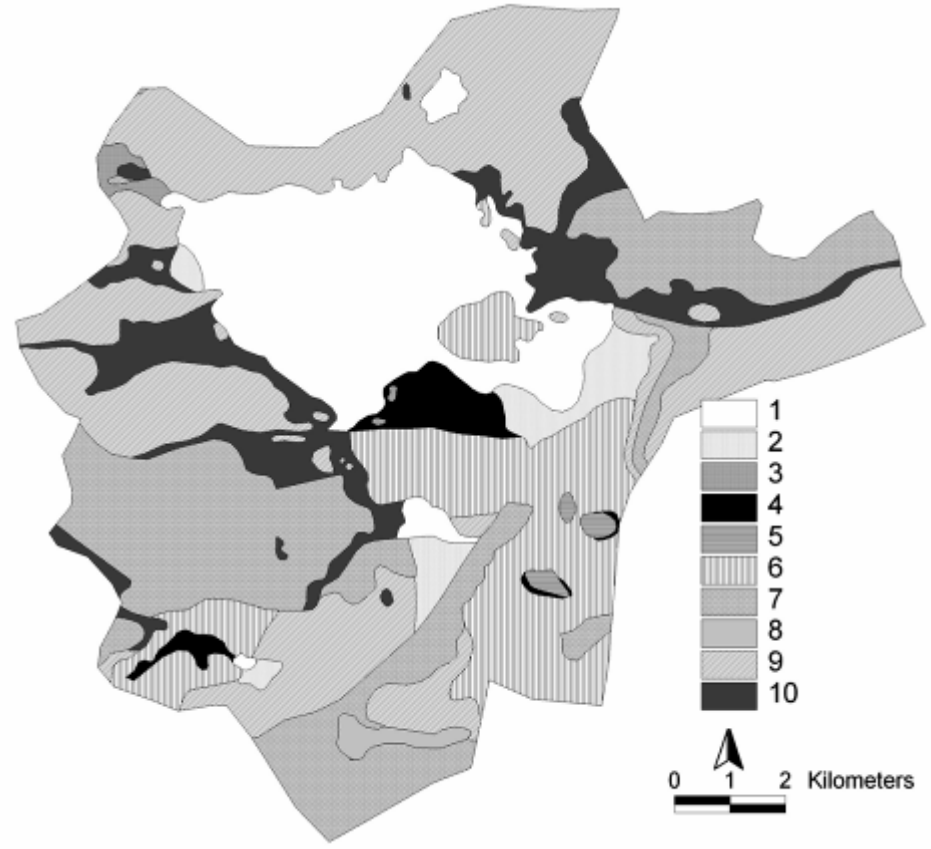

Figure 3: Geology in the Lassithi plateau: (1) Pleistocene-Holocene alluvial deposits, (2) Holocene talus cones and scree, (3) Pleistocene Breccias, (4) Upper-Eocene-Oligocene flysch, (5) Eocene limestones, (6) Cretaceous limestones, (7) Middle-Jurassic-Eocene platy limestones (Plattenkalk), (8) Middle-Jurassic-Eocene calcareous phyllites, (9) Upper Triassic-Upper Jurassic dolomitic limestones, (10) Permian-Upper Triassic phyllite-quartzites

source: Geological map of Greece 1:50000 (Agios Nikolaos, Mochos), Institute of Geology and Mineral Exploration, 1981.

A k-means cluster analysis shows two distinct groups, mainly based on the different areas of Holocene talus cone and scree and Cretaceous limestones, which are more apparent in Agios Georgios and Agios Konstantinos when compared to the other communities.

Fig. 4 shows land use for the eleven communities in the Lassithi plateau. The zones of land use intensity are exemplified in the photographs. Table 6 lists the area per land use category for nine observed communities. Most of the communities have a similar size and only two small ones occur. The area per soil type differs significantly between the communities and the distribution of land use categories varies accordingly. Less than 20% of all communal territories is cultivated, covering 23.3 km². Most intensively used land occurs in the alluvial plain and is characterized by intensive, irrigated horticulture and agriculture of cash crops such as potatoes (14.2 km²). Here, also cereals are grown, mostly combined with trees, and hence referred to in the category of "fruit trees (and cereals)" (3.7 km²). Vineyards occur on more stony soils along the borders and at the east of the plain (1.0 km²). Extensively used land corresponds mainly to abandoned terraces on the foot slopes of the mountains, which is often still in use as grazing fields. The category called "semi-natural trees with non-tree vegetation" on the land use map of the Municipality Oropedio Lasithiou (Table 6) was mostly abandoned or used for grazing during the field visit. The abandoned land in the Lassithi plateau covers 17.9 km². Shrubs, forest and waste land account for 67% of the area (86.8 km²).

