Boletín de la Asociación de Geógrafos Españoles N.º 68 - 2015, págs. 489-495
I.S.S.N.: 0212-9426

PLUVIOMETRIC DYNAMIC INCIDENCE ON SOIL DEGRADATION. SOUTH OF SPAIN

J.D. Ruiz Sinoga
Departamento de Geografía. Universidad de Málaga
sinoga@um.es
A. Romero Diaz
Departamento de Geografía. Universidad de Murcia
arodi@um.es
J.F. Martínez Murillo
Departamento de Geografía. Universidad de Málaga
jfmmurillo@uma.es
M.A. Gabarrón Galeote
Departamento de Geografía. Universidad Católica de Lovaina
miguel.gabarron@uclovain.es

I. INTRODUCTION

In the South of the Iberian Peninsula there is well defined a rainfall gradient, ranging from the humid Mediterranean climate to the semi arid. Along this gradient, a small change is enough to modify the boundaries between these two eco-geomorphological system, so many Mediterranean areas situated in the surroundings of this threshold may be sensitive to changes in the pattern of rainfall being threatened by soil degradation processes. So the potential impact of global warming on the eco-geomorphological system in certain climatic transition environments, is one of the issues that greater expectation being generated from the scientific point of view.

Within of the future climatic scenarios raised by the IPCC (2007-2013), the Mediterranean region (Giorgi and Lionello, 2008) and especially the South of Spain is set to one of the areas of greatest uncertainty, linked this to the greater or lesser proximity to the Strait of Gibraltar and, therefore, to the Mediterranean factor (De Castro et to the., 2005; Sumner et al., 2003).

The regionalization for Andalusia of the two main scenarios of climate change conducted by AEMET (Brunet et al., 2008), for the horizon 2100, an undoubted increase of maximum and minimum temperatures, coupled with a reduction in the rainfall. Both scenarios maintain similar trend although different intensity and, in any case, show a large standard deviation, i.e., an extraordinary variability. Similar trend found Sanchez and Miguez-Macho for the Iberian peninsula (2010).

Existing concern about the future development of water resources in the climate change context has attracted great interest by the study of trends of precipitation series. In the Western Mediterranean, several authors (Moreno-garcia and Martín-Vide, 1986;) De Luis et al., 2009) already appreciated a decrease in precipitation in much of the region, while Quereda et to the. (2000), in an analysis of 11 long series, found an increase in Catalonia and Castellón, and a decrease in the remaining Spanish Mediterranean side.

The Western Mediterranean basin, at the southern edge of the temperate zone, between 35 ° N and 45 ° N, might be bound, so to experience climate impacts and high current biogeographical. Accordingly, throughout the 21st century, could attend to a sensitive rehabilitation of their scenario biogeographical affected largely by an increase in evapotranspiration and decrease in precipitation, which according to current models (HadCM2, ECHAM4, Cosmo-CLM PROMES model, etc.), would be due to the progressive removal of the generation of the polar front zone.

Changes that will occur in the global water cycle, in response to global warming during the 21st century, will not be uniform. It will increase the contrast in precipitation between wet and dry regions and between stations, wet and dry, although there may be regional exceptions (IPCC, 2013). In general, anticipated that rainfall in the Mediterranean region will diminish. On the one hand, this is due to a widespread trend to a reduction in rainfall in the subtropics as a result of the increase in the divergence of steam (Held and Soden, 2006) and on the other to the migration North of the subtropical belt of anticyclonic (Trenberth et al., 2007). Also, it has been argued that global warming could lead to an increase in extreme precipitation events.

According with these theoretical predictions, simulations of 21st century climate models predict significant decreases of precipitation in the Mediterranean, and in IP (Iberian Peninsula) in particular, with special incidence in the summer, where the decline could reach 50% at the end of the 21st century (Meehl et al., 2007). The agreement between models is particularly good for this region, which increases the reliability of this projection and points to the Mediterranean region (already itself characterized by semi-arid conditions) as an area particularly vulnerable to global warming.

For the IP simulated seasonal mean precipitation playing acceptable way North-South gradients in summer and West-East in the other seasons of the year. Simulated seasonal rainfalls in the southern Spanish peninsular values are usually lower than actual climate (OECC, 2005).

