AGRICULTURAL CLIMATE RISK ZONING IN SUPPORT OF AGROECOLOGICAL ZONING OF MATO GROSSO DO SUL, BRAZIL

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ABSTRACT

Agricultural Climate Risk Zoning (ZARC) data for 16 crops in the Mato Grosso do Sul state (MS) were summarized by crop (pineapple, cotton, peanut, rice, oat, banana, sugar cane, citrus, sunflower, papaya, passion fruit, watermelon, maize, soybean, sorghum and wheat), soil type (coarse-, medium-and fine-textured) and municipality (79 municipalities), and processed in a GIS to show the spatial distribution of the climate risk of each crop per municipality and soil type, and the municipalities where the crop can grow with a maximum of 40% risk of production loss due to the occurrence of extreme climatic events. The highest climate risks are found on coarse-textured soils, which hold less water. The municipalities suitable for cropping vary by crop according to their climatic requirements. The results support and validate the Agroecological Zoning (ZAE) of MS.

Key words — ZARC, ZAE, ten-day sowing window.

1. INTRODUCTION

Agroecologial Zoning (ZAE) is a technical-scientific instrument for guiding the agricultural production of a region. It considers the capabilities and vulnerabilities of the region based on its climate, soil and relief characteristics. The ZAE of the Mato Grosso do Sul (MS) state (~357,150 km^2) is under preparation (e.g., [1]) and will encompass most of the 79 municipalities and various crops.

Each crop has specific climate, soil and relief requirements that allow its production in a region. For the climate-related requirements, specific climate and soil data (e.g., temperature, precipitation, soil available water capacity and soil water balance) can be combined, and interpreted spatially to determine where a crop can grow.

The Agricultural Climate Risk Zoning (ZARC) combines these data to estimate, for each crop, crop variety, soil type, municipality and ten-day sowing window (*decêndio*), the risk of production loss due to the occurrence of extreme climatic events [2]. The data indicates the (un)suitability of a crop to grow on a certain soil type and municipality when sowed in a specific ten-day window.

This work presents a method to summarize ZARC climate risk data and integrate it with a GIS to show the suitability to grow 16 different crops on coarse-, medium- or fine-textured soils in MS municipalities.

2. MATERIALS AND METHODS

Climate risk data for 16 crops (pineapple, cotton, peanut, rice, oat, banana, sugar cane, citrus, sunflower, papaya, passion fruit, watermelon, maize, soybean, sorghum and wheat) in MS were downloaded from the ZARC webpage (https://indicadores.agricultura.gov.br/zarc/index.htm). The municipality boundaries polygon shapefile [4] was obtained from the Agency for Agrarian Development and Rural Extension of MS (AGRAER) by email.

For each crop, the latest harvest season (*Safra*) was selected when available, or the "no harvest season" (*"SEM SAFRA"*) otherwise. The table was exported to R [3], where the following steps were performed, assuming the number of ten-day sowing windows as a proxy for climate risk:

1. For each crop, calculate the total number of ten-day windows suitable for sowing, by summing the ten-day windows (variables *1, 2, ..., 36*) with climate risks < 40%, and save it to variable *WindowSum*;
2. For each crop, calculate the total number of municipalities suitable for cropping, i.e., those with *WindowSum* > 0 – see output Table 1;
3. For each crop, calculate the mean number of ten-day windows suitable for sowing, by averaging *WindowSum* across soil types (*Solo*) and crop varieties (*Ciclo*) – see output Table 1;
4. For each crop, soil type and municipality, calculate the number of ten-day windows suitable for sowing, by filtering *WindowSum* by soil type and municipality – see output Table 2;
5. For each soil type, merge the municipality polygon shapefile with output Table 2, using municipality as the unique identifier – see Figure 1.

3. RESULTS

Most crops can be grown in all MS municipalities, except for passion fruit (77 municipalities), sunflower (77), pineapple (76), wheat (67), banana (64), papaya (58), sugar cane (57) and oat (47) (Table 1). The climate risk, represented by the mean number of ten-day windows suitable for sowing, varied from 3 to 31, with shortest sowing windows found for oat (3), passion fruit (5), wheat (5) and rice (8), and longest windows found for citrus (22), watermelon (23) and sugar cane (31) (Table 1).