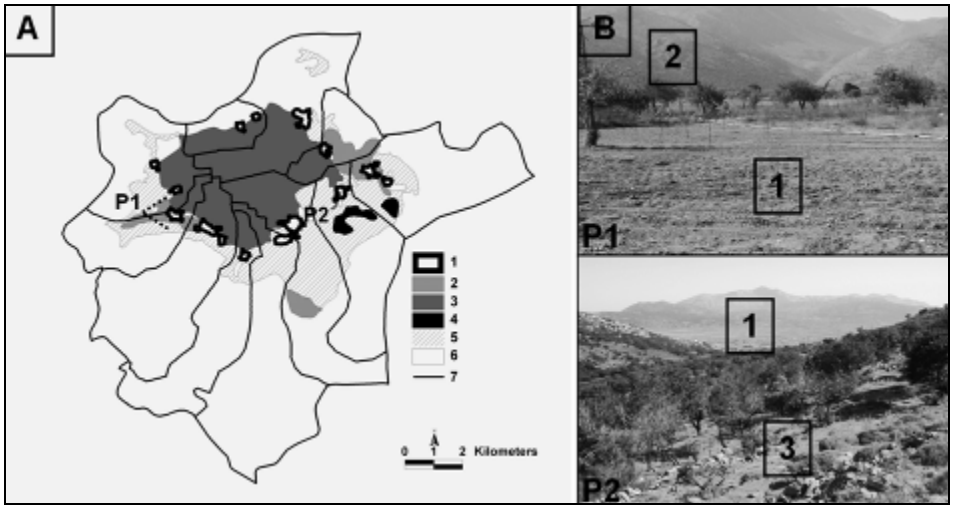

Figure 4: A. Land use and communal territories in Lassithi; (1) built area, (2) fruit trees (+ cereals), (3) horticulture, (4) vineyard, (5) semi-natural trees with non-tree vegetation, (6) waste land, (7) communal boundaries (sources: Field survey 1997, Land Use map 2002, Municipality Oropedio Lasithiou, AV Computers, Topographical map (1994) 1:50000). B. Terrain photographs (localisation of pictures: see A); (P2) irrigation systems in the xerokampos (old wind mill on the left), (P1) Terraces being abandoned covered with shrubs and trees (numbers refer to land use intensity: (1) most intensive, (2) less intensive, (3) waste land).

Using three land use intensity classes (intensive, extensive, waste land), different patterns of land use intensity can be found. Most villages lie eccentric in their territory, situated at the edge of the alluvial plain and on the foot slopes. Generally, waste land occupies most of their territory, varying from 40% (Lagou-Pinakiano) to 85% (Avrakontes-Koudoumalia). Avrakontes-Koudoumalia, Mesa Lasithi-Mesa Lasithaki and Agios Konstantinos have a similar size and population and less than 10% of intensively used land, while the small community of Lagou-Pinakiano has almost 60% of intensively used land.

Table 6: Land use in studied communities.

COMMUNITY	TOTAL AREA (KM²)	BUILT AREA (KM²)	ARABLE FIELD (KM²)	FRUIT TREES (AND CEREALS) (KM²)	VINEYARD (KM²)
Agios Georgios	14.68	0.29	3.37	0.71	0
Agios Konstantinos	12.03	0.13	0.39	0.17	0.7
Avrakontes-Koudoumalia	18.95	0.13	0.75	0	0
Farsaro-Marmaketo	5.11	0.11	1.26	1.13	0
Kato Metochi-Agios Haralambos	11.34	0.13	1.95	0.28	0
Lagou-Pinakiano	3.71	0.11	2.15	0	0
Mesa Lasithi-Mesa Lasithaki	15.24	0.21	0	0.72	0.3
Psychro-Magoulas	16.20	0.26	1.98	0.15	0
Tzermiado	13.75	0.25	5.23	0	0

(cont.)

COMMUNITY	SEMI-NATURAL TREES WITH NON-TREE VEGETATION (KM²)	NATURAL GRAZING FIELDS (KM²)	SHRUBS (KM²)	FOREST (KM²)	WASTE LAND (KM²)
Agios Georgios	0.84	3.44	0.22	0	5.81
Agios Konstantinos	0.78	2.61	2.32	0.83	4.10
Avrakontes-Koudoumalia	1.03	0.85	3.73	0	12.46
Farsaro-Marmaketo	0.28	0	0.16	0.19	1.98
Kato Metochi-Agios Haralambos	0.37	1.71	0.87	0	6.03
Lagou-Pinakiano	0	0	1.26	0	0.19
Mesa Lasithi-Mesa Lasithaki	1.27	1.21	1.72	2.09	7.72
Psychro-Magoulas	0.26	0.4	4.49	0.22	8.44
Tzermiado	0.45	0.46	1.38	0	5.98

A principal component analysis with varimax rotation using the land use categories reveals four components which explain 93.7% of the total variance (see Table 7). The correlated variables are summarized in the table.

Table 7: Total variance explained by components for land use.

COMPONENT		INITIAL EIGENVALUES	% OF VARIANCE
1	Built area and arable land, least waste land	3.997	44.4
2	Forest, vineyards and semi-natural trees	1.749	19.4
3	Orchards	1.626	18.1
4	Grazing fields	1.063	11.8

Large scores for the first component are indicative of high dynamics, whereas low dynamics are expressed by large scores for the fourth component and moderate dynamics are associated with the other components. When plotting the factor scores of the components for all observed villages (Fig. 5), some outliers appear. Lagou-Pinakiano has a large score for factor 1, indicating mainly an intensive use of the land on its territory. Agios Georgios only shows high scores for factor 4 and its territory can thus be considered a zone of generally extensive land use. Farsaro-Marmaketo has a large score on factor 3 in addition to a relative large score on component 1, indicating a combination of very and less intensive land use. A similar combined pattern is shown by Agios Konstantinos, which scores on factors 2 and 4. Mesa Lassithi-Mesa Lassithaki only scores on factor 2, indicating less intensive land use.

