DecLaRe: Decision support for strengthening land resilience in the face of global challenges

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Participatory Soil Mapping at Village Scale, Assisted by Gamma Ray Measurements: Case Study of Boukoussera, Benin

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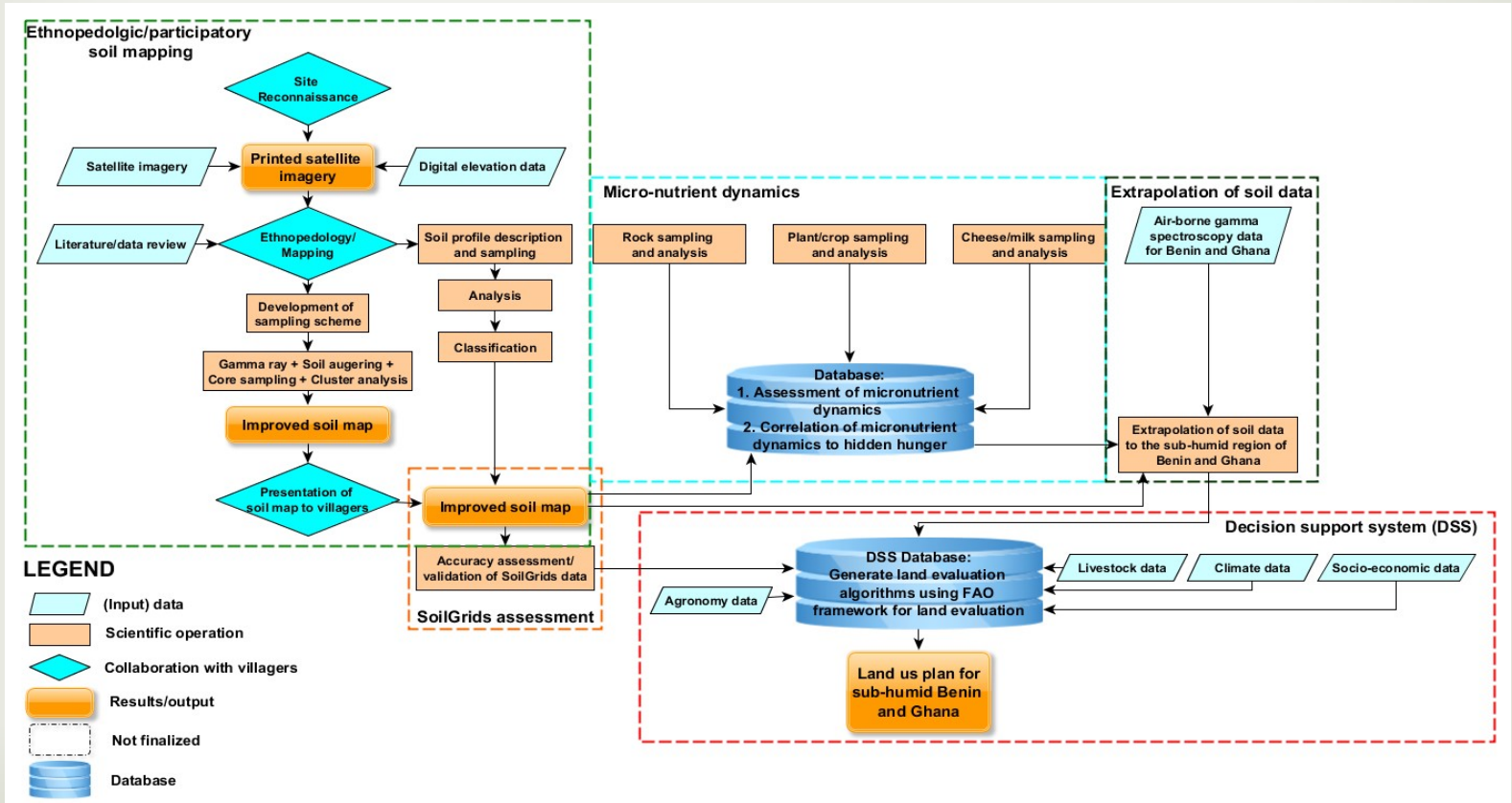
Introduction