Table 1. Number of municipalities suitable for cropping and mean number of ten-day windows suitable for sowing, by crop, in Mato Grosso do Sul state

Crop	Municipalities	Ten-day windows
Pineapple	76	15
Cotton	79	10
Peanut	79	16
Rice	79	8
Oat	47	3
Banana	64	9
Sugar cane	57	31
Citrus	79	22
Sunflower	77	9
Papaya	58	9
Passion fruit	77	5
Watermelon	79	23
Maize	79	10
Soybean	79	10
Sorghum	79	11
Wheat	67	5

Table 2. Number of ten-day windows suitable for sowing, by municipality, soil type and crop, in Mato Grosso do Sul state

Municipality	Soil type	Crop			
		Pineapple	Cotton	...	Wheat
Água Clara	Coarse	15	6	...	1
Água Clara	Medium	15	6	...	3
Água Clara	Fine	15	6	...	4
Alcinópolis	Coarse	15	6	...	1
Alcinópolis	Medium	15	6	...	3
Alcinópolis	Fine	15	6	...	5
...	...	...	...	...	...
Vicentina	Coarse	15	12	...	3
Vicentina	Medium	15	12	...	5
Vicentina	Fine	15	12	...	6

For each crop, the number of ten-day windows suitable for sowing vary by municipality and soil type (Table 2; Figures 1, 2, 3). Oat on coarse-texured soils has the most restrictive sowing window and geographic spread in MS (Figure 1A), while citrus on fine-textured soils has large sowing windows and can be grown in all MS municipalities (Figure 3C).

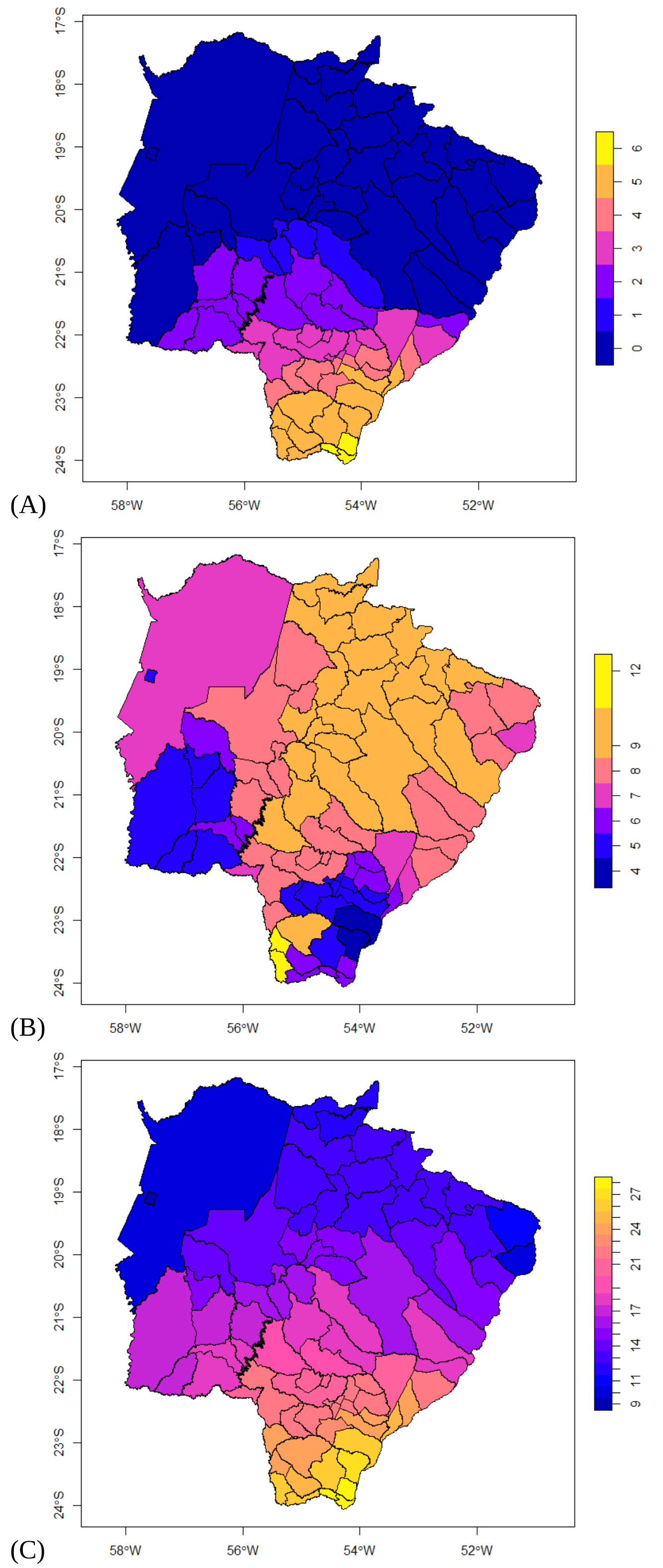

Figure 1. Number of ten-day windows suitable for sowing for oat (A), maize (B) and citrus (C) on coarse-textured soils in Mato Grosso do Sul state.