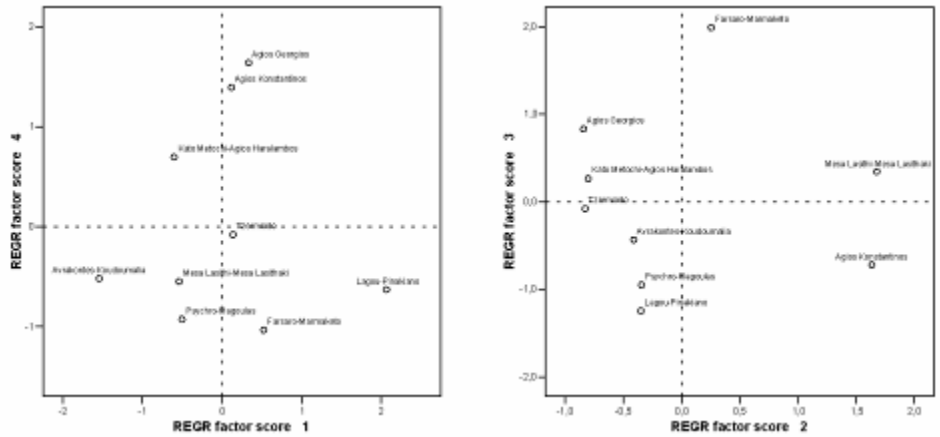

Figure 5: Factor score plots for communities by land use (PCA with varimax rotation; standardized scores).

Significant correlations exist between land qualities and land use in the communal territories. Holocene talus cones and scree carry grazing fields and vineyards (resp. r=0.888, p=0.001; r=0.806, p=0.009). Arable land appears on Pleistocene-Holocene alluvial deposits (r=0.900, p=0.001). Semi-natural trees and waste land do generally not occur on arable land (resp. r=-0.732, p=0.025; r=-0.706, p=0.034). Grazing fields are

found on Cretaceous limestones (r=0.842, p=0.004). Orchards occur on phyllite-quartzites (r=0.840, p=0.005).

Concerning geomorphology, only the area with slopes between 2-20 degrees was considered interesting, because of its potential for terracing. These slopes carry forest and semi-natural trees (resp. r=0.789, p=0.011; r=0.732, p=0.025). This indicates the foresting of area that formerly was appropriate for constructing terraces. Arable land does not appear on these slopes (r=-0.771, p=0.015).

Despite the correlations between land use and land qualities, both cluster analyses do not exactly yield the same groups. Concerning land qualities, Agios Konstantinos is an outlier, whereas it shows a combination of intensive and extensive land use.

Population and economic data

Population statistics are provided since 1920 (Office National de Statistique, Grèce). Table 8 gives some basic statistics that characterise the studied communities. The census of 1920 indicates 4174 inhabitants. The population increased until 1940 (7049 inhabitants). The increase was extreme between 1920 and 1928. Since the 1940s constant decrease has been taking place. By 1991 the population in the Lassithi plateau equals that of 1920 (4220 inhabitants). The census of 2001 reports 3185 inhabitants. Almost one quarter of the population lives in one village, Tzermiado. Present population density is on average 25 inhabitants per square kilometre, but most of the communities score less. Total employment amounts to 1835 inhabitants, of which more than 60% in the primary sector, almost 30% in the tertiary sector and less than 6% in the secondary sector. The total agricultural production in 1997 amounts to 38.642 tons, of which 84% consists of potatoes and almost 10% of other horticultural production. Agios Georgios, Tzermiado and Psychro-Magoulas are the most important producers. The cash crop of potatoes in the Lassithi plateau accounts for 83% of the total production in the prefecture of Lassithi and for 37% of the Cretan production. Dairy and meat production are less important. The visitors of the cave in Psychro-Magoulas give this community an important function for tourism as well.

Table 8: Selected basic characteristics of the communities.

COMMUNITY	NUMBER OF VILLAGES	POPULATION			
		1920	2001	DENSITY 2001 (INH./ KM²)	15-39 YRS / +65 YRS
Agios Georgios	1	591	552	38	1.14
Agios Konstantinos	1	256	184	15	0.61
Avrakontes-Koudoumalia	2	371	235	12	1.03
Farsaro-Marmaketo	1	201	110	22	0.61
Kato Metochi-Agios Haralambos	2	280	165	15	0.69
Lagou-Pinakiano	2	174	125	34	0.92
Mesa Lasithi-Mesa Lasithaki	2	344	198	13	0.64
Psychro-Magoulas	2	461	311	19	1.10
Tzermiado	1	918	748	54	1.60

(cont.)

COMMUNITY	TOTAL EMPLOYMENT 1997	PRODUCTION (TONS)			
		MEAT	DAIRY	POTATO	HORTICULTURE
Agios Georgios	313	23	139	7261	1345
Agios Konstantinos	89	4	52	800	62
Avrakontes-Koudoumalia	102	31	188	1300	101
Farsaro-Marmaketo	67	8	8	2100	526
Kato Metochi-Agios Haralambos	99	55	534	2100	124
Lagou-Pinakiano	119	18	62	2800	248
Mesa Lasithi-Mesa Lasithaki	171	42	172	400	18
Psychro-Magoulas	116	35	259	6250	95
Tzermiado	437	47	311	6750	885

A principal component analysis with varimax rotation using the census data reveals two components explaining 75% of the total variance (see Table 9). The correlated variables are summarized in Table 9.

Table 9: Total variance explained by components for census data.

	COMPONENT	INITIAL EIGENVALUES	% OF VARIANCE
1	Large young population size, a lot of services and cash crop production	18.483	61.6
2	Traditional agriculture	4.006	13.3

Component 1 has strong positive correlations with the number of schools, students and teachers (nurseries, primary schools, secondary schools), population size, accommodation centres (health, sports, culture), total agricultural production (in tons), active population in the secondary sector, percentage of population between 15 and 39 years, and the number of hotel beds. This component is negatively associated with the age cohort of 65+ and the percentage of total employment. The variables relating to the dairy and meat production (in tons), the percentage of active population less than 25 years, the percentage of active population in primary sector are positively associated with component 2. This component is negatively associated with the percentage of active population in the tertiary sector and the potato production (in tons).