- **Local participation** in soil and natural resources **mapping** is a welcome development
- It enables us to **bridge the language divide** between **rural farmers** and **researchers**
- The enhanced communication will ensure sustainable soil use and management
- This knowledge base is however, usually very **rudimentary**
- This soil mapping process can be improved using **remote sensing**, **gamma spectroscopy** and **site assessment**.

Framework


Ethnopedolgic/participatory soil mapping
Site Reconnaissance
Satellite imagery
Printed satellite imagery
Digital elevation data
Literature/data review
Ethnopedology/ Mapping
Soil profile description and sampling
Analysis
Classification
Development of sampling scheme
Gamma ray + Soil augering + Core sampling + Cluster analysis
Improved soil map
Presentation of soil map to villagers
Improved soil map
Accuracy assessment/ validation of SoilGrids data
SoilGrids assessment
Micro-nutrient dynamics
Rock sampling and analysis
Plant/crop sampling and analysis
Cheese/milk sampling and analysis
Database:
1. Assessment of micronutrient dynamics
2. Correlation of micronutrient dynamics to hidden hunger
Extrapolation of soil data
Air-borne gamma spectroscopy data for Benin and Ghana
Extrapolation of soil data to the sub-humid region of Benin and Ghana
Decision support system (DSS)
DSS Database:
Generate land evaluation algorithms using FAO framework for land evaluation
Agronomy data
Livestock data
Climate data
Socio-economic data
Land us plan for sub-humid Benin and Ghana
LEGEND
(Input) data
Scientific operation
Collaboration with villagers
Results/output
Not finalized
Database

