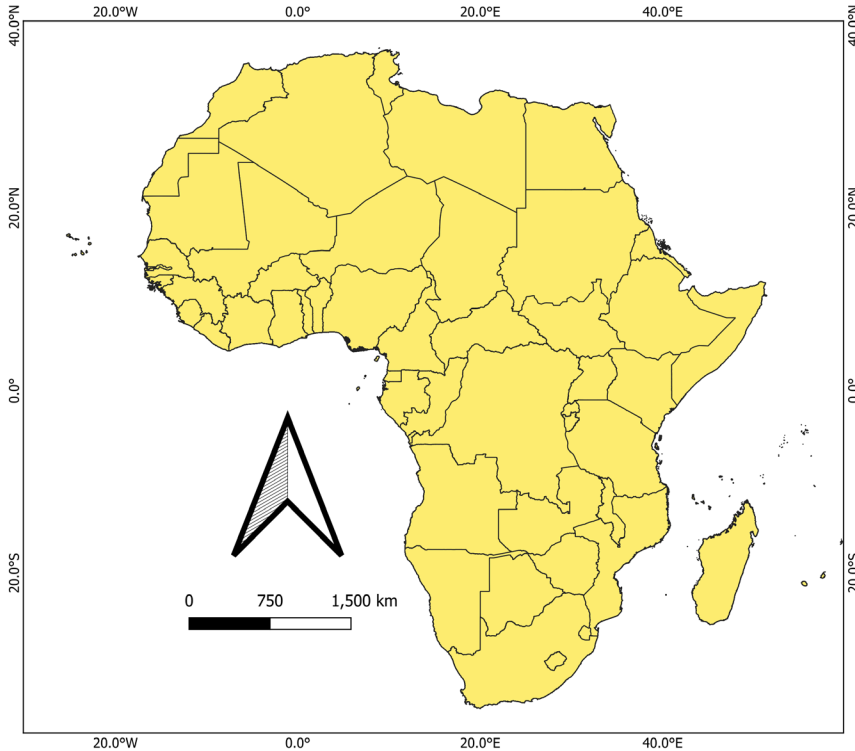


# DecLaRe: Decision support for strengthening land resilience in the face of global challenges





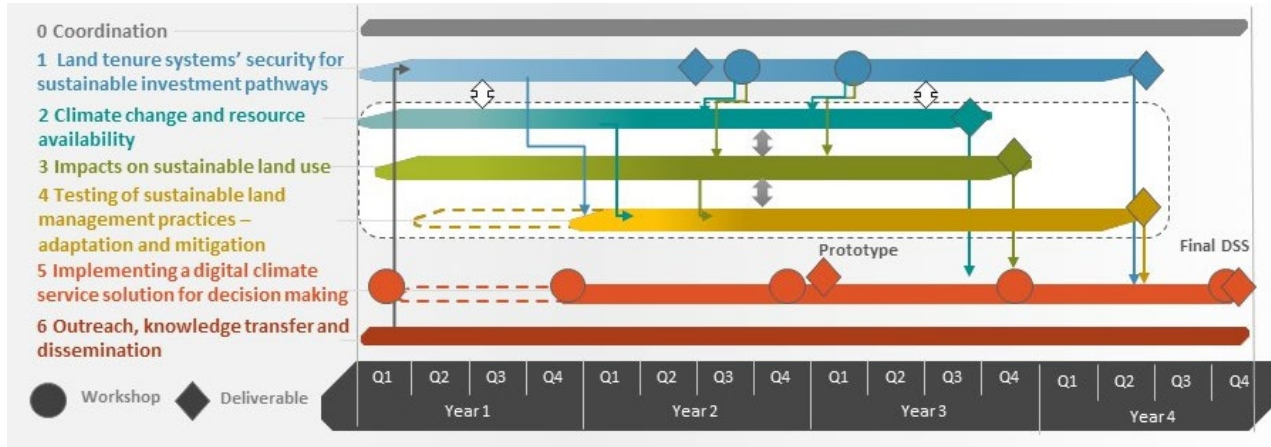
# Introduction



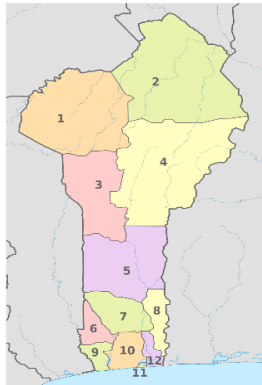
- High population growth
- Low adaptation of agric. innovations
- Deforestation & biodiversity loss
- Low chemical fertilizer use
- Food insecurity

