Application of Digital Soil Mapping Techniques to Refine Soil Map of Baringo District, Rift Valley Province, Kenya

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Introduction

Detailed and precise description of soil information is important for both developed and developing countries. The description of (as current as possible) soil status is strongly needed by various areas of speciality. Unfortunately in many countries this information is not available if so then the existing soil databases are incomplete, not exhaustive or precise enough especially in many tropical countries. The African continent is simultaneously highlighted as the most soil data-challenged land surface in the world and as the area most in need of improved soil information (Eswaran et al., 1997; Palm et al., 2007; Rossiter, 2008). Our objective was to compile a detailed digital soil class map for the Baringo area in Kenya by using auxillary variables (digital elevation model, satellite images, climate map) and to characterize an existing land classification map in terms of soil classes.

Material and Methods

<u>Study area</u>:

Baringo district is one of the arid and semi-arid districts in Kenya with low to average annual rainfall. The area lies within the Kenyan Rift valley, and encompasses the upstanding hills and eastern escarpment as well as the north and south Baringo plains of the rift valley floor (Fig. 1).

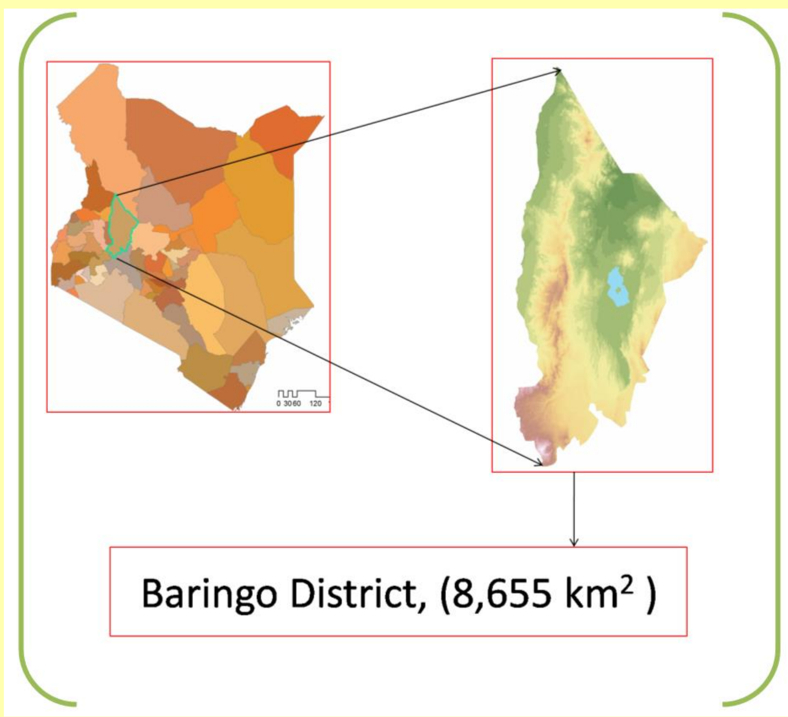

Figure 1. SRTM elevation map of Baringo District in Kenya

The altitude varies between 752 meters in the lowlands to 2600 m in the Tugen Hills. Vegetation includes temperate forests in the highlands to desert shrubs on the valley floors and evergreen forests at the highlands of the south and south west and at the summits of Tugen Hills.

<u>We have obtained five spatial datasets for the study area:</u>

[1] KENSOTER database (Bajtes and Gicheru, 2004) resol.: 1:1 million
[2] Land classification map (Touber, L., 1989) resolution: 1:500 000
[3] Elevation data by Shuttle Radar Topography Mission (Rabus et al., 2003) 90x90 m ground resolution
[4] Satellite images from Landsat 5 Thematic Mapper (NASA, 2011) 30x30 m ground resolution
[5] Climate data from Almanac Characterization Tool (Corbett et al., 1999) roughly 5x5 km ground resolution

<u>Data processing and evaluation were performed in several steps:</u>

Georeferencing and creation of a ArcGIS file and attribute table from database [2]. Correction and transformation of data into the same projection which enabled geometric calculation. Clipping Baringo area. Calculation of 2 principal components from the 7 bands of database [4] explaining 83 % of the total variance and 3 principal components from the 42 variables of database [5] explaining 96 % of the total variance. Calculation of slope and elevation from database [3].

The maps [1] [3] [4] and [5] were sampled with 999 random points and 14 major soil classes from map [1] were characterized with mean values of 9 variables (X an Y coordinates of the points, slope and elevation from [3] and 5 principal components from [4] and [5]).

The 9 variables were standardized and average distances between soil classes were calculated in this 9 dimensional space.

Then, we placed 10,000 random points on the area and calculated the distance of each point to the soil class averages in the 9 dimensional space and allocated the point to the nearest soil class. So each soil class had 10,000 probability points having 0 and 1 values depending on the allocation. Continuous probability maps with 1 km^2 ground resolution were created with ordinary kriging. Each grid cell was allocated to the soil class with the highest probability.