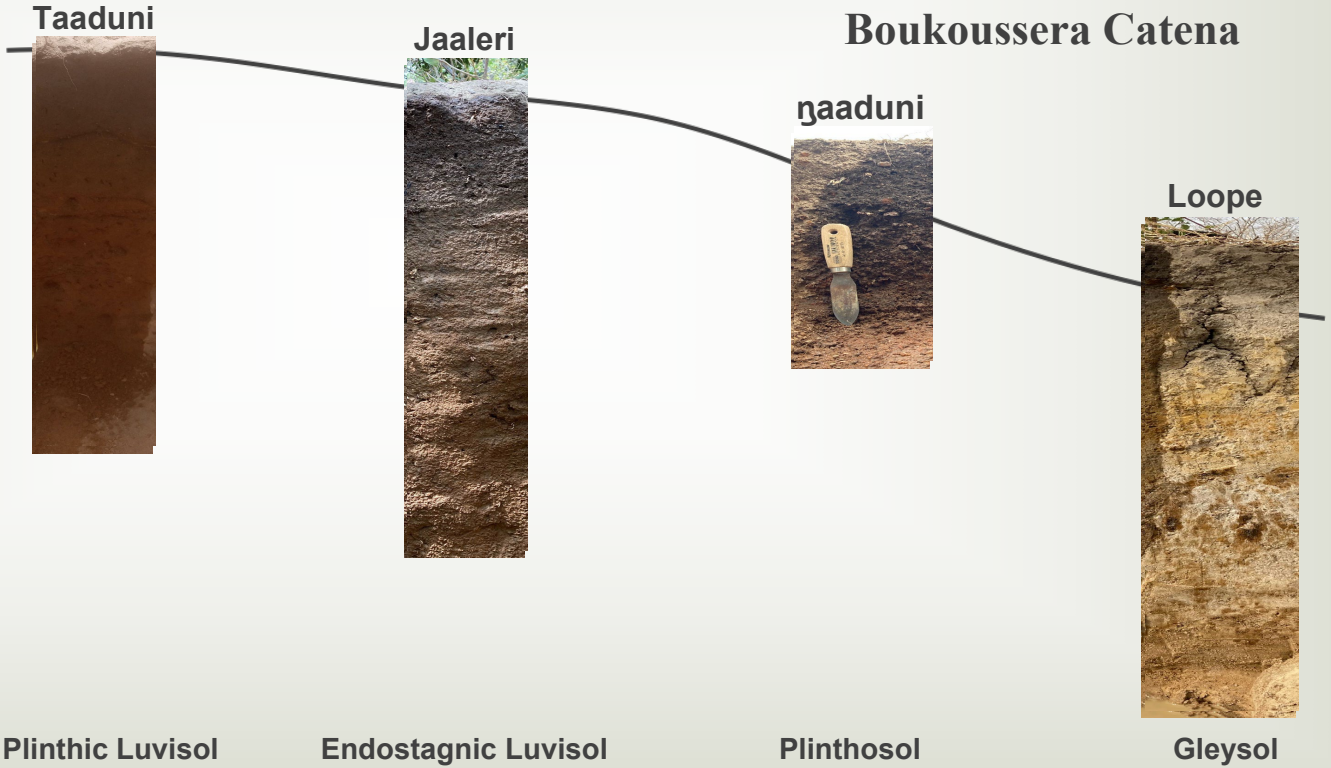
Participatory Soil Mapping

- The first stage of the soil mapping approach was based on key informant interviews
- Reference soil profiles were then identified in conjunction with the local experts.
- ***This study used an updated approach that was developed by Reinhardt and Herrmann (2017).***

Reinhardt, N. and L. Herrmann (2017): Fusion of indigenous knowledge and gamma spectrometry for soil mapping to support knowledge-based extension in Tanzania. *Food Security* 9: 1271-1284.

Visual Representation of the Soil Profiles

- The reference soil profiles and sites were described
- Soil samples were taken for laboratory Analysis



Field Operations

Soil Augering (60 auger profiles)

Description of Auger Profile

Soil profile Description (7 profiles)

- ❑ 241 proximate gamma measurements
- ❑ 57 topsoil samples

Analytics

Laboratory Analytics

1. X-ray Diffraction: *Mineral composition*
2. X-ray Fluorescence: *Total element content including micro-nutrients*
3. DTPA (“CAT”) Extraction: *Plant available micro-nutrient fraction*
4. Elementary analysis: *Total/organic carbon and total nitrogen*
5. Combined sieve and pipette analysis: *Grain size distribution*
6. Potentiometry: *Soil pH in a 1:2.5 soil to 0.01 M $CaCl_2$ solution*

