12B.2 ESTIMATION OF CLIMATIC RISK FOR AGRICULTURE IN A MEDITERRANEAN REGION

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1. INTRODUCTION

Climate variability is particularly important in determining agricultural planning and resources management. Climatic risk assessment was largely estimated and great effort was put in large-scale studies and General Circulation modelling. Parry and Carter (1988) and Rosenzweig (1982) showed how difficult is to assess climate risk for agricultural areas and crops at local scale.

Land Evaluation provides qualitative information about land, such as its cropping potential or land vulnerability risk, based on bio-physical and social-economical characteristics. There are several generic issues associated with the application of Land Evaluation (Rossiter, 1996). In particular, land qualities derived from measurements of dynamic variables (e.g. temperature) are converted to static variables for the purposes of Land Evaluation. There are few examples of Land Evaluation studies where a methodology for incorporating weather variability is developed (van Lanen et al., 1992; Hudson and Birnie, 1999).

An application of Land Evaluation for estimating agricultural climate risk at local scale is presented. Climatic, geographic and soil data from Sardinia island, Italy, were analysed using a Land Capability for Agriculture (LCA) classification system (Klingebiel and Montgomery, 1961), which comprises several classes based on a range of land quality and potential productivity.

2. MATERIALS AND METHODS

Sardinian territory was studied in relation to geographic, soil and climatic characteristics. Soil and land cover maps were analysed in order to classify the territory in Land Capability classes ranged 1 through 8 with increasing limitations to agriculture. The climatic LCA classes were built using weather data from 50 stations spread all over the island. The reference period 1961-90 was used to derive annual values of maximum soil moisture deficit (SMD_{max}) and heat accumulation. SMD_{max} was calculated by accumulating the daily moisture deficit between rainfall and evapotranspiration. Annual heat accumulation was determined calculating Growing Degree Days (*GDD*), using the Single Triangle Method and a lower temperature threshold equal to 0 °C. A plot of lower quartile of annual *GDD* versus median values of annual SMD_{max} was used to draw climatic LCA class boundaries for the 50 climate stations. Stations with similar climatic conditions were grouped using a cluster analysis methods (tree clustering).

This procedure was extended to the whole island territory using temperature and precipitation data from about 200 stations. The data were interpolated in a 10 km x 10 km grid using the optimum interpolation technique (Chessa and Delitala, 1997).

A Geographic Information System (ArcView 3.2) was used to manage, elaborate, and analyse the thematic layers (soil, climate and land use).

3. RESULTS

Sardinia was partitioned in homogeneous agro-climatic areas in relation to LCA classification. Several classes with increasing limitations to agricultural practices were obtained from a first soil LCA classification of the region. Almost 75% of the region resulted not suitable for agricultural use because of more or less severe orographic and pedologic limitations.

The plot of the median values of SMD_{max} and the lower quartile of annual *GDD* was used to define 7 climatic classes and several subclasses. The grid cells were classified in *Prime* (P, most suitable for agriculture) and *Non Prime* lands (NP, not suitable). Water deficit was the key factor in determining the climatic LCA classes. Most areas of Sardinia were classified as *Prime land*, comprising climatic LCA classes 1, 2_1, 2_2 and 3_1, as shown in Figure 1.

An overlay between the LCA soil map and the LCA climatic map of Sardinia resulted in a map of the most, moderate, least and not suitable areas of the region for agricultural capability (Fig. 2).

The probability of occurrence of land categories P and NP for each grid cell over the reference period 1961-1990 was estimated. A simple form of Markov-chain analysis was used to estimate the transitions between climatic Prime and Non Prime classes and the main result was a matrix of transition probabilities (Fig. 3). From this matrix, two forms of risk can be estimated: the probability of continuous sequences of years that land is in the climatic Non Prime category and the mean return time in years to climatic Non Prime land from Prime land.