# DecLaRe en miniature

## Time Table

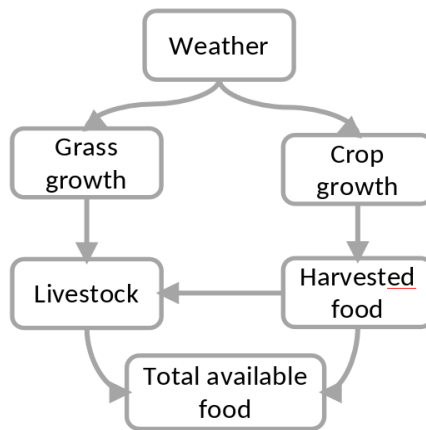


## Map layers

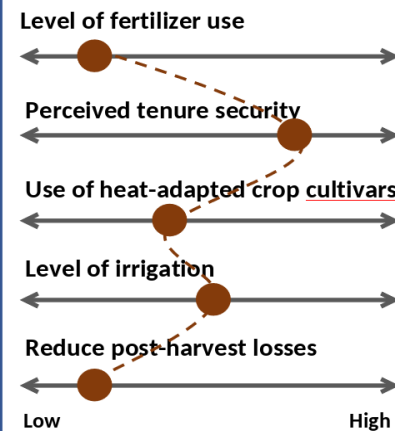


Variable: Benin admin boundaries  
Zoom

## Connections



## Scenario settings



## Decision Support System (DSS)

# The agropastoralandusesystem





Agricultural innovations can be effective only if developed with farmers



# Fertilizer Microdosing (FM)

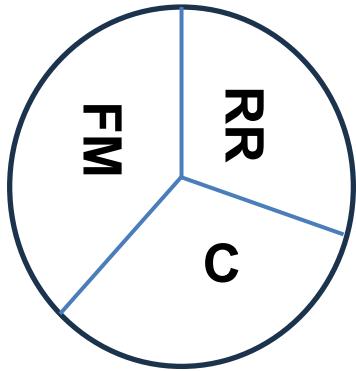


- Developed at ICRISAT-Niger in the 1990`s
- 2-6 g fertilizer
- Fertilizer types: NPK 15-15-15, 17-17-17, diammonium phosphate & urea
- Crop types: Mostly cereals

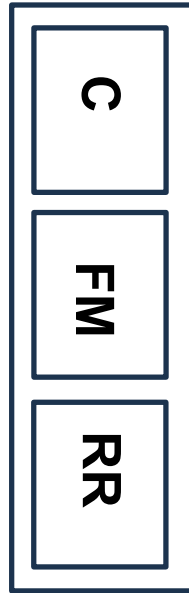


# FM under Agroforestry

## Zones A



## B



## C



- C (control, no fertilizer)
- Fertilizer microdosing (FM, 14 kg N ha<sup>-1</sup>, 6 kg P ha<sup>-1</sup> & 12 kg K ha<sup>-1</sup>)
- Recommended rate (RR, 60 kg N ha<sup>-1</sup>, 13 kg P ha<sup>-1</sup> & 25 kg K ha<sup>-1</sup>)

Shea canopy — 3 m — 20 m

# University for Development Studies (UDS, Ghana)



DecLaRe





# Mathew (Food Technology, WP1 & 4)

## Activities and experiments

- Field visits and surveys on milk and indigenous soft cheese (*Wagashi*) production and utilisation in DecLaRe communities in Ghana
- Workshops with herds(wo)men on animal health and hygienic practices to improve milk and cheese quality and safety
- Studies on household food consumption and dietary diversity among herder households
- Studies on cheese production

## Conferences and publications

- Review paper on dairy production and utilisation (Springer - *Discover Food*)
- Two conferences (Tropentag 2024 - Austria & AFROSENSE 2024 - Ghana)
- Two abstracts accepted for poster presentation at upcoming international conferences (ANH 2025 - Tanzania & ICN 2025 - France)
- Two abstracts submitted for Tropentag 2025 (Germany)
- One collaborative manuscript (with Wilfried Tossou) under internal review



# Abraham (Socio-Economics, WP1)

## Field activities

- 1st wave of the Ghana DecLaRe household survey completed ( November and December 2023)
- 2nd wave in progress (April 2025 to date)

## Publication and conference:

- One manuscript submitted to the African Journal of Agricultural and Resource Economics
- Two conferences (Tropentag 2024 - Austria & FRAGILE LIVES 2024 - Germany)
- Two manuscripts developed + two manuscripts in progress
- Development of a policy brief on land tenure security and climate adaptation strategies

## Participated in capacity-building programmes:

- IZA/FCDO G<sup>2</sup>LM|LIC Development Economics Course 2024 organised by the London School of Economics and Political Science (LSE), January 2024 to March 2024
- Communicating Research Results to Influence Implementation and Impact” on 10 October – 7 November 2024, organised by INTERFACES.
- Exchange visit to RWI and PIK in 2024, Germany (Two-month visit)