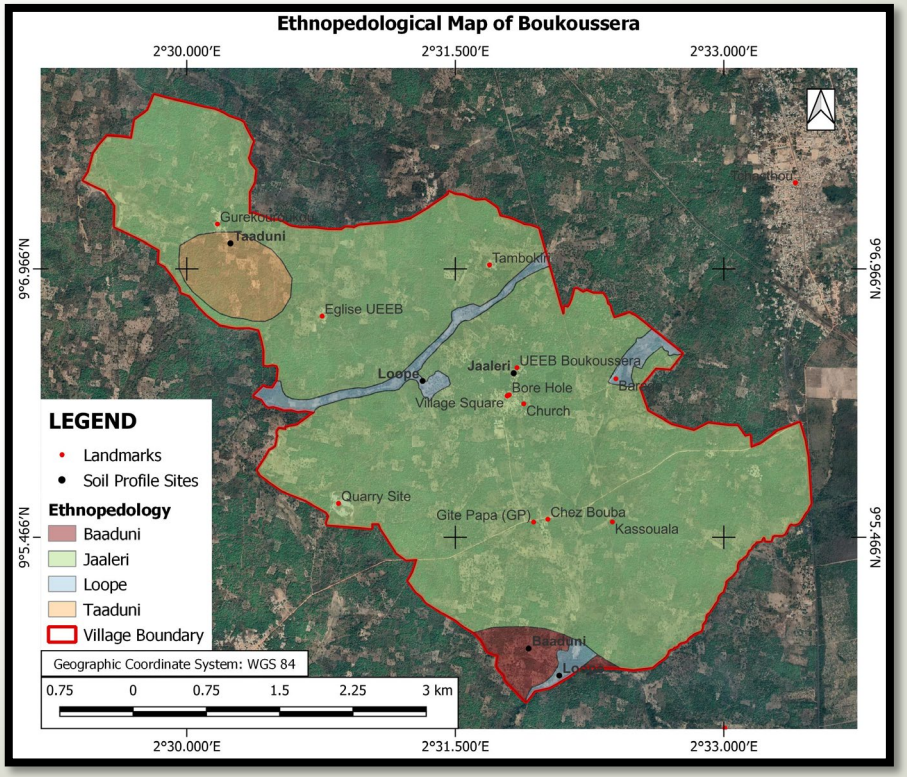
Statistical Analytics

1. Descriptive statistics (box plots, histograms, correlation and linear regression).
2. Multilinear regression and cluster analysis for soil mapping

Results

- The farmers know what soils they have in their farms
- They found it difficult delineating the boundaries on a satellite imagery, except for Loope
- They contend that the major soil in the village is Jaaleri.