Results

Table 1. Average distances between major soil classes based on nine standardized variables

	ANh	CMe	CMu	CMx	FLc	Lav	LP+CLh	LPq	NT	NTu	RGc	RGc+LVx	SNk+CL
CMe	2.3688												
CMu	4.3859	5.7412											
CMx	0.9290	2.7146	3.6385										
FLc	4.6324	2.6658	8.0166	5.1788									
Lav	4.6191	2.5922	7.7185	5.0460	0.9142								
LP+CLh	3.3382	1.2713	6.0438	3.4986	2.4241	2.0745							
LPq	2.3411	2.0061	4.1453	2.0307	4.2684	3.9807	2.0591						
NT	3.6866	4.2940	2.8811	3.0196	6.4195	6.1044	4.2588	2.3350					
NTu	3.1559	4.4822	1.4727	2.3561	6.9008	6.6558	4.8797	2.9506	2.2503				
RGc	3.7060	1.8648	6.7169	4.1167	1.4331	1.2394	1.3891	3.0008	5.0538	5.6556			
RGc+LVx	3.5449	2.0433	6.5412	4.0132	1.7732	1.6620	1.9089	3.1029	5.0352	5.5590	0.8262		
SNk+CL	3.7986	2.0058	6.2955	3.7785	3.5944	3.3377	1.8808	2.7126	4.7997	5.0085	3.0846	3.5938	
SNk+FLc	3.9895	1.7779	7.2305	4.3957	1.2026	1.0820	1.4529	3.3894	5.6422	6.0559	1.2134	1.8021	2.4233

Soil classes	Number of points	Soil units (FAO-UNESCO, 1974)
RGc+LVx	208	Calcaric Regosols + Chromic Luvisols
LPq	186	Lithic Leptosols
LP+CLh	128	Leptosols + Haplic Calcisols
RGc	123	Calcaric Regosols
SNk+FLc	88	Calcic Solonetz + Calcaric Fluvisols
Lav	42	Lava
CMe	36	Eutric Cambisols
NTu	35	Humic Nitisols
FLc	31	Calcaric Fluvisols
NT	24	Nitisols
CMx	18	Chromic Cambisols
ANh	16	Haplic Andosols
CMu	13	Humic Cambisols
SNk+CL	12	Calcic Solonetz + Calcisols
major soil classes	**960**	
RGe	9	Eutric Regosols
FLe	7	Eutric Fluvisols
GLe	7	Eutric Gleysosl
ANm	5	Mollic Andosols
CMc	5	Calcaric Cambisols
not defined	4	not defined?
LXh	2	Haplic Lixisols
minor soil classes	**39**	

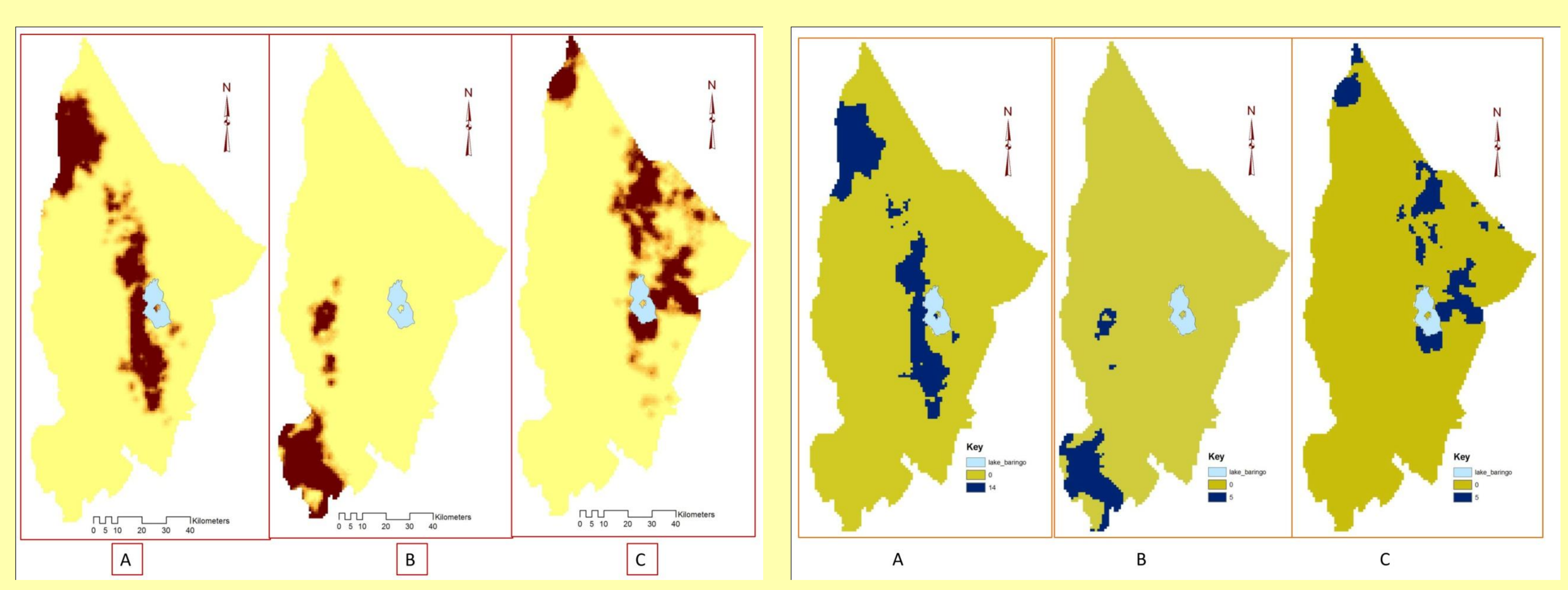

Figure 2. Probability maps and pixel allocations for three soil classes (A)= SNk+FLc, (B)= NTu, and (C) = FLc