# Amisu (Soil Science, WP 3 and 4)

## Activities and experiments

- Survey of farmers on perceptions and soil fertility indices (127 farmers)
- Analyses of soil (pH, Organic C, Ex. K, Bray P and particle size)
- Analyses of micronutrient concentrations in grains and biomass in progress
- Meta-analysis on factors (soil properties and weather) that influence micronutrient potential to enhance cereal grain yield (in progress)

## Conferences and publications

- Tropentag 2024 (Austria)
- First manuscript in progress

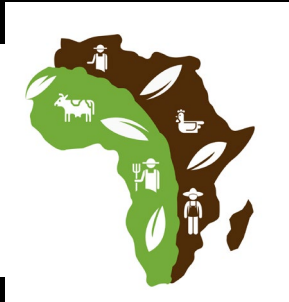
## Challenges

- Total N analysis pending due to the pending installation of CNH Analyzer
- Lack of a digestion chamber in our lab, stalling grain and biomass sample analysis

# WASCAL



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# Research Activities / PhD Supervision

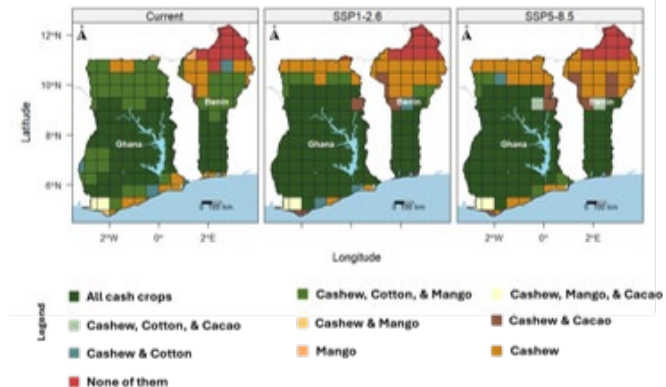
## How can crop modelling and land tenure perceptions support SLM?

### Objectives

- Current and future crop suitability patterns under different climate scenarios
- Perceptions of farmers on land tenure security (Mental model)
- Integration of crop suitability and land tenure security to inform and support SLM strategies

### Some preliminary results

- Climate-driven shifts in crop suitability areas informing targeted planning for SLM
- Significant differences observed in gender and migration status for farmers' perceptions on land tenure security.



*Fieldwork completed, ongoing data analysis and paper writing*



# ResearchActivities /PhD Supervision

## Assessing the sustainability of agroforestry parkland systems in West Africa

### Objectives

- Effect of fertilizer microdosing (FM) on maize yield in shea-maize agroforestry parklands
- Characterization shea-maize parkland systems in Northern Benin
- Soil fertility indices of shea-maize agroforestry parklands under different fertilizer application strategies



### Some preliminary results

- Maize yield increases with tree density up to an optimum (19–20 trees/ha) and then declines
- FM produces 24% to 46% grain yield increase compared with no fertilizer
- FM is 8% significantly less labor-demanding than recommended rate (RR)

*Fieldwork completed, lab analysis almost completed, and ongoing data analysis and paper writing*



# Research activities/PhD Supervision

**Relationships between LU/LC change and climate and their implications for sustainable land and water management in Northern Ghana**

## Objectives

- Identification of socioenvironmental drivers for LULCC,
- Mapping of transitions from the past to the future LULC,
- Analysis of land and climate interactions,
- Evaluation of the suitability of land for reservoir development.



## Some preliminary results

- Literature review (2020-2025) with 75+ peer-reviewed sources on the biogeophysical and biogeochemical feedback between LULCC and climate.
- Farmers attribute LULCC primarily to population pressure, climate variability, and deforestation.
- Examination of ground-truth data shows spatial variation in agricultural practices and other LULC

*Fieldwork completed, and ongoing data processing and analysis*



# Participation, Outreach, Dissemination (WP6)

- Stakeholders' engagement in Northern Benin and Ghana to introduce DecLaRe and contribute to the co-development of gender-responsive ToCs.
- 2 blog articles (**Microdosing** and **Mental model**) developed and 1 policy brief (**Land suitability for crop production**) in preparation
- Development of two courses for the e-certificate: **Land tenure systems** and **fertilizer microdosing**, with partnership for its dissemination.
- Knowledge Management for Agriculture Development (KM4AgD) supported by INTERFACES with development of policy and knowledge briefs on:
  - Microdosing
  - Integrated Soil Fertility Management (ISFM)
  - Women's land access
  - Right crop selection considering climate and soil data



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

# University of Parakou (Benin)



Federal Ministry  
of Research, Technology  
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DecLaRe