There are rainfall analysis that show certain trends to the South of Spain (Ruiz Sinoga et al., 2011) confirming forecasts offered to regional levels by different climate models listed, and what can be the impact within the Mediterranean eco-geomorphological system. To do this, it will be necessary to analyse the biotic, abiotic and human components of the geosistem, especially those that serve as indicators of the health and responsiveness of it to global warming.

Changes produced in the soil properties along a rainfall gradient can show how a reduction in annual precipitation could mean a smaller amount of water for plants, delaying its germination and reducing its microbiological activity, which can decrease the content of organic matter at the time that it would increase the concentration of salts. As a result, it could decrease the percentage of clay, affecting the structural stability of soils, and modify-

ing its infiltration capacity and permeability. This implies an increase in the rate of runoff and surface flow, whose consequence is the appearance of frequent superficial crusts or the onset and intensification of processes of erosion, in a feedback loop (Lavee et al, 1998).

In the short term, has been analyzed the eco-geomorphological response of rainfall changes in certain Mediterranean environments in the South of Spain, reflected in the modification of some soil properties and different strategies of adaptation of the plant communities (Ruiz Sinoga and Martínez Murillo, 2009). In addition, pluviometric conditions in the field sites and the antecedent soil moisture that produced precipitation, are factors that will directly influence the physical and hydrological properties of the surface formations and biotic characteristics of the medium (Imeson and Lavee, 1998). Definetively, along a rainfall gradient and by reproduction of similar situations, such as predictive method, such a process can be checked (Bergkamp et al., 1999).

Under these approaches, the objectives of this study were:

1. Analyze the pluviometric evolution, trends or cycles during the last half century in the Bétics coastlines mountains, where there is a longitudinal gradient of rainfall.
2. Check in that area as a reduction in rainfall gradient affects some soil, biological and hydrological properties and, therefore, in the eco-geomorphological system, and may allow the identification of soil degradation processes, verifying if some of the analyzed soil properties can be used as indicators of degradation of the system.
3. Validation of the method for reproduction of similar situations in a rainfall gradient, as a good alternative to the comparative study of degradation processes of the soil degraded and desertificacion areas, with similarities in morphology, but contrast in climate, reflecting on possible scenarios for the future, in the event of continuing rainfall analyzed dynamics.

II. GEOGRAPHICAL SCOPE OF STUDY

The field of study is the South of Spain and in particular the Cordilleras Béticas coastlines, which from the point of view of climate can be distinguished between subtropical, subdesert, and indoor climate. (Figure 2 text in spanish)

III. MATERIAL AND METHODS

III.1. Determination of the gradient and rainfall dynamics

The climatic gradient observed in the study area was defined through the analysis of a series of daily rainfall data (1961-2007), which included a total of 271 pluviometric stations distributed from the Strait of Gibraltar to Almeria, along the Andalusian Mediterranean basin, which belongs to the ancient Confederation basin of the South of Spain, now Andalusia water agency. The precipitation gradient map was obtained using technical geostatistical kriging and adjusting a spherical model the distribution of points. However, analyzing the pluviometric dynamics of the last half-century, despite having an appropriate spatial representativeness of observatories (271), to check the behavior and evolution of rainfall, some

have discontinuities, gaps, or simply short series, which in total have considered only 196 observatories. (Table 1)

III.2. Analysis of the dynamics and trend of dry gusts

It has been determined the evolution of dry periods by using the index DDSLR (Dry Days Since Last Rain), in order to characterize the trends of the number of dry days across a rainfall gradient, determine how the DDSLR changes along the gradient from the semi-arid Mediterranean areas to you wet them, and therefore to assess their contribution to the dynamic soil-water - vegetation (Ruiz Sinoga et to the.)2012). DDSLR method (Aviad et al., 2009; Reiser and Kutiel, 2010) allows the calculation of the probability of the occurrence of dry days (days without rain) at any time of the year, evaluating the risk of deficit of water for the vegetation during the active period, and determining the temporal variability of hydrological and geomorphological processes that depend on the soil moisture throughout the year.

