EVALUATION OF THE SCS-CURVE NUMBER DISTRIBUTION IN SOUTHERN PORTUGUESE WATERSHEDS

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ABSTRACT

Based in an aggregated large-scale vectorized soil and land cover datasets a new map was generated with the spatial distribution of the Soil Conservation Service Curve Number in the southern region of Portugal. The methodology and data showed that the most dominant Hydrological Soil Group in the study region is D (72% of the total area) – low permeability soil – followed by B (12%) and C (9%).

The spatial averaged SCS-CN in the study region is 77, varying from 63 in Ribeiras do Algarve to 81 in Arade, Guadiana and Mira watersheds. In 94.4% of the area the SCS-CN is above 60 and in 45.8%, comprehended between 80 and 100, suggesting a high capacity for generating surface runoff. Significant differences are observable between existing SCS-CN maps and the new one, which may ease the implementation of models based in this parameter at regional to local scales.

Keywords: Curve Number; watershed; surface runoff; Hydrological Soil Group; Land cover.

1. INTRODUCTION

In a scenario of increased climatic variability and more recurrent extreme events, the use of alternative methods such as Managed Aquifer Recharge (MAR) may provide complementary tools in water resources management aiming at the storage and the recovery of surface water and at the reduction of the magnitude of extreme hydrological events. The work presented is part of the framework of a decision support protocol to implement MAR measures based on the hydrogeological characteristics of the subsurface, on the soil type and land use and on the modelling of the water availability for infiltration. As for the latter, a daily sequential budget model, based in the U.S. Dep. of Agriculture Soil Conservation Service method (USDA, NRCS, 2004), is being implemented for the calculation of direct runoff using the Curve Number, CN.

The Soil Conservation Service Curve Number (SCS-CN) is a parameter that accounts for the main watershed characteristics such as soil type and land use. It is used to estimate the precipitation losses and consequently the surface runoff (USDA-NRCS, 2004).

Aggregation of large-scale geographical information, aided by increased computational capabilities, may help to provide detailed SCS-CN maps. Previous mapping applications were conducted in order to provide global scale distribution of the SCS-CN parameter (Jaafar et al., 2019, based in Ross et al., 2018) but with poor spatial resolution, not compatible with regional to local applications as local variance was not be fully captured (Ling et al., 2019). For Portugal, a map for SCS-CN for average antecedent moisture conditions (AMC-II) was developed by Vermeulen et al. (1993) and adopted by INAG (2009), based on the soil type chart at 1:1 000 000 scale and the CORINE Land Cover (2000) maps.

The objective of this work is to obtain a detailed and improved spatial distribution of SCS-CN and to compare it with existing maps.

2. STUDY AREA

The study area refers to the southern region of Portugal and includes seven main watersheds: Ribeiras do Alentejo (2.4% of the total study area), Arade (3.9%), Barlavento (5.4%), Sotavento (6.3%), Mira (6.3%), Sado

(30.0%) and Guadiana (45.7%) – being Guadiana and Sado two of the most important Portuguese watersheds given the presence of important dams on which depend most of the regional economic activities. The region is characterized by high seasonal variability of the rainfall (Trigo and DaCamara, 2000, Durão et al., 2010) and prone for prolonged periods of drought with expected increasing recurrence (Santos et al., 2010).

3. MATERIALS AND METHODS

The integration and manipulation of geographical data was conducted within OSGEO QGIS software, making use of GRASS GIS and SAGA tools. Soil data at the scale of 1:50 000 was previously vectorized and made available on the EPIC WebGIS platform (LEAF-ISA, 2008).

An initial implementation of an equivalent methodology at national scale was developed by Vermeulen et al. (1993), based in the Portuguese soil map at 1:1 000 000 scale. The analysis of the soil classification defined for 1:50 000 maps was conducted by Oliveira et al. (1997) based on (a) soil thickness, coarse elements percentage, clay percentage and permeability from SROA (1973), (b) drainage capacity and soil thickness from SROA (1965) and (c) qualitative description of the soil families by texture, depth, water existence and type of clay present (SROA, 1970). The comparison of the Portuguese soil map at 1:1 000 000 scale with the families represented in the 1:50 000 scale soil map (Cardoso et al., 1973) was also considered by Oliveira et al. (1997) who associated a specific Hydrologic Soil Group (HSG) to each type of soil, following the U.S Department of Agriculture classification (USDA) (USDA-NRCS, 2009).

This information was combined with the CORINE Land Cover (CLC) 2018 (Copernicus, 2018) and with the tables that couple the CLC soil use classification and the SCS-CN – adapted from Vermeulen et al. (1993), based on David (1976) and Correia (1983), *in* Oliveira (2004, 2006).

4. RESULTS

The HSG soil map obtained [NCNM] was compared with the Portuguese SCS-CN 1:1 000 000 map based on Vermeulen et al. (1993) method and with the Global Hydrologic Soil Groups [HYSOGs] developed by Ross et al. (2018), with a geographical resolution of 1/480 decimal degrees (approx. 250 m), to support implementation of the USDA-based curve-number method at regional and continental scales presented by Jaafar et al. (2019) [GCN250]. Comparison between maps is shown in Figure 1. HSG-A – low runoff potential – is the major soil group in Sado watershed while HSG-D – high runoff potential – is the most common in Guadiana watershed. The use of a different, more detailed, classification in the 1:50 000 soil maps allows to consider other characteristics beyond those of the general soil characteristics in 1:1 000 000 maps, which resulted in a broader set of occurrences of different HGSs, as observed in Figure 1. HSG-A is now occurring where, in the pre-existing maps, only HSG-C and HSG-D were the most recurrent.