In Figure 4 the southern part of Sardinia (the most important agricultural district) and the related

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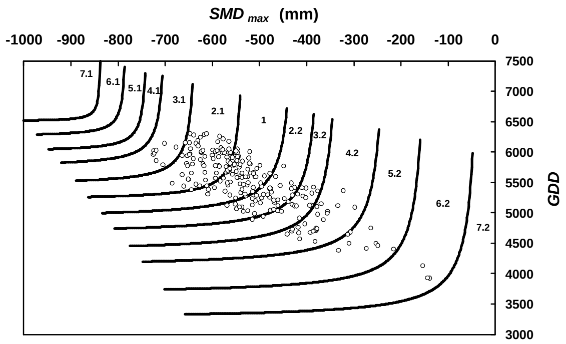

Figure 1. Distribution of grid cells into the climatic LCA classes.

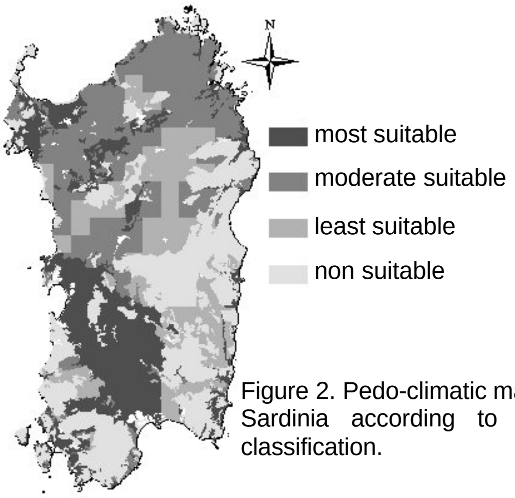

Figure 2. Pedo-climatic map of Sardinia according to LCA classification.

$$\begin{bmatrix} P \Rightarrow P & P \Rightarrow NP \\ NP \Rightarrow P & NP \Rightarrow NP \end{bmatrix} \begin{bmatrix} 17\,(0.739) & 6\,(0.261) \\ 6\,(1.000) & 0\,(0.000) \end{bmatrix}$$

Figure 3. Matrix of transition probabilities between climatic Prime and Non Prime categories in two consecutive years (left) and an example of transition counts and probabilities (in brackets) for one of the grid cells (right).

climatic risk index are shown. The numbers reported in each cell indicate the mean return time in years to climatic Non Prime land.

4. CONCLUSIONS

The results showed that the LCA methodology provides an useful technique for incorporating weather variability into Land Evaluation and for assessing climatic risk vulnerability of different agricultural zones at a local scale.

5. ACKNOWLEDGEMENTS

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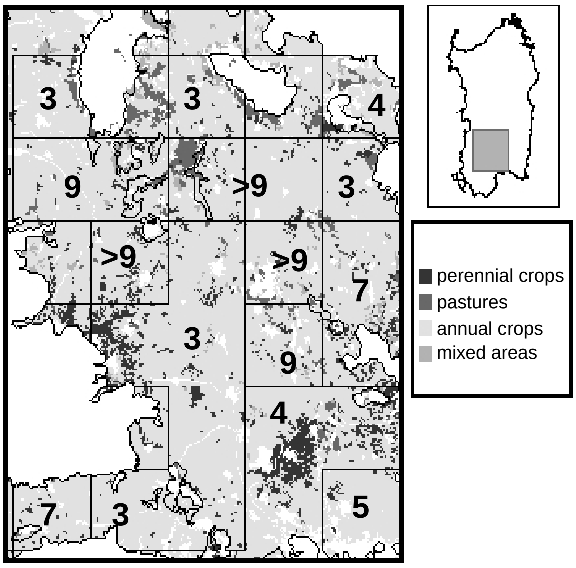

Figure 4. Climatic risk index and main crops for southern Sardinia. The numbers reported for each cell indicate the mean return time in years to climatic Non Prime category.

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