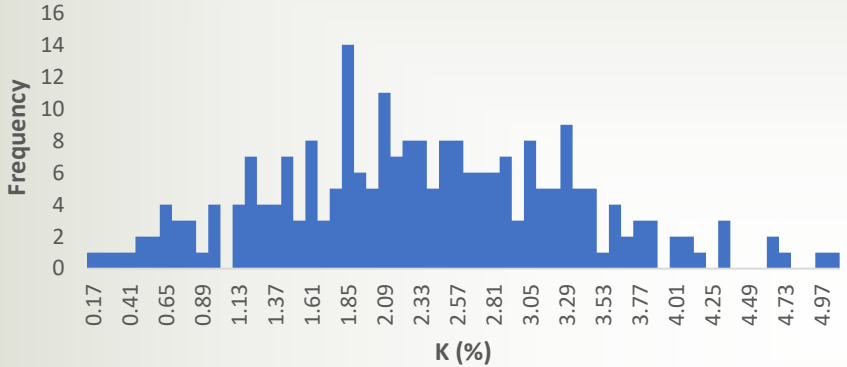
First Version of Soil Map

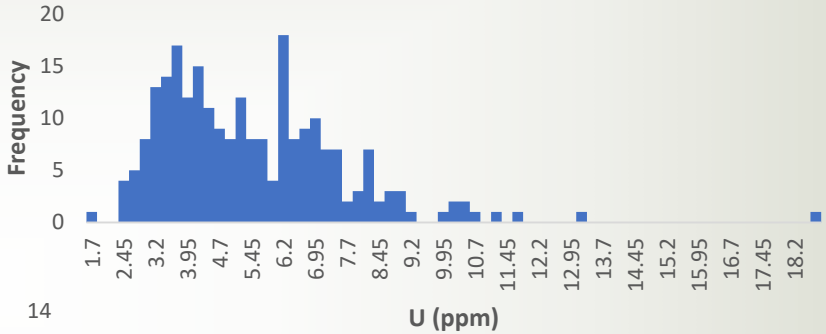


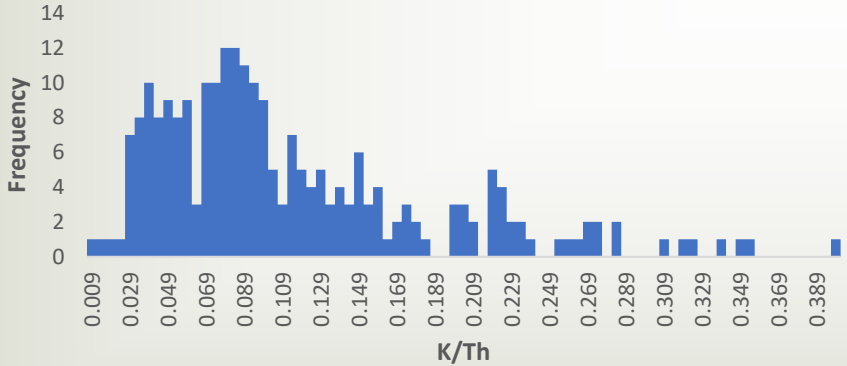
Farmers' Description of the Soil Classes

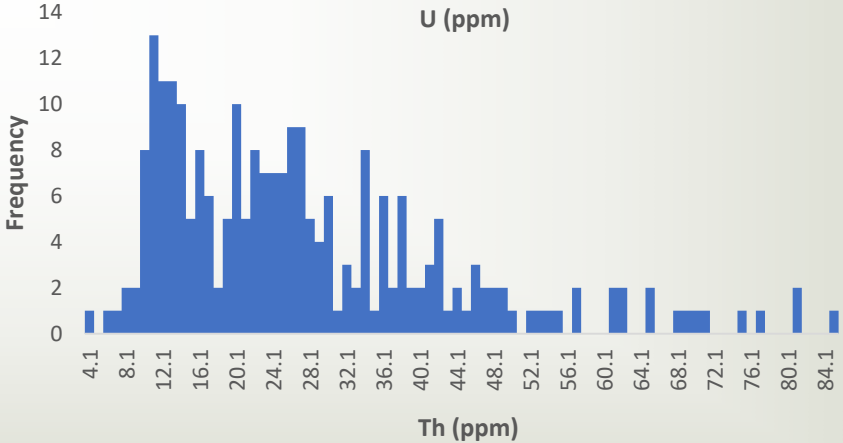
Soil Type	Description	Recommended Land Use
Jaaleri	Sandy surface, reddish subsoil, concretions	Mostly used for cassava, yam, and to some extent, soya beans and cowpea
ŋaaduni	Dark, sandy surface soil, plinthite (or maybe hard-setting soils), reddish subsoil with concretions (many)	Maize, sorghum and cassava production
Taaduni	(Bleached) sandy to loamy sand topsoil; reddish, clayey subsoil with concretions deeper in the soil	Maize, sorghum
Loope	Clayey (seasonally swampy) lowland soils (barage)	Rice and vegetable production

