GLOBAL SYMPOSIUM ON

SALT-AFFECTED SOILS

20 - 22
October, 2021
Virtual meeting

Status of Salt-Affected Soils in Cameroon

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Presented by

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PRESENTATION OUTLINE

1 - Introduction

2 - Methodology

3 – Results and Discussion

4 – Conclusion and future directions

Acknowledgements

References

1 - Introduction

1.1. Definition of salt-affected soils

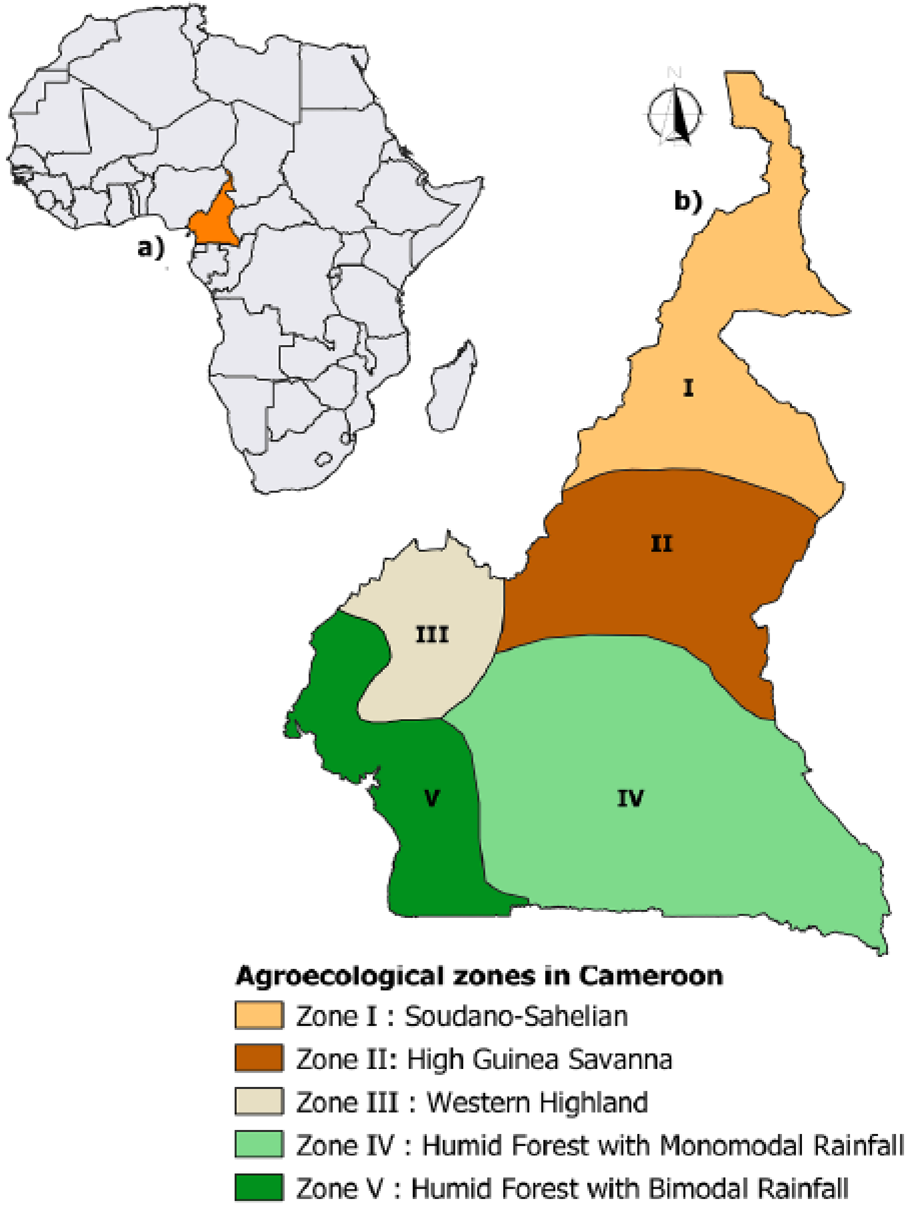
Salt-affected soils (SAS) are of three main types (Eynard et al., 2005);

(i) **Saline soils** in which electrical conductivity (EC) is > 4 dSm^{-1} and the exchangeable sodium percentage (ESP) is < 15%;

(ii) **Sodic soils** in which the ESP is > 15% and the EC is < 4 dSm^{-1}; and

(iii) **Saline-sodic soils** in which the EC is > 4 dSm^{-1} and ESP is > 15%

1.2. Occurrence of salt-affected soils in Cameroon



In Cameroon, SAS are dominant in the northern semi-arid region where the Sudano-Sahelian climate prevails (Zone I), with mean annual temperature of 29°C and mean annual rainfall of about 550 mm.