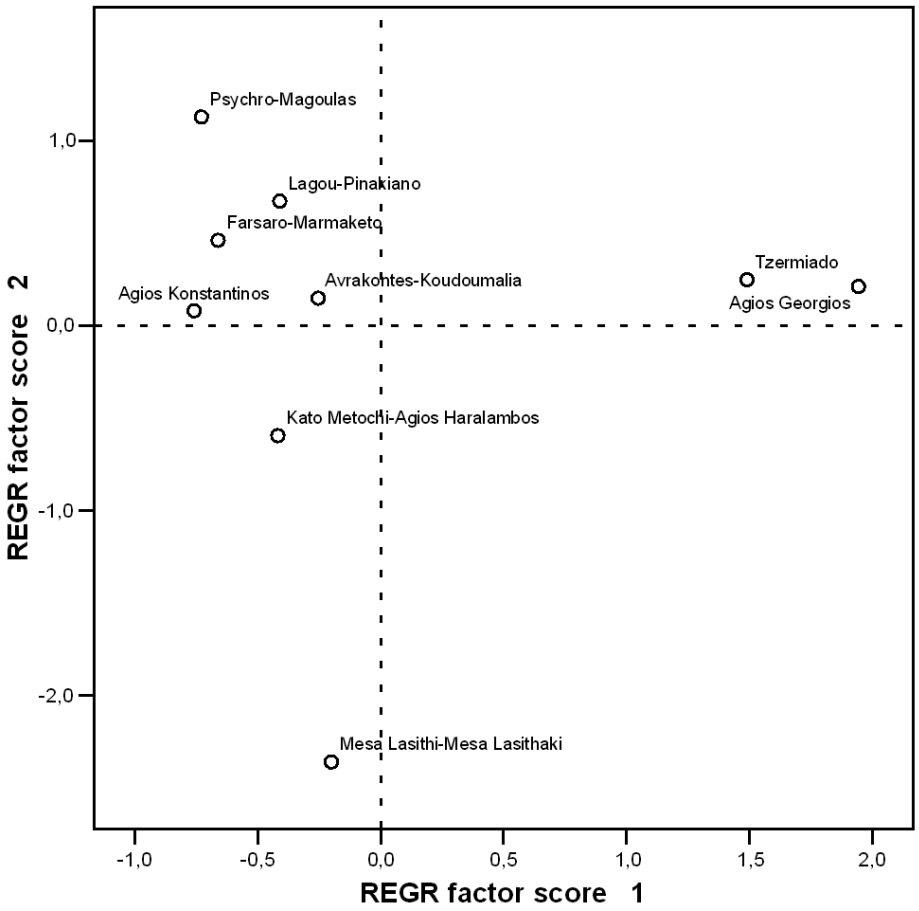

Figure 6: Factor score plots for communities by economic and census data (PCA with varimax rotation; standardized scores).

From the factor score plot of the villages some groups can be observed (Fig. 6). On factor 1 Agios Konstantinos has the smallest score and Tzermiado and Agios Georgios have the largest scores, whereas Psychro-Magoulas has the largest scores and Mesa Lassithi-Mesa Lassithaki has the smallest score on factor 2. Tzermiado and Agios Georgios are highly dynamic villages concerning population and economic characteristics. Both villages host services (health, sports, culture, schools) and have a considerable potato and horticultural production. Some differences however exist between them. Tzermiado is characterized by a constant larger population size with a greater proportion of the age cohort between 15 to 39 years, whereas Agios Georgios experienced a greater population increase between 1920-1991. A larger deal of the active population of Tzermiado is employed in the tertiary sector compared to all other villages. In the group of all other villages, the more traditional dairy and meat

production, however, is larger, the population is significantly older and more people are employed in the primary sector.

The economic occupations as given in the OTE phonebooks show some agreement with the census data and ($r>0.800$, $p<0.01$). Total employment derived from OTE phonebooks and active population in 1997 agree. Some other relevant and rather obvious correlations exist, e.g., between the number of people employed in catering and the number of hotelbeds, the number of people with a job in agriculture and the active population in primary sector, the number of people employed in construction and active population in secondary sector, between technicians and active population in primary and secondary sector, between number of people employed as clerks or in services and active population in tertiary sector. No clear groups could be observed using cluster analysis.

Village survey

Table 10 shows the percentages per building condition and age category for the nine observed communities. As relates to the building age, about half of the buildings were perceived as old buildings. Less than 5% are recent and less than 1% is under construction. On the other hand, 37.6% of the buildings appeared to be in good condition and 8.1% in very good condition. This indicates that villages do not expand substantially but are well maintained.

Table 10: Building condition and building age in studied communities.