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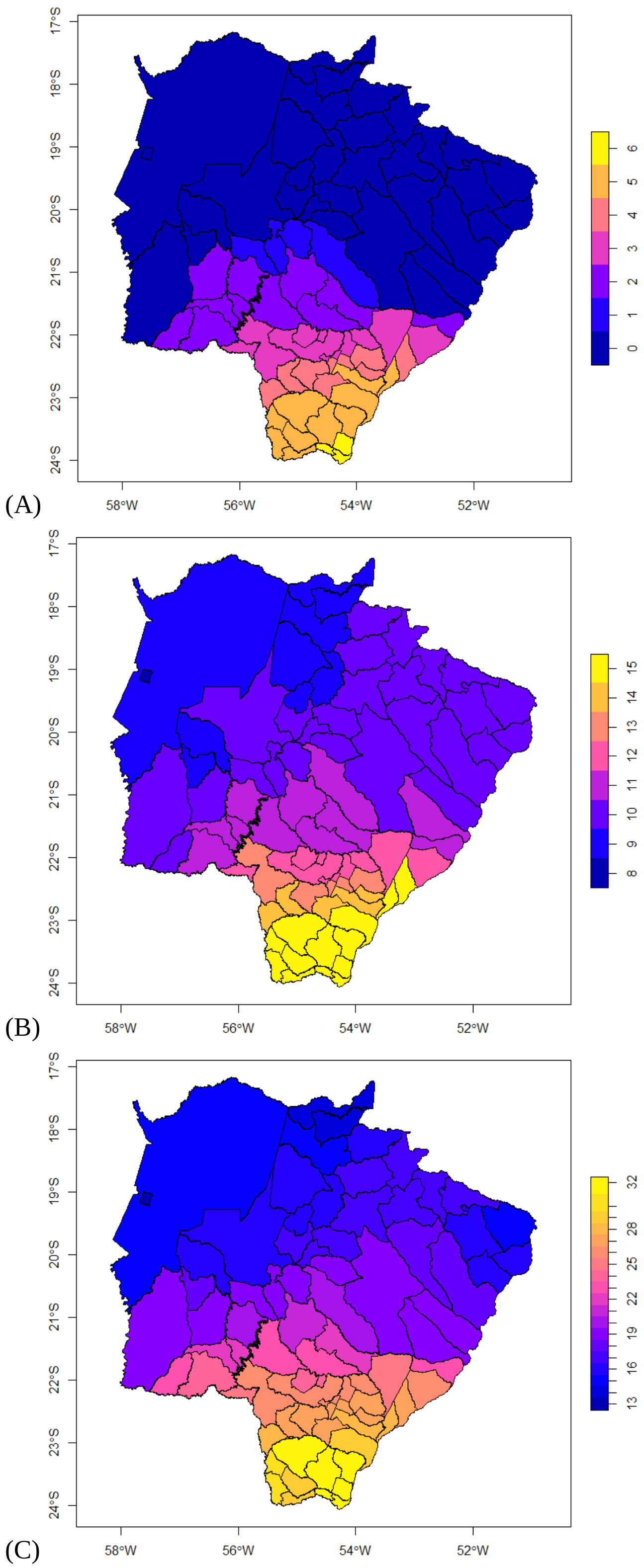

Figure 2. Number of ten-day windows suitable for sowing for oat (A), maize (B) and citrus (C) on medium-textured soils in Mato Grosso do Sul state.