1.3. Background on the spatial extent of salt-affected soils in Cameroon

(1) Estimates by Ngachie (1992): Based on the FAO-UNESCO (1977) soil map of Cameroon, soils with excess Na (ESP > 15%) occupy about 3% (1,418,670 ha) of the total land area of the country while saline soils (EC > 4 dSm^{-1}) occupy about 1% (472,890 ha).

(2) Estimates by Massoud (1977) indicate that Cameroon has a total of 671,000 ha of salt-affected soils (sodic/solonetz).

To a lesser extent, salt-affected soils are also found in the coastal southern parts of the Country, where the equatorial climate prevails, with high temperatures and high mean annual rainfall (> 2000 mm). However, these have not been quantified yet.

1.4. Problem statement

Although it well known that the major drivers of these SAS in Cameroon are **climate** (rainfall and temperature), **topography** and **hydrography**, there is no adequate information on their spatial distribution and the precise linkage with the drivers.

1.5. Objective

The main objective of this study was to make the best use of modern techniques of digital soil mapping to generate baseline information on the spatial extent and intensity of the SAS in Cameroon within a soil layer of 0-30 cm.

This information may be helpful in decision-making vis-à-vis land use and land management, and serve as starting point for developing a detailed mapping of SAS in Cameroon.

2 – Methodology

2.1. Digital mapping methods

Digital mapping of salt-affected soils in Cameroon was carried out following procedures described by Omuto *et al.* (2020), using a machine learning approach.

