

Digital mapping of soil nutrients for the Republics of Burundi and Rwanda

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Abstract

Lack of awareness about soil fertility constraints is a major limitation to developing sound liming and fertilizer recommendations in sub-Saharan Africa. Detailed maps of soil nutrient concentrations and soil acidity can help to identify areas with soil fertility constraints. For this purpose, maps of primary (P, K), secondary (Ca, Mg, S) and micronutrients (Cu, Zn, B), as well as pH, soil acidity (Al+H), effective CEC and organic matter were generated for the 0-20 cm soil layer by means of digital soil mapping using random forest models at a 250 m spatial resolution for Burundi and Rwanda. The models explained between 20% and 45% of the variation in the data.

Objective

To update the currently available soil nutrient maps of Burundi and Rwanda in terms of resolution and soil variables, including micronutrients, to support soil fertility management programs.

Methodology

- Around 1,000 field observations of soil fertility parameters for each country were used to calibrate random forests models (Fig. 1).
- Over 100 environmental GIS data layers representing land cover, soil, terrain and climate were used as covariates in the models (Fig. 1).
- Model calibration and mapping were done for each country separately.
- A kriging step was added if the model residuals showed spatial autocorrelation.
- Prediction uncertainty was quantified by the 90% prediction interval and accuracy with 10-fold cross-validation.

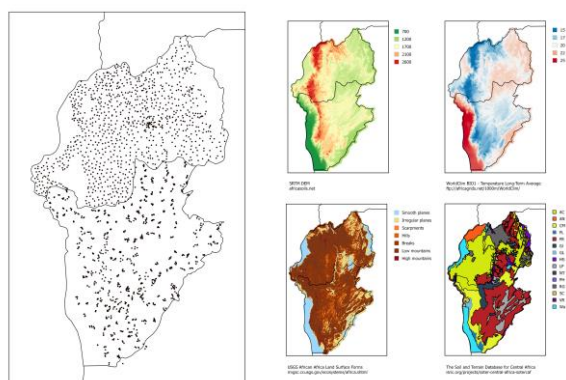


Fig. 1. Distribution of the sampling sites and covariates examples.

Results

Twelve soil nutrient maps were generated for each country. Fig. 2 shows examples for Ca, S, Cu and B. Covariates related to climate and terrain proved to be the best predictors.

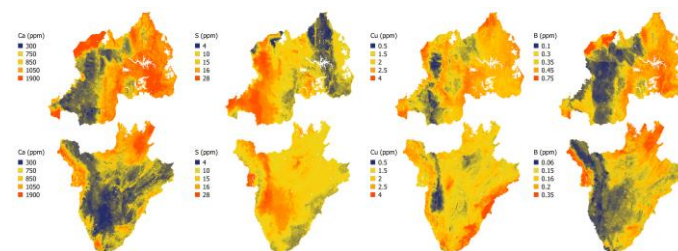


Fig. 2. Predicted secondary (Ca, S) and micronutrients (Cu, B) for the 0-20 cm layer.

Table 1 presents the cross-validation results as percentage of explained variation (R^2), that ranged between 12% and 49%, and the Root Mean Square Error (RMSE).

Table 1. Ten-fold cross-validation results.

Property	R^2		RMSE	
	Burundi	Rwanda	Burundi	Rwanda
P (ppm)	0.21	0.22	10.85	69.76
K (ppm)	0.12	0.21	103.58	231.57
Ca (ppm)	0.32	0.46	629.42	906.84
Mg (ppm)	0.35	0.42	140.88	170.57
S (ppm)	0.37	0.37	7.98	11.31
Cu (ppm)	0.39	0.41	1.34	1.44
Zn (ppm)	0.20	0.25	1.86	6.81
B (ppm)	0.38	0.39	0.12	0.30
pH	0.31	0.40	0.48	0.67
Soil acidity (meq/100 g)	0.46	0.42	4.28	4.13
Effective CEC (meq/100 g)	0.38	0.41	3.90	5.82
Organic matter (%)	0.49	0.42	0.87	0.94

Conclusions

The models captured between 20% and 45% of the variation in the data. The maps generated are a significant update of the current available nutrient maps, being a valuable information source to better target fertilizer applications for a more balanced provision of crop nutrition in soil fertility management programs in both countries.



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