Overview of Proximate-sensed Gamma Spectrometry Data



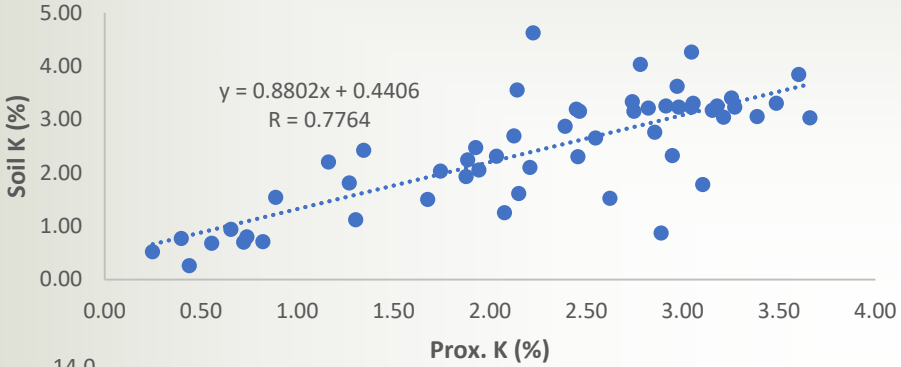


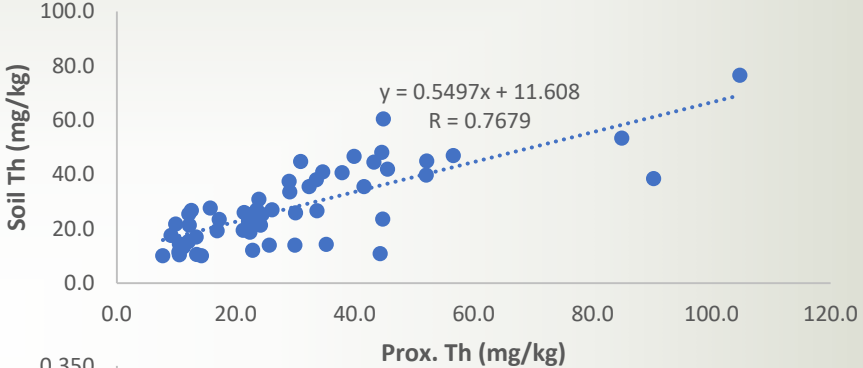


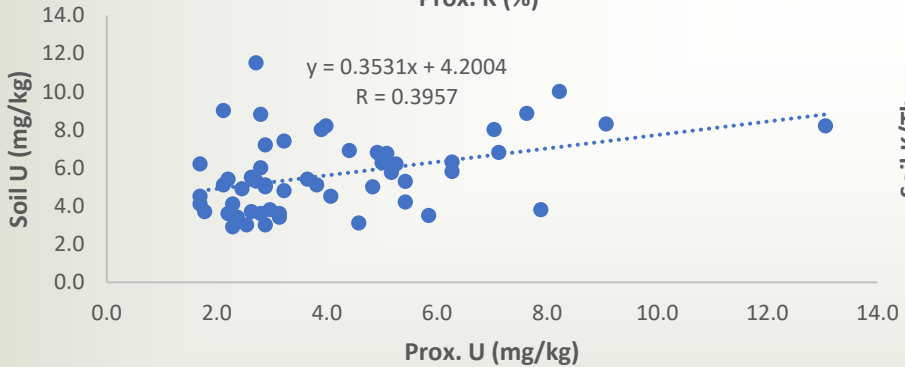


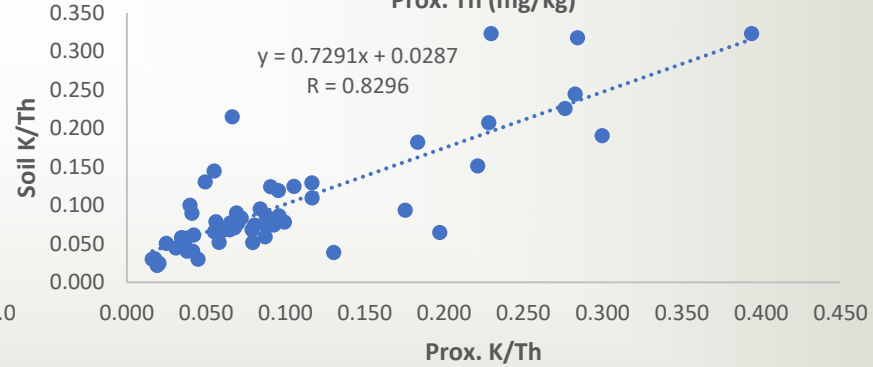
- The histogram of K, U, Th and K/Th show that up to 4 soil classes can potentially be differentiated.

