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Mapping the diachronic changes of stocking rates in a Mediterranean rural area of North Greece

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Abstract. Livestock husbandry has rapidly changed over the last 50 years in the Mediterranean region. The main changes are the continuous processes of (i) land abandonment in the less accessible areas at a high altitude, and (ii) population transfer to more favourable areas, mainly plains. The study of the temporal spatial evolution of stocking rates is a useful tool for monitoring and analyses of sustainable rangelands management. This tool was used in the 32 Municipal Districts (MDs) of Lagadas Municipality for a period of fifty years (1961-2011). Inventory data were collected for the study area and GIS software (ArcGIS) techniques were implemented in order to produce temporal maps and tables of stocking rates (1961, 1971, 1991, 2001 and 2011). The general stocking rate decreased since 1961 in the study area. However, at low elevation, stocking rate remained higher (characterised as extreme overgrazed) than in zones of intermediate and high elevation. Interestingly the stocking rate was correlated to both proximity of settlements and population status. What is a necessity for the study area is the development of a medium and long term sustainable management plan for grazing which will deal with the issue of livestock distribution which will be developed under a serious public consultation. This consultation can ensure the involvement of the local society to the plan's local adaptation and implementation in a long term basis.

Keywords. ArcGIS – Socioeconomic conditions – Land abandonment – History of grazing animals.

Cartographier les changements diachroniques du taux de chargement dans une zone rurale méditerranéenne au Nord de la Grèce

Résumé. L'élevage a changé rapidement au cours des 50 dernières années dans les régions méditerranéennes. Les principaux changements sont le processus continu d'abandon des terres dans les zones d'altitude moins accessibles et le transfert de la population vers des zones plus favorables, principalement en plaine. L'étude de l'évolution spatio-temporelle du taux de chargement est un outil utile pour le suivi et l'analyse de la gestion durable des parcours. Cet outil a été utilisé dans les 32 districts municipaux (MDS) de Lagadas sur une période de cinquante ans (1961-2011). Les données d'inventaire ont été recueillies pour la zone d'étude et des logiciels techniques de SIG (ArcGIS) ont été appliqués afin de produire des cartes et des tableaux de chargement temporels (1961, 1971, 1991, 2001 et 2011). Le chargement global a diminué depuis 1961 dans la zone d'étude. Cependant, dans la zone de basse altitude, le chargement est resté plus élevé que dans les zones intermédiaires et d'altitude. Ce qui résultait intéressant était que le taux de chargement était en rapport à la fois avec la proximité des peuplements et le statut de la population. Il est nécessaire pour la zone d'étude d'élaborer un plan de gestion durable du pâturage à moyen et long terme qui traitera de la question de la répartition spatiale du bétail, et qui sera développé dans le cadre d'une consultation publique sérieuse. Cette consultation peut assurer l'implication de la société locale à l'adaptation et la mise en œuvre du plan d'action sur le long terme.

Mots-clés. ArcGIS – Conditions socio-économiques – Abandon des terres – Historique du pâturage.

I – Introduction

Livestock husbandry in Greece basically relies on communally state-owned rangelands. These rangelands are parts of the typical Mediterranean pastoral landscapes that have been shaped by grazing activities for many centuries (Papanastasis and Chouvardas, 2005). During the last 50 years, important changes occurred in the livestock sector, following the general trend of land abandonment in rural areas of the Mediterranean region. This trend was more severe in high

altitude rural areas with diverse terrain (Farina, 1998). A consequence is the decline of the number of young people engaged in the primary sector resulting in a direct effect on agriculture forestry and traditional animal husbandry (Ispikoudis and Chouvardas, 2005). Nomadic livestock flocks, which were the main element of traditional husbandry, have decreased in number. On the other hand household livestock and use of conserved feeds have increased, as a result of the difficulty of old people to shepherd their animals far away from their villages. Therefore, grazing pressure is concentrated near the villages, while the most remote parts of rural areas are less grazed (Ispikoudis and Chouvardas, 2005). These changes have contributed to the gradual degradation of rangelands.

The study of the stocking rates, meaning the number of livestock that graze on a particular area at a specific period of time divided by the surface area (Society for Range Management, 1989) is a useful tool to record and examine the progress of livestock husbandry but also to plan management policies for rangelands. This paper aims at studying and mapping the diachronic changes of stocking rates in a rural area of North Greece.