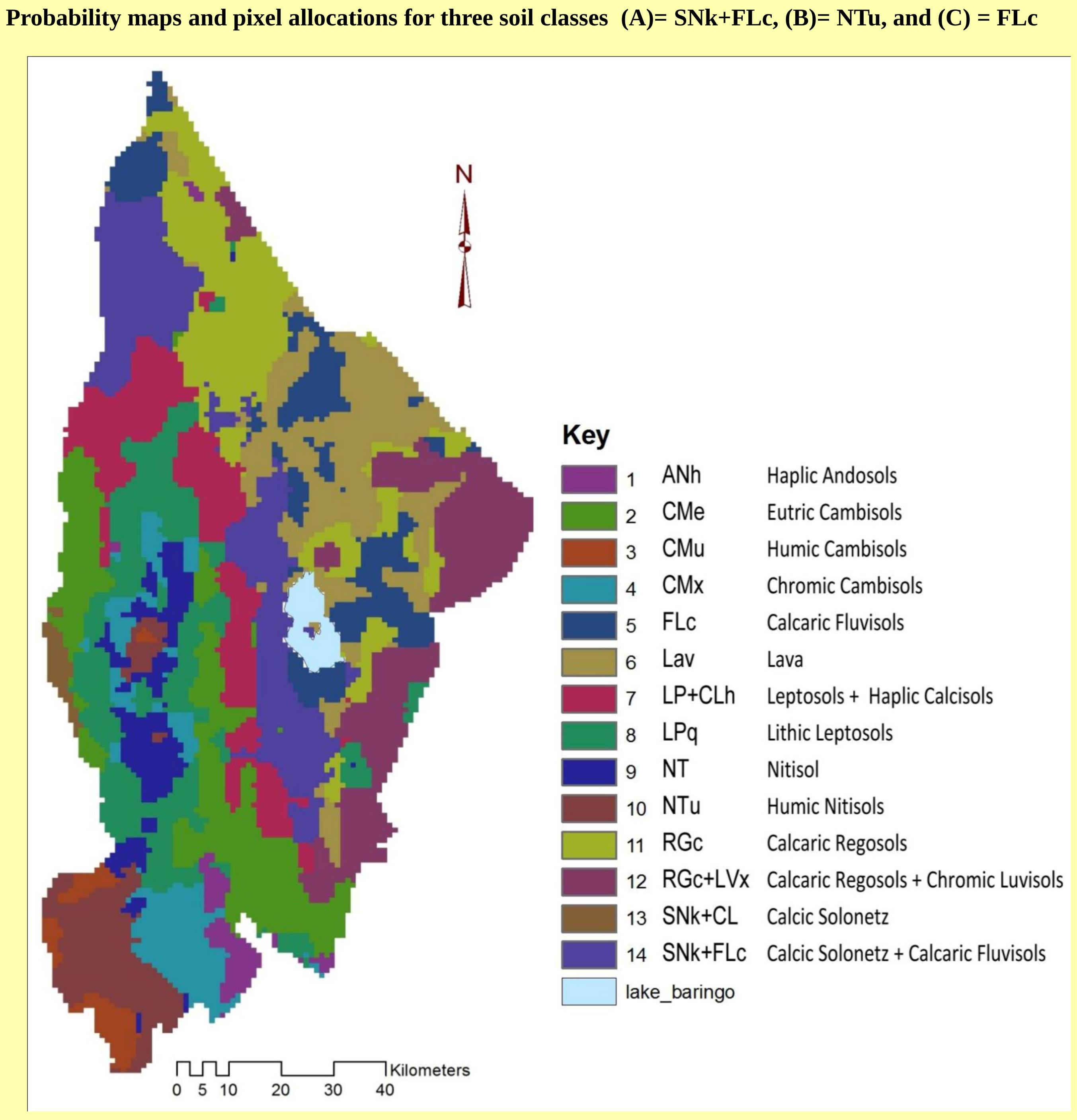

Figure 3. Predicted soil map for the Baringo area

Summary

With help of auxillary variables, we were able to predict a soil map with three fold complexity compared to the original KENSOTER database and we have spatially allocated an average 3.2 soil classes pro land class in the land classification map.

Possible further impovements:

- considering minor soil classes,
- considering second and lower ranked probabilities of soil occurance,
- calculating smaller grid sizes,
- cleaning the predicted map based on further spatial rules.