Correlation of Proximate and Soil K, U and Th



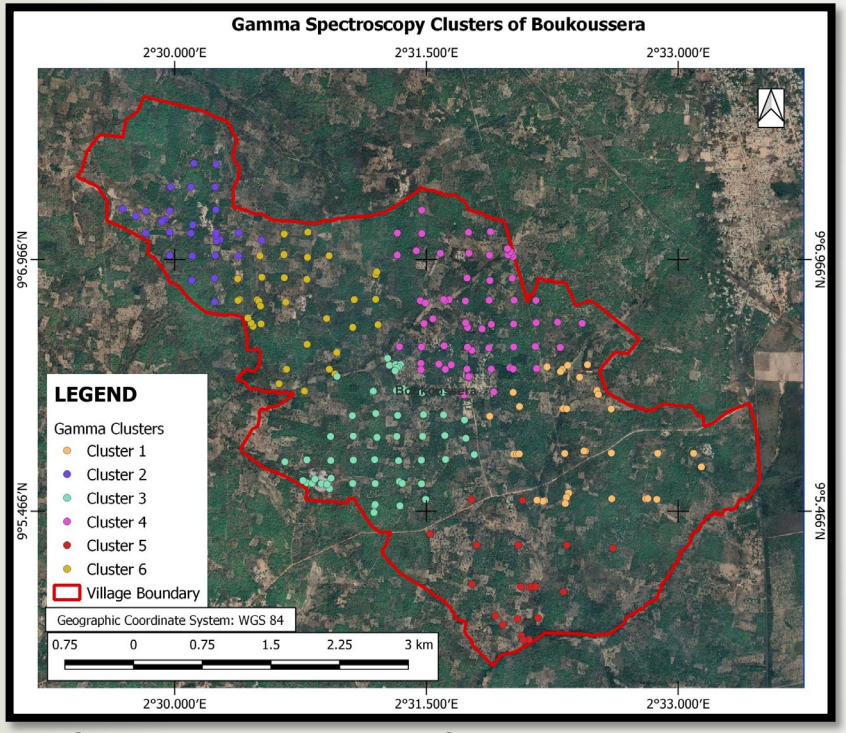




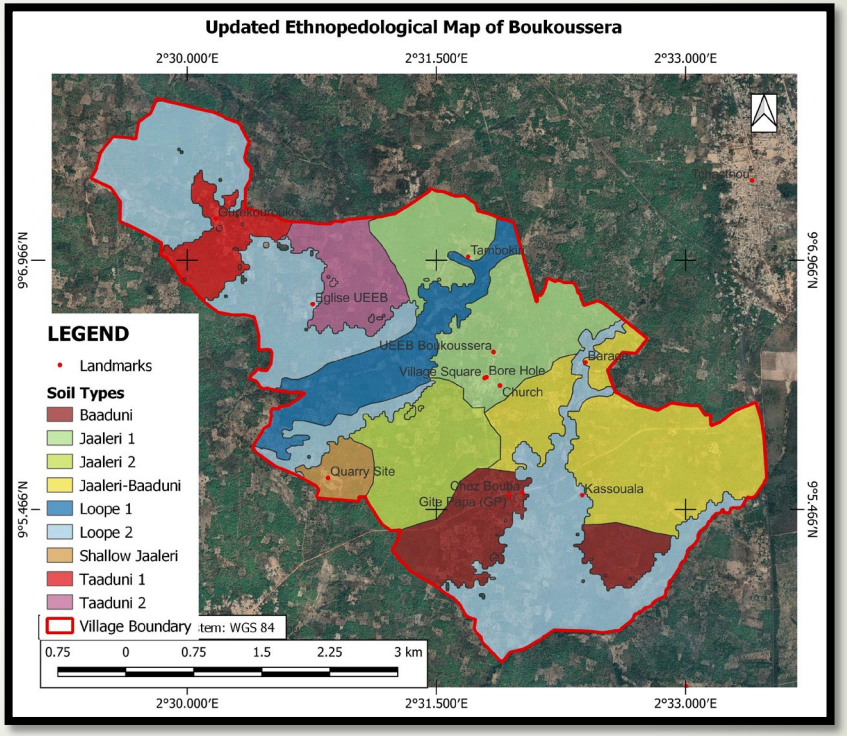


- ❑ All the variables show strong correlation between the proximate and the soil dataset, except for U
- ❑ Proximate gamma spectrometry shows strong potentials for predictive mapping of soil in the area