II – Materials and methods

The study was conducted in the municipality of Lagadas, in central Macedonia, Northern Greece. The climate is characterized as semi-arid to sub-humid Mediterranean conditions. Soils are shallow, sandy and acid mainly derived from metamorphic rocks. The study area includes 32 Municipalities Districts (MDs) and covers a surface area of 122,193 ha. The dominant vegetation is rangeland from which the most typical type is the *Quercus coccifera* (kermes oak) shrubland.

The first phases of the study consisted in collecting a large number of inventory data (number of livestock animals). These data were mainly collected from diachronic census reports of the National Statistical Service of Greece (NSSG) and the Direction of Agriculture of Lagadas County. The following phase included the analysis of the raw census data by using MS Office Excel sheets and GIS Software (ArcGIS v10). The final phase combined all these data and resulted in the development of analytical diachronic digital maps and databases of datasets regarding the number of livestock animals (cows, sheep and goats) and their stocking rates for the years 1961, 1971, 1991, 2001 and 2011. These datasets were analysed both temporally and spatially by dividing the study area into three elevation zones: low zone (average altitude below 200m), intermediate zone (average altitude between 200-600m) and high zone (average altitude over 600m).

Stocking rate was expressed in animal units per unit area, i.e. by dividing the number of free grazing animal units of each MDs with the area of rangelands registered in the NSSG land use reports. In the communal management system of the state-owned rangelands of Greece, livestock usually graze at the rangelands of the MDs where the farmer is officially registered. Stocking rate calculation included the total numbers of sheep and goats and the free grazing cows. The grazing units were expressed in sheep equivalents (5 sheep for each cow). The 32 MDs were classified into five stocking rate categories: Lightly Grazed (0-0.5 animal units/ha), Properly Grazed (0.5-2.0 au/ha), Heavily Grazed (2.0-3.0 au/ha), Very Heavily Grazed (3.0-5.0 au/ha) and Extremely Overgrazed (over 5.0 au/ha).

III – Results and discussion

The results from the diachronic census reports revealed that the number of livestock animals of the Municipality of Lagadas decreased by 27% during the time period from 1961 to 2011 in all altitude zones (low, intermediate, high). During the same time period cows and sheep were reduced by 21%, and 44% respectively, while the number of goats was on average increased by 2%, probably as a result of shrub encroachment in the area (Papanastasis and Chouvardas,

2005). For the period 1999 to 2009, Toro-Mujica *et al.* (2015) reported a decrease in sheep numbers in Andalusia region, Spain, mainly due to the uncoupling of EU CAP sheep subsidies.

A temporal reduction of the stocking rates from 1961 to 2011 (from darker to lighter colours) was recorded to the mountainous MDs of Lagadas (located mainly to the northern part of the study area, Fig. 1) due to social changes that related with land abandonment.