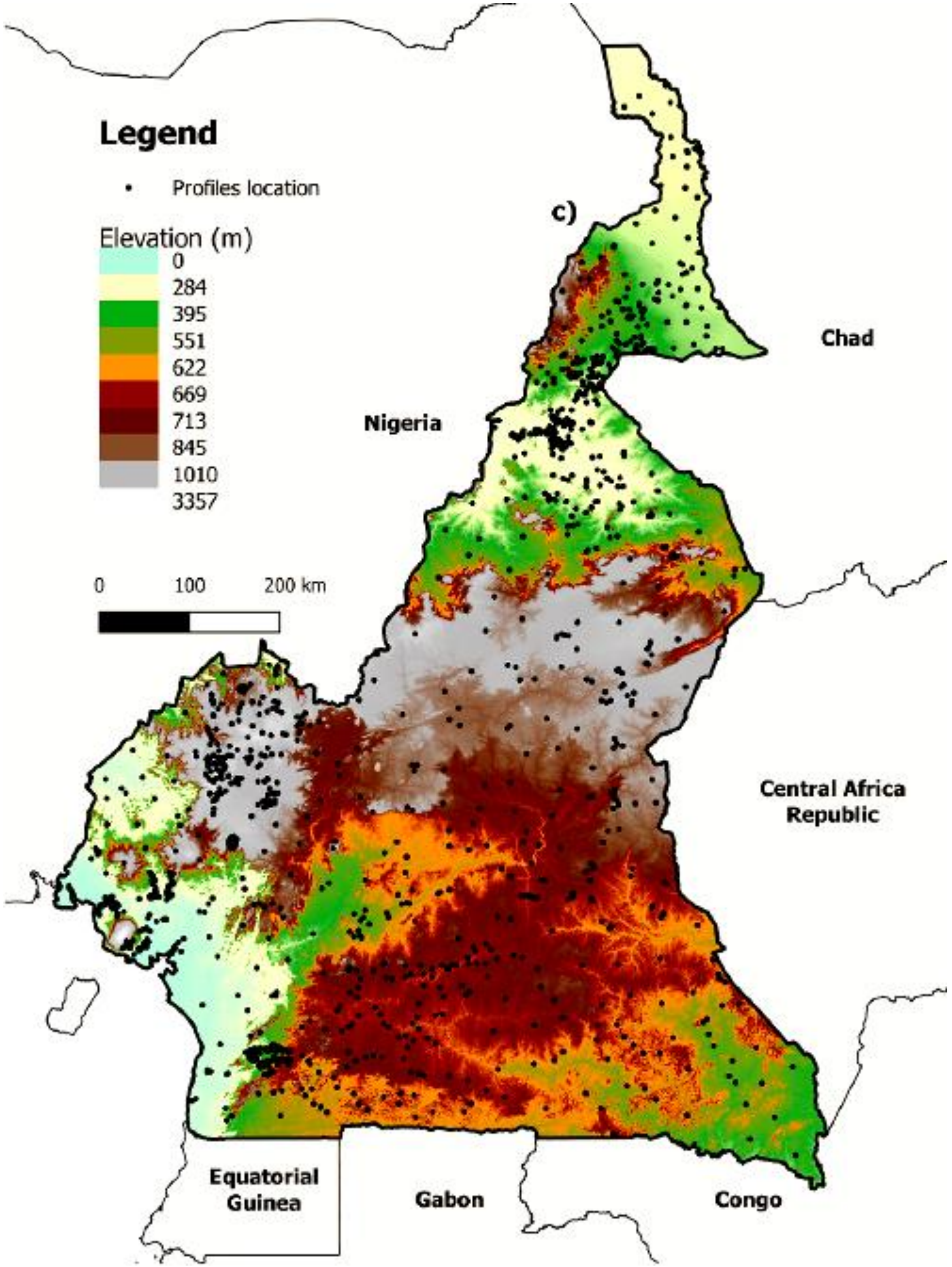
INPUT DATA

(1)-Georeferenced soil data (EC, pH and ESP)

EC (0-30 cm) = 291 sampling points and 285 points for EC (30-100 cm);
pH (0-30 cm) = 938 sampling points and 1458 points for pH (30-100 cm);
ESP (0-30 cm) = 1083 sampling points and 924 points for ESP (30-100 cm);

(2)-Soil forming factors as covariates

climate (rainfall, minimum temperature, maximum temperature), land cover, topography (DEM), slope, and multispectral remote sensing land reflectance data including Bands 3, 5, and 7 of the Landsat



Spatial distribution of soil profile data in Cameroon on a topographical background

Source: Silatsa *et al.* (2020)

2.2. Data sources

Soil profile data were obtained from the national harmonized soil legacy database of Cameroon (Camsodat 0.1) (Silatsa *et al.*, 2017), generated over the period 1975 - 2019.

Soil EC was obtained from measurements conducted on a 1:5 soil/water ratio using a conductivity meter, measured in dS/m. Soil pH was obtained from measurements conducted on a 1:2.5 soil/water ratio. Exchangeable sodium percent (ESP) was estimated from CEC and exchangeable Na^+ using the formula;

$$ESP = (Na^+ / CEC) \times 100$$

Where *ESP* = exchangeable sodium percent, Na^+ = exchangeable sodium and *CEC* = cation exchange capacity.

All covariates were obtained from different online sources including the Worldclim (https://www.worldclim.org/), ESA (https://www.esa-landcover-cci.org/) and the USGS (https://earthexplorer.usgs.gov/) databases, at a spatial resolution of 30 m.

2.3. Prediction model and assessment of prediction accuracy

Prediction models

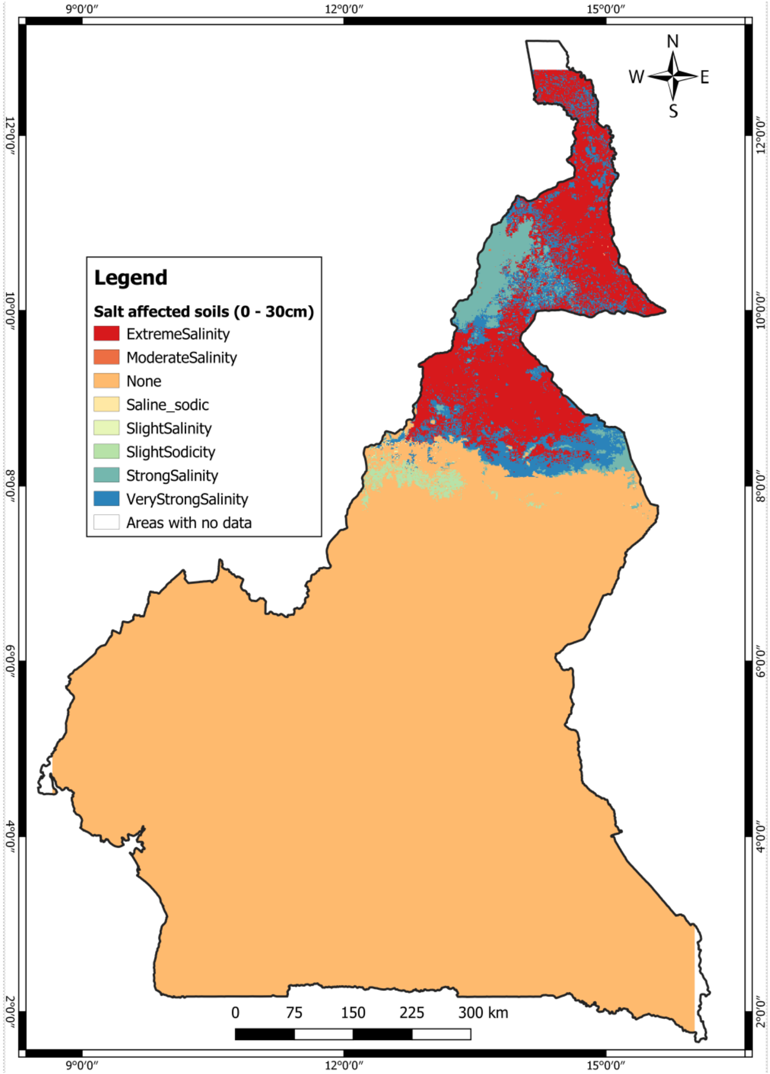
We performed the spatial prediction models of pH, EC and ESP for harmonized soil depth intervals and then made use of the Random Forest (RF) algorithm to improve prediction accuracy.