III.3. Selection of the study areas and eco-geomorphological characteristics

Throughout the Bethics coastlines mountains, different representative areas, have been selected from the rainfall as eco-geomorphological point of view. On the one hand, it has analyzed the series of daily rainfall records of 9 meteorological observatories, located along the coast 5 and 4 in the following inside country (Figure 2 and table 1 text in spanish). On the other hand, we have studied 8 representative slopes which share topographic features (facing South and convex profile with increase of the slope to the base or depression), geological (geological substratum of metamorphic rocks) and use of the floor (near-natural conditions with non-intensive grazing). The differences are related with: weather, changes in the composition and pattern of vegetation, soil and geomorphological processes properties. From Gaucín (GA) to Gérgal (GE) there is an important reduction of the vegetative cover, precipitation and appearing plant species becoming more adapted to the lack of water (Figure 3, Table 2, text in spanish)

III.4. Analysis of the eco-geomorphological system

The methodology uses a Mediterranean rainfall gradient (Imeson and Lavee, 1998), for which several representative study areas (slopes) are selected through the application of criteria (topography, geology and land use) similarities and differences (related to the weather conditions). It took a total of 469 surface soil samples (0-5 cm): 40 in Marbella (MA), 90 in Gaucín (GA), 60 in Almogía, 52 in Colmenar (CO) (to the), 63 in Campanillas (AC), 50 in Berja (BE), 54 in Albuñol (AB) and 60 in Gérgal (GE). The number of total samples by study area varied according to the surface sampling on the slopes. The samples were collected both altered how unchanged in cylinders of 100 cm3.

III.5. Statistical analisis

Database was applied the Pearson correlation coefficient to evaluate the degree of correlation between the variables analyzed. Also, applied the test of Bartlett and KMO (Kaiser-Meyer-Olkin) to evaluate the possibility of applying a factor analysis (later ACP), which was conducted to determine associations between variables. This factor analysis was performed using the matrix of covariance (raw data) and correlations (standardized data), using the statistical program SPSS-15 (Chicago, USA). Through the use of the matrix of correlations, «eigenvalues» factors 1 were held and subjected to «Varimax» rotation to maximize their level of correlation.

IV. RESULTS AND DISCUSSION

IV.1. The uneven rainfall dynamics

In spite of that the interannual rainfall irregularity is the general temporal pattern, there are significant differences, depending on the geographical location of the observatories, in terms of the number and duration of cycles unusually wet or dry (Figure 4 text in spanish).

Table 3 describes the observed trend and its annual incidence. In this case they become to notice differences derived from the location of the Observatory.

- On the East coast there is a negative trend towards a lower annual total precipitation (Almería and Motril). Even the Observatory of Malaga, located in a central position on the Spanish Mediterranean South, could join this group.
- On the West Coast, Marbella and San Roque, are appreciated some positive trends towards a greater annual precipitation, with annual rainfall increases of 2.7 and 2.2 mm/year respectively.
- Inland, a negative trend with a considerable annual rainfall (Trevelez, Antequera and Gaucín) reduction can be also observed.

Precipitation trends are less intense in the southern coast Mediterranean East (Almería, Motril, Gérgal), regardless of your interior or coastal, position on the Western observatories (Marbella, San Roque, Gaucín).

According to Guijarro (2002), high variability spatio-temporal seasonal precipitation, together with low statistical significance sometimes found (due to a high variability of the own precipitation), can lead to underestimate the importance of the indicated rainfall trends, however, stay on time, they would mean drastic changes in the availability of water by the ecosystem, which would directly affect the management and consumption of water by the vegetation, and consequently, in adaptation strategies.

IV.2. Incidence of dry gusts

The probability of a day with rain has a seasonal variation. During the summer there are changes gradual, increasing the DDSLR continuously until the end of September/beginning of October, reducing the likelihood of rainfall threshold is reached. However, in the central and eastern sector of the baetic system coastal the probability of rain fell when the

DRT increased, even in November, with a range of implications on the ecogeomorfologico system. In the western sector, the probability that precipitation exceeds the threshold of 10.0 mm was significantly higher and reached 90% in October. However, the reduced (0.1 mm), during the autumn precipitation was greater in the eastern end, although the amounts were insignificant. In short, throughout the South of Spain, as it lowers threshold (DRTs = 0.1 - 5.0 mm) lower are the differences, while in the high DRTs are large differences in the probability of rain.

The spatial and temporal variability of the number of days without rain, or days of rain with different thresholds, is a climate characteristic of the analyzed pluviometrico gradient. In observatories more Western there is a marked and significant decrease of the number of days with precipitation exceeding 10 mm, however, in the remaining observatories, there is a significant increase of the number of days with more than 30 mm of precipitation. These events of heavy rains are common in the end of winter and the beginning of the autumn and have a marked effect on the soil erosion since at that time the plant cover is scarce or non-existent. However, in the East, while reduced the days with no intense precipitation, torrential events increase (≥30 mm), resulting in an increase in aridity, a reduction in vegetation cover and the onset of desertification processes.

