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SITE WATER BALANCE AS AN INDICATOR OF DRYLAND DEGRADATION STATUS: CONCEPTS AND APPROACH

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INTRODUCTION

The extent and spatial distribution of the land affected by degradation processes is roughly known at a global scale. At local and regional scales, the level at which land management decisions are usually made, knowledge on the current land degradation status or the magnitude of the potential hazard, is often incomplete and fragmented, or may even be entirely lacking. This makes it very difficult to plan strategic mitigation, reclamation or prevention measures. We have developed a new approach to assessing the degradation status of non-agricultural land under subtropical, semiarid and arid environmental conditions. We define land degradation as the human-induced loss of the land's biological potential, which calls for a method that consists of two components: i) a characterisation of the biological potential of the land in undisturbed conditions, and ii) a measure to quantify the deviation of the actual status of the land from the undisturbed reference situation. We have operationalised this approach by focusing on the long-term relationship of site water balance and vegetation density.

This approach is based on the following working assumptions: i) the vegetation density is a reliable expression of the biological potential, ii) the density of the vegetation is mainly a function of plant available soil moisture, iii) dryland degradation can be understood as a deterioration of soil hydrological properties, and iv) can be detected by an associated shift in the local water balance from a predominance of water losses that contribute to local vegetation growth (i.e. transpiration) to water losses that do not (e.g. soil evaporation, runoff, deep drainage). From these working assumptions we developed a framework for the quantification of dryland degradation status as the ratio of mean annual actual evapotranspiration (E_a) to precipitation (*P*), here called the rain use efficiency (*RUE*). In so doing we give a slightly different interpretation to the original *RUE* concept (Le Houérou, 1984).

APPROACH

In our approach *RUE* is quantified from spatial anomalies in vegetation density, using: i) a simple method to predict potential vegetation density from a regression against Specht's (1972) topoclimatic moisture index (*k*); ii) the measurement of actual vegetation density, using remotely sensed vegetation indices; and iii) a conceptual model to 'translate' the deviation of actual and potential vegetation densities in terms of a ratio of water inputs and outputs. Under the assumption that long-term E_a rates of relatively open vegetation stands increase linearly with cover (e.g. Seevers and Ottman, 1994), and that long-term precipitation (*P*) is known, we use the deviations between the actually observed vegetation density (*f*) and predicted potential vegetation density (f_0) to compute E_a for any site in an area:

$$E_a = a.f + b \quad \text{for} \quad 0 < f \leq 1.0 \qquad \text{(eq. 1)}$$

$$E_a = P \quad \text{for} \quad f = f_0 \qquad \text{(eq. 2)}$$

$$E_a = P(1 - RC_0) \quad \text{for} \quad f = 0 \qquad \text{(eq. 3)}$$

$$E_a = P(1 + RC_0(\frac{f}{f_0} - 1)) \quad \text{for} \quad f \neq f_0 \qquad \text{(eq. 4)}$$

where RC_0 is the long-term runoff coefficient for a bare soil surface, and *a* and *b* are constants. The coefficients *a* and *b* in equation 1 are, obviously, determined by the two points that are defined by the assumptions made in equations 2 and 3. The former, assumes that in undisturbed environments E_a approaches *P*. The latter, about E_a for a site without vegetation cover, requires information on the long-term runoff coefficient for a bare soil surface (RC_0), at slope lengths comparable to the spatial resolution of the study at hand. Such information will often not exist for a study area, but may be approximated from basic climate and terrain data using simple rainfall/runoff models such as the curve number method (Soil Conservation Service, 1986).

A REGIONAL CASE-STUDY IN SOUTHEAST SPAIN

As part of the MEDALUS project the performance of the method was evaluated in a 900 km^2 area in the Río Guadalentín basin, SE Spain. Input data consisted of a digital elevation model and long-term climate records, used for the spatial distribution of monthly potential evapotranspiration rates and Specht's (1972) topographic moisture index *k*, together with a series of six Landsat Thematic Mapper images from the hydrological year 1993-1994 from which vegetation density maps were derived. For a large sample of pixels from locations where topographic position and landform exclude lateral water inputs, Specht's *k* appeared to be a good predictor of the maximum values of the Normalised Difference Vegetation Index, *NDVI* (R^2=0.97; p<0.000). We used this relationship to predict potential vegetation density and, applying equation 1 to 4, E_a and *RUE* for the rest of the area.

The *RUE* values were standardised for the main lithological units and terrain types and then classified in three broad classes of land condition. Predicted land degradation status was found to agree well with the nature and intensity of land degradation phenomena at georeferenced field locations. A geostatistical analysis of errors in the input data and their propagation through the assessment procedure (Burrough and McDonnell, 1998) showed that most of the study area could be classified with less than 35% uncertainty into three broad classes of land condition (see Figure 1).

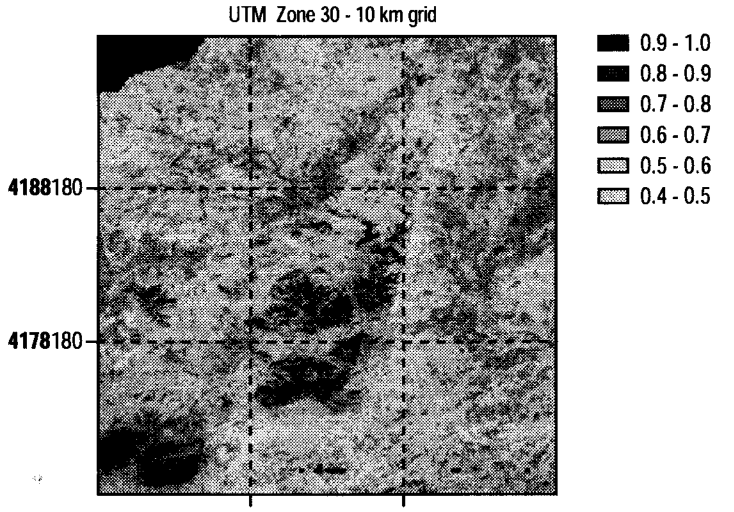

Figure 1: Spatial distribution of the probability of being consistently classified into one of three broad land condition classes, as resulting from the geostatistical error analysis. Using information on the geostatistical properties of all the input maps, 40 realisations were generated of *RUE* and the land condition assessment. The map values show the relative frequency of classification into one and the same land condition class.

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