COMMUNITY	NUMBER OF BUILDINGS	BUILDING CONDITION (*)						RELATIVE BUILDING AGE	
		%VG	%G	%M	%B	%VB	%UC	%R	%O
Agios Georgios	844	6	42	44	5	2	0	44	4
Agios - Konstantinos	283	8	35	49	4	4	0	53	3
Avrakontes - Koudoumalia	446	4	44	46	5	1	0	45	1
Farsaro - Marmaketo	203	10	35	46	5	3	1	40	6
Kato Metochi - Agios Haralambos	265	4	26	64	6	0	0	46	3
Lagou - Pinakiano	188	13	27	46	10	4	1	28	3
Mesa Lasithi - Mesa Lasithaki	246 (*)	3	44	47	4	2	0	42	1
Psychro - Magoulas	308 (**)	16	32	37	10	5	0	36	6
Tzermiado	278 (***)	10	53	33	1	0	3	13	15
Average (std. dev.)		8.2 (4.4)	37.6 (8.9)	45.8 (8.6)	5.6 (2.9)	2.3 (1.8)	0.6 (1.0)	38.6 (11.8)	4.7 (4.3)

(*) VG: very good; G: good; M: moderate; B: bad; VB: very bad; UC: under construction; R: most recently built; O: oldest

(**) only one village of two surveyed

(***) only lower part of the village surveyed

A principal component analysis with varimax rotation using the building condition and age category reveals two components explaining 86% of the total variance (see Table 11). The correlated variables are summarized in the table.

Table 11: Total variance explained by components for building condition and age.

COMPONENT		INITIAL EIGENVALUES	% OF VARIANCE
1	Well maintained new and recent buildings and under construction	4.331	54.1
2	Variable condition of buildings	2.544	31.8

Component 1 has also strong negative correlations with the percentage of old buildings, and buildings in bad and moderate condition.

From the factor score plot of the villages (Fig. 7) some groups can be observed. Agios Konstantinos has the smallest score and Tzermiado has the largest scores on factor 1, whereas Psychro-Magoulas and Kato Metochi-Agios Haralambos have the largest scores on factor 2. Tzermiado is exceptional because of its high number of buildings under construction. Agios Konstantinos is characterized by a lot of buildings in moderate condition, whereas most of the buildings in Psychro-Magoulas and Kato Metochi-Agios Haralambos are either in very good or in (very) bad condition.

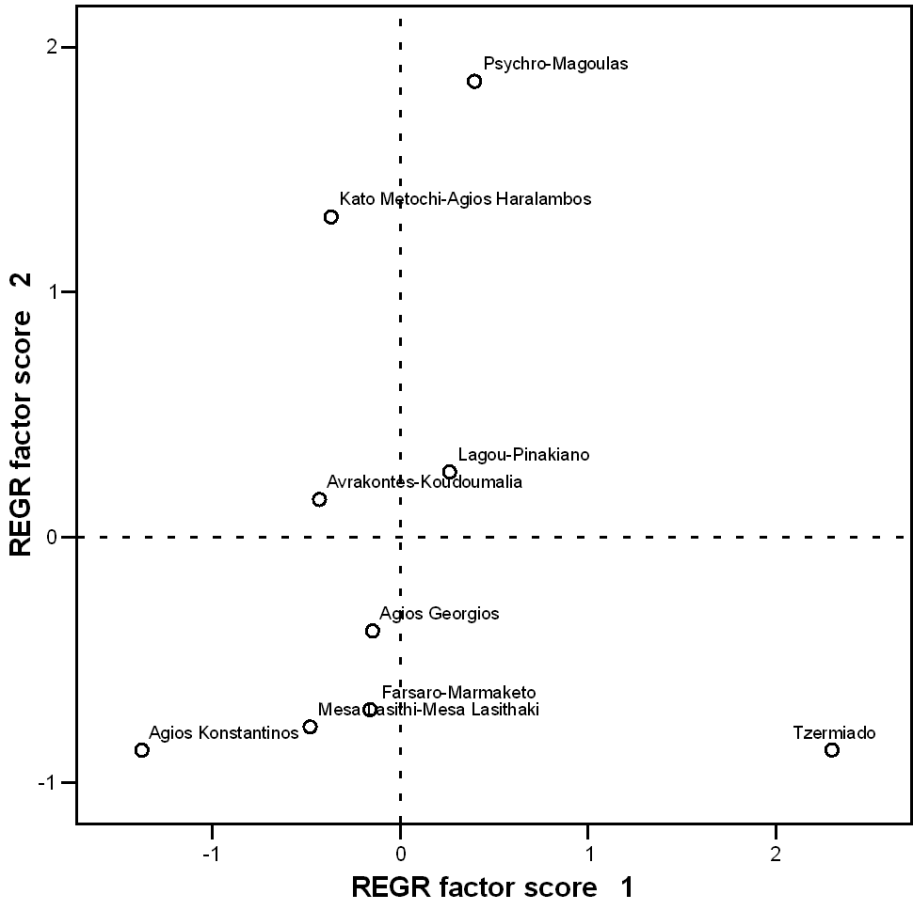

Figure 7: Factor score plots for communities by building condition and age (PCA with varimax rotation; standardized scores).

During the field survey, a difference in building condition and age was perceived within the villages between the higher parts on the footslopes and the lower parts along the main road in the alluvial plain. Therefore, a more detailed analysis was made at the local scale level of the village. The main road was considered the border between two parts; in each, the average number of buildings by condition and age category was compared for all observed villages. Results are displayed in Table 12. Following trends can be observed concerning the building condition. On average less moderately and more well maintained houses occur in the lower village parts. Significantly more badly maintained houses occur in the higher village parts (Mann-Whitney U-test, $p=0.016$). Also, significantly more older houses are found in the higher parts ($F=0.175$, $df=16$; $p<0.001$). Neglect and ageing of the buildings occur in the higher village parts, whereas the lower parts are not really expanding towards the alluvial plain at the expense of fertile arable land.

Table 12: Average building condition and age in lower and higher village parts of studied communities.