IV.3. The eco-geomorphological dynamics

The existence of a rainfall gradient, as the analysand, implies a varied spatial distribution of available water by the eco-geomorphological system, which can result in different processes within the soil-water-plant relationships. Hence the need to carry out a comprehensive analysis of the main hydrological, chemical and physical properties of the soils on which are based the Mediterranean ecosystems, in order to determine the factors affecting the control of geomorphic processes. As it has already been reviewed, and given the amount of samples and variables analyzed, have used different statistics in this regard. Initially, and in order to determine the relationship between all the selected variables was a matrix of correlation of Pearson (table 4 text in spanish). The results showed a very high statistical significance between the majority of the analyzed variables.

Have been observed how an increase of rainfall along the gradient, would increase other variables such as: humidity (average and maximum) soil, vegetation cover, biodiversity or number of plant species, the content of soil organic matter, the amount of organic carbon retained the cation exchange capacity, and the hydraulic conductivity. And on the other hand, there was a reduction of the erodibilidad of the soil (K-factor). Also, properties that offered a more elevated and significant including correlation were the contents of organic matter, the amount of organic carbon retained, the cation exchange capacity and the K-factor. (Table 4, Table 5, Table 6 text in spanish).

In general terms, the pattern of soil degradation is different according to the climate field: in more humid environments, the degradation appears to be controlled by the soil moisture associated with the indicator of stability properties, while the driest is the absence of vegetation related to soil degradation processes. In any case, are the biotic factors that show the stability or instability of the system, thus, organic matter or organic carbon retained in soil are properties that are more determinants linked to the factors.

V. CONCLUSIONS

Concern about scenarios of scarcity of water resources in the context of climate change and its eco-geomorphological implications in the Cordilleras Béticas coastlines, has shown the need to carry out a critical analysis of the temporal evolution of precipitation in the area, in order to establish whether a progressive reduction is occurring.

1. The results shows the existence of a rainfall gradient from the West to the East, and marked contrasts both longitudinal as latitudinal, and thus, while a decrease in precipitation was observed in the South-East Coast, on the southwest coast the tendency has been the opposite, contrasting with the scenarios that arising out of the use of certain predictive models have been reported. In the Interior of the Cordilleras Béticas coastal areas, the decrease of precipitation trends are evident, especially in winter and autumn.

2. The index DDSLR increases in proportion to the aridity, which is logical, and therefore the vegetation has adapted to these Xeric conditions. However, there is little variation along the pluviometric gradient with respect to the DDSLR values between rains of small quantity (less than 1 mm/day), and great differences between rains of certain entity (entre10.0-30.0 mm/day). In the Oriental environments increases the number of days without precipitation, but also suffer from an increase in the probability of extreme rainfall exceeding 30 mm day.

3. Along a Mediterranean rainfall gradient from wet conditions to semiaridas-aridas the relationship between biotic and abiotic factors control soil degradation processes. Depending on the dominant factor and pluviometric Dynamics training/soil degradation process is changed.

4. As the rainfall is reduced, the indicators of soil degradation are linked to a greater or lesser humidity, without any bonding between soil water content and plant cover, manifested through the cycle of organic matter. In the humid Mediterranean processes of soil formation are linked to a greater rainfall, which affects the percentage of vegetation cover, soil moisture content, and the increase of the organic fraction, assuming a positive feedback process. On the contrary, in semiaridos-aridos Mediterranean environments, the existence of plant cover, is only linked to structural soil factors as bulk density, and the major or minor soil moisture contents directly related textural factors as immediate response of scarce rainfall.

5. This process of degradation is linear, with the threshold of soil degradation environment 500 mm/year, since it is from there, when vegetation is not associated with the existence of higher soil moisture content, adapting to the degradation of the same, as it can be seen by the emergence of xerophyte species.

6. To continue the current rainfall trend, a large part of the eco-geomorphological system in the South of Spain, would be below that threshold of soil degradation, with the consequent evolution of aggregate scenarios.

7. The method of dealing with the study of the processes of soil degradation, using the approximation from the definition of rainfall gradients and the analysis of the trend of rainfall, as well as considered to be properties of the soil, is suitable for determination of incidental factors therein. To do so, has shown very satisfactory application of the principal component analysis method.