Commentary

An Atlas of Desertification for Spain

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1. The Lack of Desertification Maps

As occasions like Desertification and Drought Day draw near or news headlines highlight new temperature records, a renewed interest on desertification is raised. Alongside this, the media often raises customary inquiries. Among the initial queries is the one concerning the scope of the issue. They presume that we experts know all this, and that we have a perfectly quantified variable that measures desertification. They assume that the dense network of satellites allows us to monitor the problem almost instantaneously, and that it is enough to take a look at this map, and issue a brief report: in this province, there is this percentage of desertification, this percentage is severe and this percentage is medium, and this percentage is severe.

We are far from it. We don't really have an answer to something basic, which is the state of desertification. There is a disparate estimation of the global extent of desertified lands provided to date, ranging between 4–74% of drylands (Safriel, 2007). The extent of desertification is an elusive figure, often presented as partial information even in official documents. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (2018) equates the problem to population affected (from 2.7 billion in 2010 to 4 billion in 2050) rather than to amount of land. The Intergovernmental Panel on Climate Change (Mirzabaev et al. 2019) gives a precise figure: "9.2% of drylands (±0.5%) experienced declines in biomass productivity" during 1980–2000, which is based on studies that estimate a 24-29% decline in global biomass (Le et al., 2016). Similarly, the United Nations Convention to Combat Desertification (2022) estimates that 20% of global land is degraded to some extent.

This pattern holds true at both the national and regional levels. In the case of Spain, outdated statistics have persisted, such as the assertion that 20% of its land area is undergoing degradation processes. This statistic originates from a study conducted for the period of 2000–2010, which evaluated land condition considering the rain use efficiency paradigm (Sanjuán et al., 2014). However, the assessment of desertification must include more factors, such as the degradation of groundwater bodies (which in the above map are revealed as positive anomalies), a serious problem in the drylands of Spain.

Alongside this map, which reflects the current state, there is another map of desertification risk, constructed using the Mediterranean Desertification and Land Use methodology (European Commission, 1999). Its validity has been questioned due to its lack of statistical and conceptual rigor. Specifically, this map is a simple algebraic operation to add up the effect of four factors (aridity, erosion, use of aquifers and area burnt by forest fires), excluding the possibility of synergy between them. For example, in a territory with higher aridity, and therefore lower productivity rates, soil loss has a greater impact than in less arid areas, since soil formation rates are lower. These types of interactions are not considered in the methodology used in the Spanish National Action Plan against Desertification, which also ignores the causes of the problem. Moreover, the factors are weighed subjectively. For example, if soil erosion estimated by the Revised Universal Soil Loss Equation is between 12 and 25 t ha^{-1} yr^{-1}, the weight of the erosion factor is 2, but nothing justifies these thresholds.

The lack of desertification maps, not only in Spain, but on a global scale, was certified by the latest World Atlas of Desertification (WAD) (Cherlet et al., 2018), which warns on the first page: "Although 'desertification' remains in the title, [...] deterministic maps on global land degradation are not presented." The rationale behind this gap in knowledge is multifaceted and arises from the inherent intricacies of desertification, encompassing a spectrum of degradation processes. These span from erosion and biodiversity loss to the overexploitation of water resources, and include economic degradation. Consequently, the pursuit of an indicator capable of harmonizing this diverse array of variables has encountered obstacles. Another contributing factor is the pronounced level of subjectivity in desertification assessment. Many experts have classified landscapes

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characterized by sparse, non-lush vegetation—typical of arid regions and exhibiting ochre hues—as areas undergoing degradation.

2. How to Fill this Critical Gap

Given the impossibility of mapping, the WAD proposes Convergence of Evidence (CE) to detect desertification processes at an early stage. CE emphasizes the importance of the context of each site and considers a series of biophysical and socio-economic variables to portray the potential threat of desertification. Without being an original approach—in 1998 the Surveillance System for Assessing and Monitoring of Desertification project (http://www.eeza.csic.es/surmodes/) already used this idea to identify the "desertification landscapes" of Spain (Martínez-Valderrama et al., 2022)—the idea is a fabulous diagnostic tool, as it makes it possible to anticipate degradation before it leads to irreversible deterioration of the socio-ecosystem.

However, the CE raises doubts. It does not provide a global framework in which to compare desertification states in different places, precisely because it prioritizes the local conceptual component, i.e., by considering that each context provides an idea of what desertification is. Moreover, it leaves empty all those maps that are constantly asked about. The problem with not having a map is that any map will do. Media questions are one thing, but the needs of the administration in decision-making are another, and these often come at a time that is not conducive to reflection. Indeed, when politicians become interested in desertification (or fires, or droughts, or plastic pollution) it is often too late, and there are very short deadlines to respond to very complex problems. In this context, it is not surprising that, for example, aridity maps are used to represent desertification. This is a major error, as aridity maps represent only where desertification can potentially occur.

It is not an option, if the problem is to be tackled with guarantees, to lack desertification maps. An example of this, in the case of Spain, is the express request for a desertification map by the Spanish Government in the latest National Strategy to Combat Desertification. Our project aims to address the challenge through the use of artificial intelligence algorithms. To do so, all available geospatial information on desertification (e.g., aridity index, soil organic carbon, land use changes, state of groundwater bodies, per capita income, etc.) will be gathered, and cases of desertification in Spain will be identified. We then train our prototype with these cases, relating them to the mapped variables under different climate change scenarios. From these relationships we will be able to detect, through the various maps that the project will generate, more cases of desertification that may initially go unnoticed or that have not been identified to date. In order to identify the main predictors and their importance in desertification in Spain, we will carry out a Random Forest permutation analysis (Breiman, 2001). Thus, in addition to having identified the places with desertification, we will have an idea of its causes, which will guide the design of solutions.

Our aim is to provide decision-makers with a useful tool for diagnosing desertification, which is the first step towards tackling the problem with guarantees. Only by knowing where the problems occur and with what intensity, will it be possible to start designing measures to reverse the problem (when it is already too advanced) or to redirect land uses that are beginning to cause land degradation.

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