VILLAGE PART	BUILDING CONDITION (*)						RELATIVE BUILDING AGE	
	%VG	%G	%M	%B	%VB	%UC	%R	%O
Lower part	12.6	38.3	42.4	5.4	1.0	0.3	4.8	25.1
Higher part	5.8	28.7	52.7	8.1	4.5	0.2	2.4	49.8

(*) VG: very good; G: good; M: moderate; B: bad; VB: very bad; UC: under construction; R: most recently built; O: oldest

A principal component analysis with varimax rotation using the functions of the building reveals four components explaining 98% of the total variance (see Table 13). The correlated variables are summarized in the table.

Table 13: Total variance explained by components for land use.

COMPONENT		INITIAL EIGENVALUES	% OF VARIANCE
1	Many buildings with functions related to services	6.034	60.3
2	Many abandoned buildings	1.740	17.4
3	Many restaurants	1.045	10.5
4	Many popular cafes (“cafeneia”)	1.005	10.0

Component 1 is also negatively associated with buildings used for storage accommodation and stables.

From the factor score plot some groups can be observed (Fig. 8). All villages, except for Tzermiado and Agios Georgios, have negative scores on factor 1. Tzermiado has a very large score, differentiating it from all other villages because of the number of banks, stores, hotels and services. Factor scores of the villages for components 2 and 4 have a rather normal distribution, as all villages host popular cafes and abandoned buildings. Psychro-Magoulas appears as an outlier for factor 3, due to the many restaurants associated with the tourist attraction of the cave.

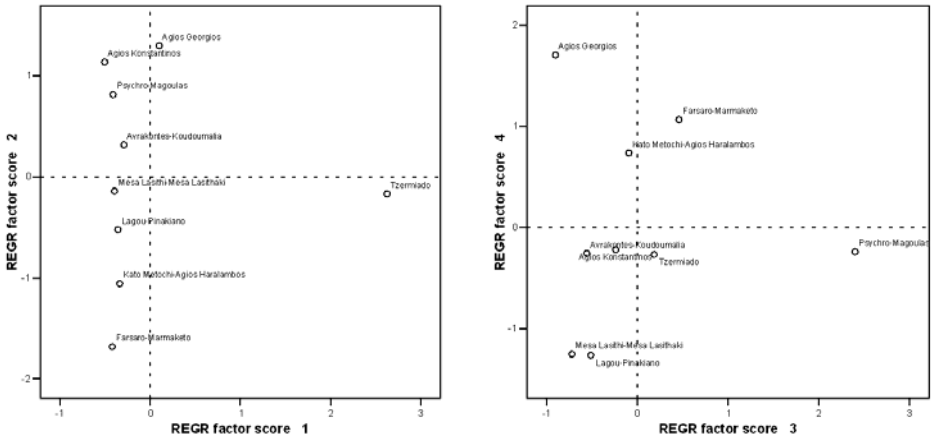

Figure 8: Factor score plots for communities by function of the building (PCA with varimax rotation; standardized scores).

Analogous to the observations of building condition an age, the difference between the upper and lower village part relates to functions as well. All functions except housing, agriculture, and popular cafes occur in the lower parts.

Summary

Obviously, land use intensity and dynamics in the Lassithi plateau are not spatially homogenous at sub-regional scale. The statistical analyses of the data reveal a substantial difference between all observed villages, and always show outlying villages. However, these outliers differ across the different data sets. There is a certain coherence between the groups of villages yielded by census- and survey-based data. Some variables of both data sets are clearly correlated. In places with the largest population size, the largest variation is found in functions of the buildings, and most new buildings and buildings under construction are found. Places that have most ageing people (65+) have few different functions and buildings under construction. Old buildings and storage buildings are mainly found in villages with a large employment in the primary sector. There are almost no new buildings here. High employment in the secondary sector is found in places with hotels and a lot of recent buildings. The tertiary sector employment is related to the number of restaurants. Administrative and public services correlate with place with recent buildings and a large variation of functions. Villages with an important agricultural production also have a lot of services to offer.

Contrarily to this, the principal component analyses using the map-based data result in a completely different classification of the villages. Few significant correlations exist between map-based and survey-based variables. For example, very few old buildings appear in villages with a lot of arable land, whereas villages with many well maintained buildings have less area with semi-natural trees. Despite the expected relationship, no correlations exist between either waste land or alluvial deposits and the occurrence of many functions and services. Similarly, the correlations between map-based and census-based variables are not clear either. Population size does not correlate with any variable derived from the maps. Thus, the extent of intensively used land e.g., is not related to demography. Some correlations exist between map data and employment, but they are not always significant. Villages with a lot of arable land have a large employment in the secondary sector. Also, areas with fertile alluvial soils are not associated with employment in primary sector, but with employment in the secondary and tertiary sector. Also, barren limestone areas are associated with employment in the primary sector. Also agricultural production does not show a coherent picture when compared to the land use map.

Consequently, the three different data sets do not lead to a consistent picture of the Lassithi plateau concerning land use intensity and landscape dynamics. The map data give a more abstract assessment than the statistical data do. However, following remarks

can be made. First, the maps used are at a scale of 1:50000, which may add to the degree of abstraction. Second, data on land use and land qualities were expressed relative to the community territories, whereas in reality the social organisation of the Lassithi plateau has always been characterized by collaboration between settlements. Exemplary for this, the plateau probably carries the only traditional example of a geometric grid of rectangular fields, separated by draining ditches, confined to the lowest part (Watrous, 1982; Rackham and Moody, 1996: 150). At present, farmers still own parcels dispersed over several communal territories. Finally, distinct data sets can be combined to yield a more complete assessment of the landscape. Caution is needed, however, as different data sets that are aimed to measure the same, can differ substantially. Data from field surveys that are geographically situated allow refining conclusions at the local scale.