Assessment of prediction accuracy

Model performance was evaluated with cross-validation, using the coefficient of determination (R^2), root mean squared error (RMSE) and the Nash–Sutcliffe model efficiency coefficient (NSE).

3 – Results and Discussion

3.1. Country map of SAS and proportions of affected areas



About 16% of the country is covered by salt-affected soils dominating in the northern part of the country where the Soudano-Sahelian climate prevails. The group of saline soils is the most dominant but with varying intensity as follows:

Extreme salinity (9.02%),
Very strong salinity (4.08%),
Strong salinity (2.08%),
moderate salinity (0.01%),
Slight salinity (0.03%) and
Slight sodicity (0.61%).

Prediction performances of the Random Forest Model :

RMSE = 13.10
R^2 = 0.28
NSE = 0.35

The small R^2 values and large RMSE values indicate that model performance was poor. These results could be explained by the fact that the most appropriate predictors (covariates) were not used. For example, this study didn’t make use of predictors such as geologic maps and spectral bands 1, 2 and 6 of Landsat.

Studies have shown that more accurate and less uncertain soil property maps could be obtained when predictors are optimally scaled, as compared to maps created with original not scaled or all multiscale predictors (Dormik *et al.*, 2022). Additionally, only a subset of carefully selected predictors works better for mapping a given soil property compared to models based on all the available predictors.

Thus, future studies are envisaged to identify the best predictors of SAS in Cameroon, with the overall objective to improve the accuracy of SAS mapping.

3.2. Drivers of SAS in Cameroon

Major drivers of SAS in Cameroon include climate and parent material

Climate:

In areas where evapotranspiration exceeds precipitation such as in the Soudano-Sahelian zone of Cameroon, the downward flow of water through the soil profile is only sufficient to remove the most soluble weathering products such as Na^+ salts, and accumulation of less soluble compounds is prominent due to limited water flow.

The low rainfall (mostly < 500 mm annually) is irregular and insufficient to remove soluble salts from the soil. With occasional rain, they are moved down the profile and when dry conditions resume, they may be drawn upward again through capillary rise and deposited on the soil surface.

Parent material:

The presence of primary minerals as the special constituent of parent material (e.g. gypsum, lime) is the most important factor for genesis of salt-affected soils.

In arid to semi-arid climatic conditions of the Soudano-Sahelian agroecological zone of Cameroon, the weathering products accumulate *in situ* and result in the development of salinity and/or sodicity. The major processes involved in the formation of these soils are salinization (and alkalinization), desalinization-alkalinization and solonetzation (Yerima and Van Ranst, 2005).

It is important to mention that other soils near coastal areas usually have high salt concentrations as sea water contributes significant quantities of salts, with localized action along Cameroon coastal soils.

4 – Conclusion and Future directions

In Cameroon, saline soils are more dominant than sodic soils. This information is helpful in decision-making vis-à-vis land use and management in Cameroon. Although this preliminary study did not identify salt-affected soils along the Cameroonian coast, their presence should not be ignored and future assessment approaches should include mechanisms to identify and map them.

Acknowledgements

This work was made possible with the collaboration of Dr. Francis B.T. Silatsa and Dr. Martin Yemefack.

Immense thanks to the FAO's Global Soil Partnership (GSP) for providing training on digital mapping of SAS.

The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of FAO.

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