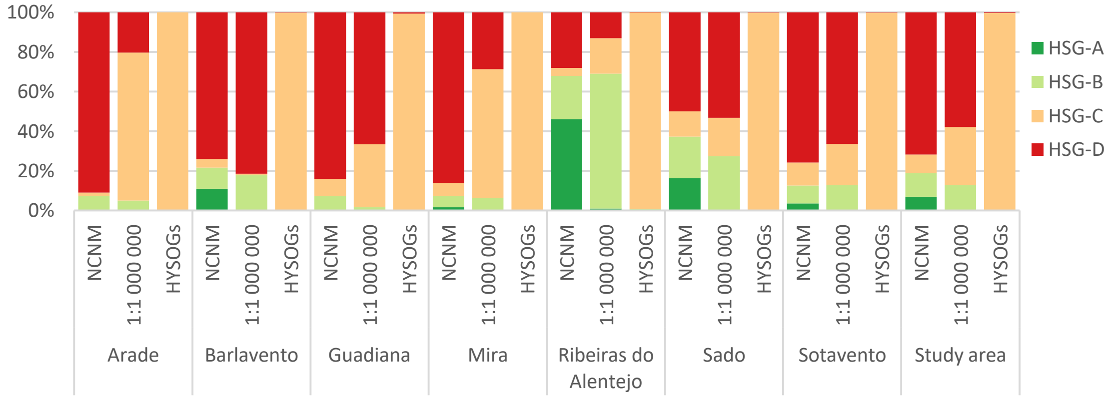

Fig. 1. Comparison between HSG maps in terms of area of occurrence of different soil groups.

Following the described methodology, the detailed map of the SCS-CN was generated (Figure 2). The lowest SCS-CN range – between [0 to 20[– only occurs in 0.01% of the studied area. Higher SCS-CN values are predominant, with [60-80[range taking 48.6%, followed by [80-100] range with 45.8% of the whole area. More than 50% of the area of both Guadiana and Sotavento watersheds is within the [80-100] range.

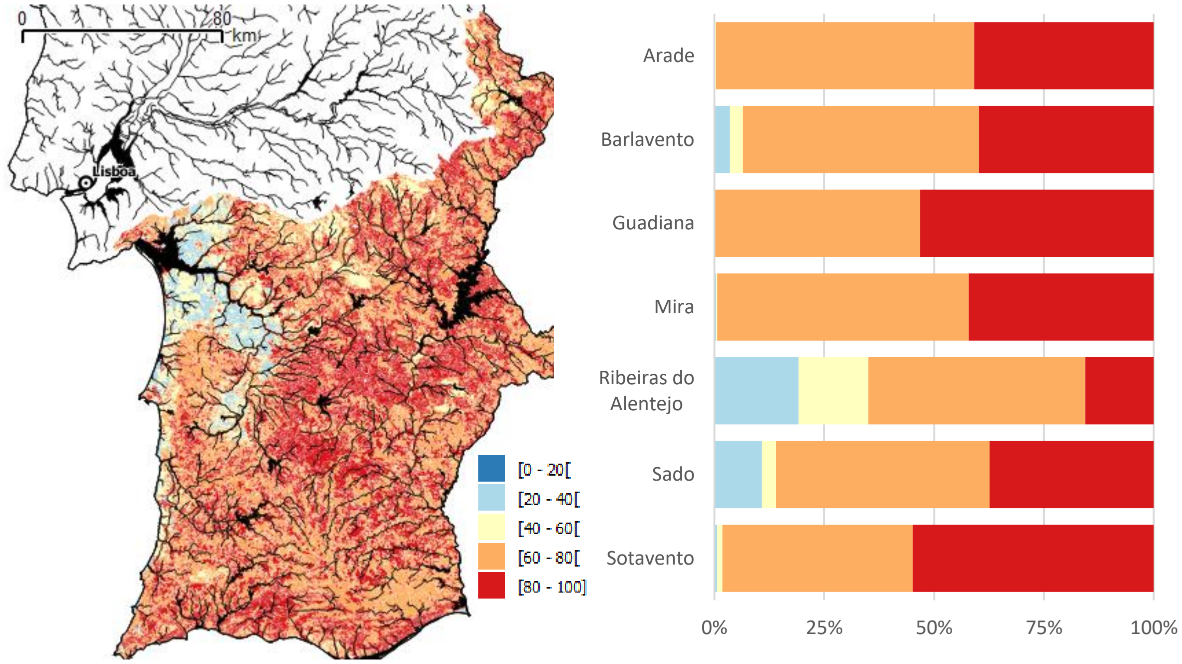

Fig. 2. Detailed soil map [NCNM] SCS-CN distribution (left) and evaluation of percentage of watershed area by SCS-CN ranges (right).

Table 1 summarizes the computed average SCS-CN weighted by area of occurrence for all the watersheds within the study area. The lowest SCS-CN is computed for Ribeiras do Alentejo (63) followed by Sado (72). Arade, Guadiana and Mira show the highest SCS-CN with 81.

Table 1. Average SCS-CN weighted by total area of occurrence for the watersheds in the study area.

Watershed	**Average SCS-CN** (weighted by area)	**Watershed**	**Average SCS-CN** (weighted by area)
Arade	81	Rib. do Alentejo	63
Barlavento	77	Sado	72
Guadiana	81	Sotavento	80
Mira	81		

Average SCS-CN for the study area	**77**

5. CONCLUSIONS

Evaluation of water availability is one of the main pillars in the development of a decision support protocol for the implementation of Managed Aquifer Recharge, MAR. Although depending on the rainfall-runoff model, the SCS-CN spatial distribution mapping may be fundamental for the accuracy of the direct runoff estimates and, consequently, of the volumes of water available for aquifer recharge. In the study region the methodology and data applied allowed for a detailed spatial characterization of the SCS-CN thus representing a relevant improvement, namely, when compared with the existing maps.

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