Sub-regional *versus* regional landscape assessment

In the OECD Report the regional scale level relates both to Crete as a NUTS II-region and to Lassithi as an administrative prefecture. According to the Report, the Lassithi plateau forms part of what is called the "rural areas" in Crete. The actual population density on the plateau is on average 25 inhabitants per square kilometre. This agrees with the OECD Report that states that rural areas show densities between 0.8 and 39 inhabitants per square kilometre for the municipalities, while Crete as a whole counts 72.1 inhabitants per square kilometre. The Report states that in 1991, of all Cretan settlements, only 4.4% had a population higher than 2000 inhabitants, 10.1% had a population of 501-2000 inhabitants, and the remaining had a population of less than 500 inhabitants. On the Lassithi plateau however, no community has more than 2000 inhabitants in 1991, and only 2 of 9 communities on the plateau have more than 500 inhabitants. The OECD Report states that Crete has one of the highest rates of population increase of all European regions: 11.3% between 1991 and 2001 for the region and 8.04% for the prefecture of Lassithi. Most communities on the Lassithi plateau also had a population growth between 1920 and 1940, but majority registered serious population losses of approximately 25% between 1991 and 2001. An overview map in the Report gives a more differentiated picture per municipality. Nonetheless, the OECD reports that rural population rate in the Lassithi prefecture is higher than that of the NUTS II Region (50.26% and 42.02% respectively). The Report also describes the area of the settlements with a population lower than 500 in 1991 and those with a population decline over the decade 1981-1991. The Lassithi prefecture is mentioned, but the plateau is not.

In terms of age profile, the OECD Report states that the rate of young people aged up to 39 years is higher in Crete than in the country as a whole, while on the other hand the percentage of people older than 80 years is higher than the national average: the population of Crete is younger and longevity appears to be greater. In the Report this is not specified per municipality within the text, but the migratory patterns from rural areas are mentioned and maps give a more differentiated picture. The relative

proportions of the age cohorts in the Lassithi plateau show a different pattern than that for Crete as a whole. The Cretan population of aged 25-39 years counts for about 23%, whereas in the plateau it only amounts to 14%. Population older than 65 years takes a regional proportion of about 14%, whereas in the communities this age cohort attains on average 23%. Among the communities there are differences as the most dynamic communities have relatively more young people. As relates to employment in 1997, 37.8 % of the workforce in Crete was employed in the primary sector, 12.5 % in the secondary sector and 49.7 % in the tertiary sector. In the prefecture of Lassithi, the figures in 2001 are respectively 32.3%, 12.9% and 48.9%. For the communities of the Lassithi plateau, figures were only available for 1997, respectively 64.4%, 5.6% and 30%. Consequently, the number of employees per sector gives a substantially different picture between the observation scales. As relates to agricultural production (meat, dairy, potatoes, and vegetables) the figures for the region of Crete generally differ from the figures obtained in the Lassithi plateau.

From the landscape assessment at sub-regional scale(s), the Lassithi plateau does not appear as a homogenous entity. Similarly, the overview of the Cretan profile in the OECD Report concludes that there is not one unique rural picture in Crete. It situates the majority of rural areas in difficulty in the mountainous areas of the interior (and some on the southern coast) and some in the vicinity of major urban settlements. It describes that certain extensive areas in the mountainous zones present a worrying picture, with negative demographic and economic indices. The Lassithi plateau, however, is not mentioned. Despite the population decrease and ageing in the Lassithi plateau, the field survey showed that some communities do not expand substantially but that buildings are nonetheless relatively well maintained. Thus, the field survey, though agreeing with the census data, added extra valuable information.

In the study on land use change (Sarris *et al.*, 2005), the observation scale is reduced to Crete as an entity. The premise is that there is a high degree of land-use mixture all over the Mediterranean island territories. The recent temporal changes of land–use are studied using 9 Landsat-5 TM and Landsat-7 ETM, spanning from 1985 to 2003. Supervised classification for land-use was performed by taking into account all the spectral bands of each image. Training data were collected through field surveys using GPS and from ortho-rectified aerial photographs, in order to create a more definite separation of adjacent categories. From the spectral signature of the urbanized environment, the study derives a shift of the population moving from the agricultural mainland towards the more tourist-attractive north (and even south) coast, which is correlated with the decreasing of vegetation cover within the urban and suburban areas. This is confirmed by population decrease in the Lassithi plateau. The study notices similar decrease in the forest and wild flora areas, which is not true for the Lassithi area. Here, abandoned terraces continue to be invaded by vegetation. The study mentions the abandonment of the traditional crops (olives and grapes) and the adoption of more complex cultivations. In the Lassithi plateau, cash crop of potatoes and other

horticultural production remain most important. The study concludes that the edges of the homogenous areas in the plains have become fuzzier in the recent years, in contrast to the corresponding ones in the mountain regions. In the plateau, however, a clear spatial distinction can still be made between vast areas of abandoned or waste land and cultivated land despite the changing land use. Thus, the conclusions in the study are kept rather general, hence difficult to compare with the situation on the Lassithi plateau at the sub-regional landscape scale.