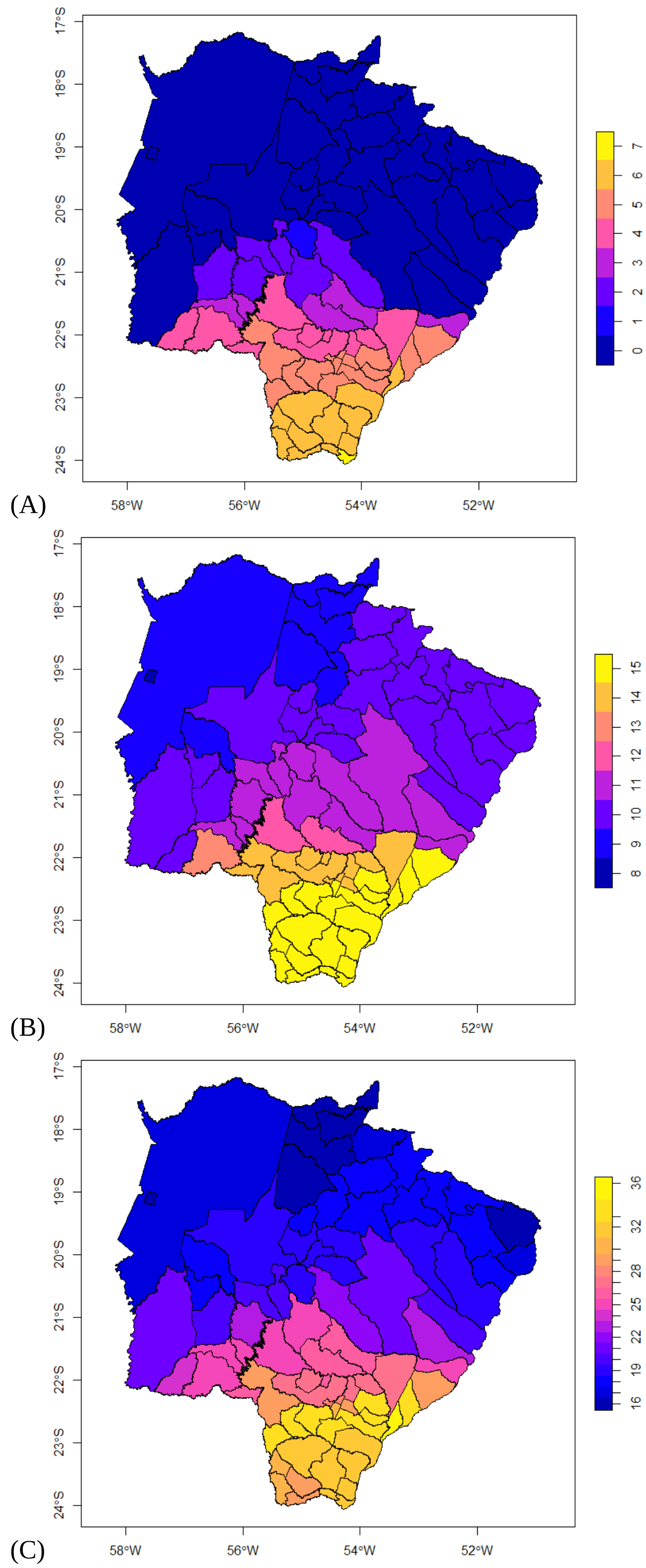

Figure 3. Number of ten-day windows suitable for sowing for oat (A), maize (B) and citrus (C) on fine-textured soils in Mato Grosso do Sul state.

4. DISCUSSION

The number and location of municipalities suitable for cropping indicates the potential geographic spread for the crop in MS. Oat has the most restrictive spread as it requires low temperatures for growing, and thus is restricted to the southern MS municipalities (Figures 1, 2, 3). On the other hand, most crops can be grown in all MS municipalities, however their sowing windows vary by municipality and soil type, with smallest windows found on coarse-textured soils, which hold less water (Table 2; Figure 1). Thus, most crops can be grown in all MS municipalities with controlled climate risk as long as the sowing window is obbeyed and adequate management practices are applied.

The ZARC data is provided by municipality and does not detail where each soil type occurs within the municipality. Therefore, a precise delineation of the locations within the municipalities of lower (fine-textured soils), medium (medium-textured) or higher (coarse-textured) climate risks for each crop will require combining the ZARC data with soil texture data, with the former bringing in the climate risk data, and the latter discriminating where the different soil types occur within the municipality, respectively.

Additionally, for each soil type, the value of the soil available water capacity – the total volume of water held by the soil that can be used by the crop – is an informed guess based on approximated values of the soil available water for coarse-, medium- and fine-textured soils, respectively, and of the root zone depths of the different crops. An updated version of ZARC will bring six soil available water classes instead of the three soil textural classes [5][6]. As an alternative, soil available water maps may be incorporated to ZARC and ZAE to improve agricultural climate risk maps and agroecological zone maps, respectively.

The mean number of ten-day sowing windows for each crop was calculated by averaging the number of ten-day sowing windows (i.e., the *WindowSum* variable) across soil types and crop varieties for that crop. As such, it is a aggregate measure of climate risk and does not specify exactly which ten-day windows are suitable for sowing. This information is available in the varaibles *1* to *36* of the downloaded ZARC table, representing the first (01/01 to 01/10) to the last (12/21 to 12/31) ten-day periods of the year, respectively.

5. CONCLUSIONS

The ZARC data presents estimated climate risks of growing different crops on specific municipalities and soil types for specific sowing periods. For that, it integrates historic climate data (temperature, precipitation) with soil (texture, available water), crop (root depth, climate requirements) and crop variety (crop cycle duration) data. The ZARC tables and maps are validated among experts and stakeholders, and support public policies (e.g., [7]). Thus, it is a powerful source of information to support, complement and validate crop-related studies and other policies, including ZAE.

The tables and maps produced in this work provide aggregated, summarized information on the climate risk for different crops in MS. This information will be used to complement, improve and validate the spatial information as well as the recommendations produced by the ongoing ZAE of MS.

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