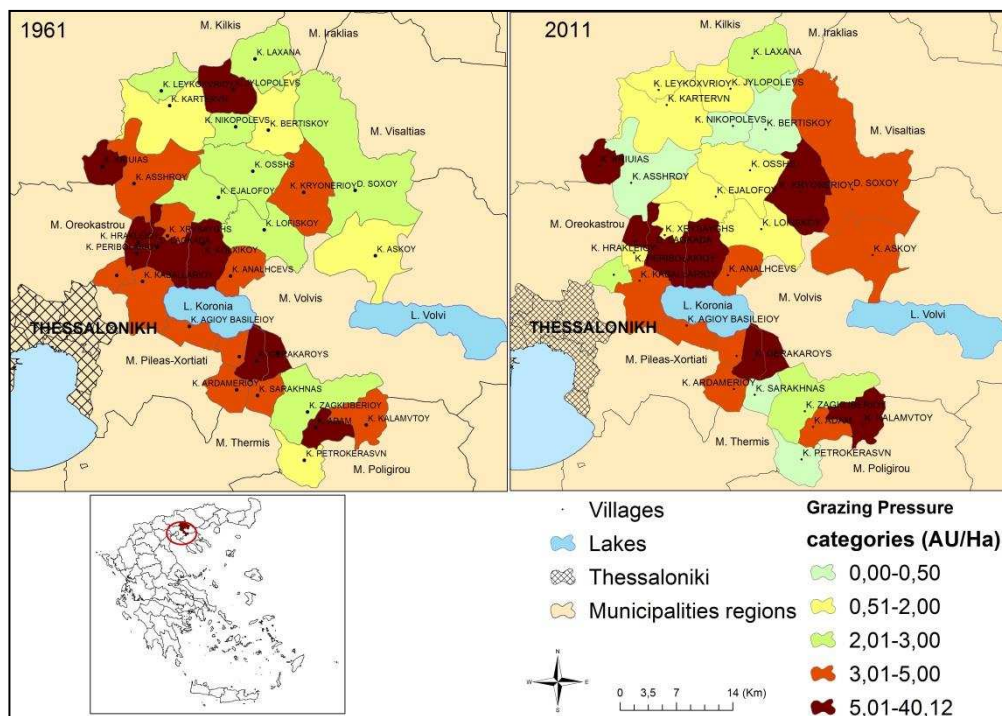


Fig. 1. Stocking rate maps of Lagadas Municipality Districts (MDs) from 1961 to 2011.

Land abandonment in these MDs contributed to an extended diachronic decrease of young people engaged to primary sector and to a reduction of livestock (unpublished data from Lagadas Municipality). Exception of this trend was the three MDs of Sochos, Askos and Kryoneri located in the eastern part of the study area (Fig. 1). The stocking rates diachronically tend to increase at these MDs, although they are mountainous and with harsh environment, mainly due to the fact that their social structure (high rate of young people engaging to primary sector) was maintained unchanged over the years (unpublished data from Lagadas Municipality). Similarly, the stocking rates were temporally increased and/or were stable from 1961 to 2011 at the MDs of low elevation zones (plain areas) located mainly around Lake Koronia and in the southern parts of the study area. This was also as a result of no important socioeconomic changes in the MDs of low elevation (unpublished data from Lagadas Municipality).

The stocking rate was diachronically decreased by 46.2% and 28.4% (Table 1) at the MDs of the low and intermediate elevation zones respectively. However, the rangelands of the low altitude zone were still highly overgrazed (6.1 au/ha) while the ones of the middle altitude zone were still heavily grazed (2.8 au/ha) (Table 1). Finally, the stocking rates at the MDs of the high

zone was slightly increased by 4% maintaining at a rather satisfactory rate of 2.3 au/ha (Table 1).

Table 1. Evolution of stocking rate (au/ha) in the elevation zones of Lagadas County and its changes from 1961 to 2011 in percentage (%)

Elevation zones	1961	1971	1991	2001	2011	(%) change
Low zone	11.4	15.9	9.9	8.9	6.1	46.2
Middle zone	3.9	2.9	3.4	2.6	2.8	28.4
High zone	2.2	1.6	2.0	2.5	2.3	4.1

Despite the fact that the total number of livestock animals in the Municipality of Lagadas has been continuously reducing from 1961 to 2011, the unbalanced distribution of the grazing animals in the rangelands has produced high stocking rates mainly at the low zone around Lake Koronia and at the east part of the study area (mountainous area). Moreover, the under-grazed rangelands were in MDs that located at the north part of the study area. However, on overall the sum of heavily grazing rangelands in the study area is being diachronically decreased which is consider as a positive trend.

This research has put forward the necessity of a sustainable grazing management plan for the area which will take into consideration the different rangelands, their available grazing production, the current livestock, the socioeconomic conditions and the possible limitations. The key factor of this plan should be the rearrangement of the livestock in a way that all the available sources are used sustainably.

IV – Conclusions

The sum of the livestock census in the Municipality of Lagadas has been continuously reducing from 1961 to 2011. There is an unbalanced distribution of the grazing animals in the rangelands of the study areas since there are high stocking rates at the low altitude zone around Lake Koronia and at a part of the high elevation zones and low rates to the less accessible and lower density population areas. What is a necessity for the study area is the development of a medium and long term sustainable management plan for grazing which will deal with the issue of livestock distribution which will be developed under a serious public consultation. This consultation can ensure the involvement of the local society to the plan's local adaptation and implementation in a long term basis.

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