CONCLUSIONS

This study compared the assessment of the landscape in the perspective of polarisation and dynamics, using different data sets at sub-regional scale *versus* regional observation scale. This comparison reveals inconsistencies, both between different data sets at the same scale level and between the resulting conclusions at different scale levels. On the sub-regional scale level, the statistical analyses using the different data sources give evidence for a heterogeneous landscape. All assessments yield both average and some outlying communities, but the outliers generally differ across the different data sets. Certain coherence exists between the census-and survey-based assessments, whereas the map-based data result in a completely different landscape classification. In general, and rather surprisingly, map data appear to be more remote from the perceivable landscape than statistical data. The conclusions revealed at different observation scales are even more inconsistent. In the study on land use change, the conclusions are kept too general to compare with the situation on the Lassithi plateau. The OECD Report, however, which differentiates between municipalities and even between communities, does not capture the small distinctions existing in the rural areas. Here too, the map data of the study on land use change give a more abstract assessment than the statistical data.

From this study, some suggestions can be made concerning data sets and observation scales for landscape evaluation. Different data sets should be combined with caution at the same observation scale in order to obtain a more complete assessment. This goes for the regional and higher scales too, where statistical data are often subordinate and considered less reliable than map data.

REFERENCES

Antrop, M. (2004). Assessing multi-scale values and multifunctionality in landscapes. In J. Brandt & H. Vejre (Eds.), *Multifunctional landscapes. Theory, values and history* (pp. 165-180). Southampton: WIT Press.

Antrop, M. (2004). Landscape Change and the urbanization process in Europe. *Landscape and Urban Planning, 67*, 9-26.

Antrop, M. (2004). Rural-urban conflicts and opportunities. In R. H. G. Jongman (Ed.), *The New Dimensions of the European Landscape* (pp. 83-91). Springer.

Bonnefont, J. C. (1971). *La Crète: étude morphologique*. Thèse présentée devant l'université de Paris IV le 26 juin 1971. Service de reproduction des theses, Université de Lille III: Université de Paris IV; 72.

Bunce, R. G. H., Groom, G. B., Jongman, R. H. G., & Padoa-Schioppa, E. (Eds.) (2005). *Handbook for Surveillance and Monitoring of European Habitats* (1st ed.). Alterra-rapport 1219. Wageningen: Alterra.

Caraveli, H. (2000). A comparative analysis on intensificiation and extensification in mediterranean agriculture: dilemmas for LFAs policy. *Journal of Rural Studies, 16*, 231-242.

Claval, P. (2005). Reading the rural landscape. *Landscape and Urban Planning, 70*, 9-19.

Council of Europe (2000). *European Landscape Convention and Explanatory Report*. Council of Europe.

Dramstad, W. & Sogge, C. (2003). *Agricultural impacts on landscapes: Developing indicators for policy analysis*. Paper presented at the NIJOS/OECD Expert Meeting on Agricultural Landscape Indicators. Oslo - Norway.

EU (2005). Retrieved May, 2005, from http://europa.eu.int/comm/agriculture/capreform/index_en.htm

European Environment Agency (2005). *Agriculture and environment in EU-15 - the IRENA indicator report*. Copenhagen - Denmark: European Environment Agency.

Greger, S. (1988). *Village on the plateau. Magoulas, a mountain village in Crete*. Worcestershire: Redditch.

Klijn, J. A. & Vos, W. (2000a). A new Identity for Landscape Ecology in Europe: a Research Strategy for Next Decade. In J. Klijn & W. Vos (Eds.), *From Landscape Ecology to Landscape Science* (pp. 149-161). Wageningen: Kluwer Academic Publishing.

Klijn, J.A. & Vos, W. (2000b). *From Landscape Ecology to Landscape Science*. Dordrecht: Kluwer Academic.

Paquette, S. & Domon, G. (2001). Rural Domestic Landscape Changes: a survey of the residential practices of local and migrant populations. *Landscape Research, 26*, 367-395.

Paquette, S. & Domon, G. (2003). Changing ruralities, changing landscapes: exploring social recomposition using a multi-scale approach. *Journal of Rural Studies, 19*, 425-444.

Parris, K. (2004). Measuring changes in agricultural landscapes as a tool for policy makers. In J. Brandt, J. & Vejre, H. (Eds.), *Multifunctional Landscapes. Theory, Values and History* (Vol. I, pp. 193-218). Southampton: WIT Press.

Rackham, O. & Moody, J. (1996). *The Making of the Cretan Landscape*. Manchester and New York: Manchester University Press.

Sarris, A., Maniadakis, M., Lazaridou, O., Kalogrias, V., Bariotakis, M., & Pirintsos, S. A. (2005). *Studying land use patterns in Crete Island, Greece, through a time sequence of Landsat images and mapping vegetation patterns*. Paper presented at the meeting of the WSEAS International Multi-Conference on International Conference on Environment, Ecosystems and development. Italy, Venice. Retrieved March, 2006, from http://www.ims.forth.gr/publications.html.

Van Eetvelde, V. & Antrop, M. (2004). Analyzing structural and functional changes of traditional landscapes - two examples from Southern France. *Landscape and Urban Planning, 67*, 79-95.

Vos, W. & Klijn, J. (2000). Trends in European Landscape Development: prospects for a sustainable future. In J. Klijn & W. Vos (Eds.), *From Landscape Ecology to Landscape Science* (pp. 13-30). Wageningen: Kluwer Academic Publishers.

Vos, W., & Stortelder, A. (1992). Vanishing Tuscan Landscapes. *Landscape Ecology of a Submediterranean-Montane area (Solano Basin, Tuscany, Italy)*. Pudoc Scientific Publishers Wageningen.

Watrous, L.V. (1982). *Lassithi, a history of settlement on a highland plain in Crete*. Princeton, New Jersey: American School of Classical Studies.