Soil Delineation (aided by Gamma Data)



- Cluster analysis of the gamma ray spectroscopy enabled the differentiation of six mapping units



- The inclusion of field and topographic data in the mapping process enabled the delineation of nine units

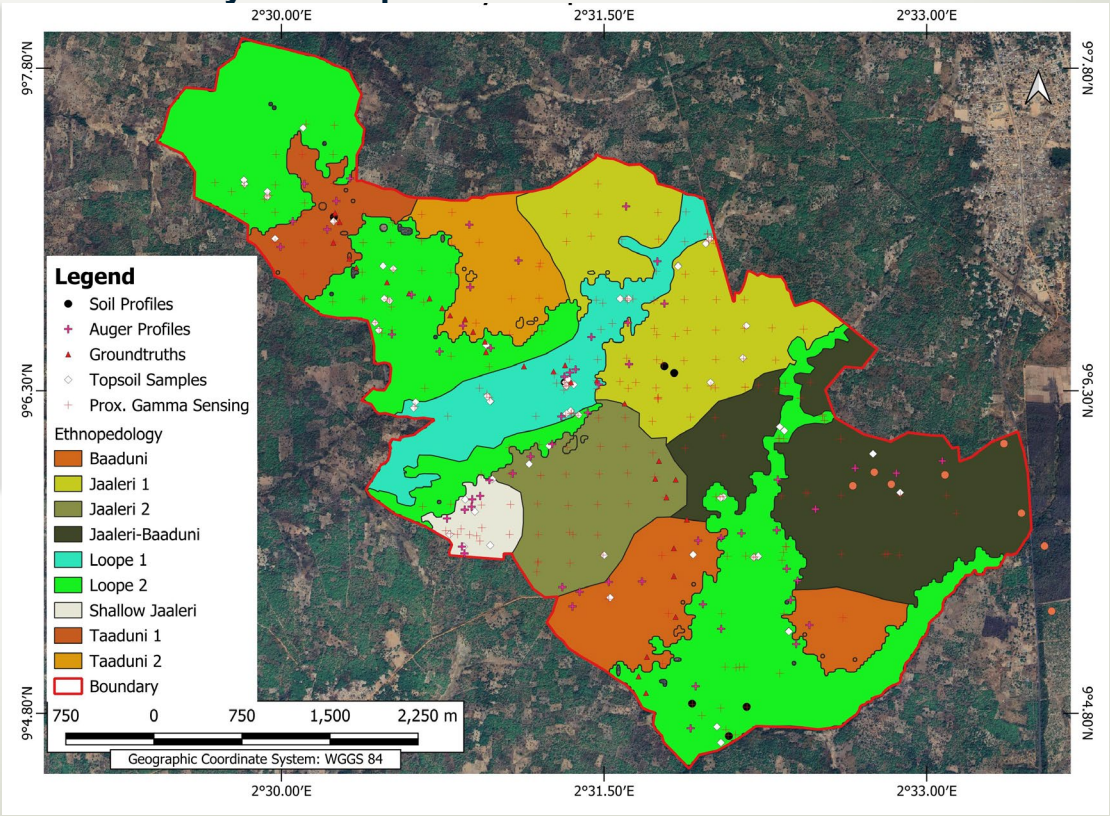
Participatory Ground-truthing

Participatory Ground-truthing

31 ground-truth sites were assessed to

- ❑ determine the actual soil boundaries
- ❑ Adapt the map to reflect the needs of the local people
- ❑ Merge units with similar properties

Preliminary Soil Map of Boukoussera



Conclusion

- Indigenous/participatory soil classification/mapping can be improved considerably through the
  - integrated use of remote sensing
  - gamma spectroscopy (proximate sensing), and
  - site assessment
- ensuring relatively improved communication and feedback between farmers and researchers.

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