# Ethnography / Achievements

- Local knowledge production through long-term community engagement Deeper understanding of rural land tenure systems and adaptation strategies in agropastoral communities in northern Benin, particularly in the context of ongoing rural land reform processes
- Two MSc students enrolled at the University of Parakou One of them completed and defended his thesis titled “ *Land Security in Benin: Perceptions and Strategies of Agropastoral Communities in the Commune of Tchaourou*” The second student has completed all required coursework and is preparing to begin field data collection. As an indigene of one of the working communities, the student has strengthened the team's local ties and enhanced the project's relevance and contributions at the community level.
- The doctoral candidate presented findings at international conferences, workshops, and colloquia in Benin, Canada, Germany, and Mexico.  
⇒ Reception of the Global Scholar Award at the Global Land Programme's Open Science Meeting.



# Ethnography / Constraints & Perspectives

## Constraints:

- Limited access to statistics on land registration.
- Kinship relationships influence who can speak and what can be shared regarding land and local dynamics. Nevertheless, the extended case study method allowed the team to build trust over time and involve key informants and local interpreters in accessing diverse perspectives.

## Perspectives:

- Organise or participate in interdisciplinary panels to share research findings and encourage cross-disciplinary dialogue.
- Share our research findings, including policy briefs, community reports, and media reports, which can be widely distributed and remain accessible to all stakeholders after the project ends.



# Livestock / Achievements

- **Baseline Survey:** Established initial conditions, identified livestock and rangeland management practices that are unsuitable for the system sustainability.
- **Data Collection & Monitoring (bi-monthly):** Tracked soil nutrients, vegetation shifts, biomass production, and livestock health over two years
- **Livestock Rearing Systems:** Sedentary (66.3%) relies on cultivated fodder, while semi-sedentary (33.7%) migrates seasonally for better forage sourcing
- **Pasture Access & Forage Quality:** 94% decline in pasture access leads to 100% forage scarcity and 75% poor quality, forcing 97% of herders to migrate.



# Livestock / Achievements

- **Mobility Challenges** Expansion of cropland and land tenure issues (69%) limit sustainable grazing
- **Rangeland Management Barriers:** Land-use conflicts (50%), limited technical knowledge (35%), and insufficient forage cultivation (44%) threaten rangeland sustainability.
- Findings establish basis for creating sustainable rangeland management scenarios that enhance ecosystem services, reduce carbon and nitrogen emissions, and boost animal performance
- Participated in conferences/seminars in Benin, Ghana, Austria, Germany, and USA
- **Upcoming activities** will focus on completing data analysis, writing and manuscript publishing.



# Food Technology/ Achievements

- Contributed to assessment of food security, dietary diversity, and the contribution of animal source foods (ASF) to settled Fulani households' diets: Longitudinal (12 months) data collection.
- Conducted sensory analyses of “*Wagashi*” testing two main innovations: the use of various coagulants — *Calotropis procera*, *Carica papaya*, and *Citrus limon juice* — at defined concentrations; and **partial substitution** of **cow's milk** with **soybean milk** at incorporation rates ranging from 0% to 20%.
- Participated to the co-development of a gender-responsive Theory of Change (ToC) for Sustainable Land Management in Northern Benin with the production of a documentary on “*Wagashi*” processing in Boukoussera.
- Active collaboration with Ghanaian Tandem resulting in a joint manuscript.
- Participated in colloquium and conferences in Benin, Ghana, and Austria.



# Food Technology/ Achievements

- Findings indicate generally **high dietary diversity** and **food consumption scores** across the study period. Temporal (monthly) variations significantly influenced both indicators. Pulses, legumes, and nuts; roots and tubers; fruits, and ASF (Milk and dairy, meat, fish, eggs) consumption exhibited seasonal fluctuations.
- Dairy products emerged as the most frequently consumed ASF (**4.2 times/week**), surpassing meat, fish, and eggs combined (**2.5 times/week**).
- The **type of coagulant has a significant impact on sensory attributes**, and overall acceptability whereas partial substitution of cow's milk with soymilk up to 20% did not.
- Focus on assessment of the **potential of innovations** on physico-chemical and microbial **quality of "Wagashi"** => Participation in the upcoming International Congress of Nutrition in Paris (France); Writing and publishing of manuscripts.



# Progress

- **Local knowledge production through long-term community engagement**

Deeper understanding of rural land tenure systems in agropastoral communities of northern Benin in the context of an ongoing land reform. We have worked with state and non-state actors to understand land governance and management systems

- **Participatory Research**

Seven focus group discussions and knowledge-sharing sessions with farmers, agropastoralists, and other stakeholders => mutual learning and feedback

- **Capacity building and training**

Two MSc students have enrolled at University of Parakou. Dobougui Djoule has defended his thesis on *“Land Security in Benin: Perceptions and Strategies of Agropastoral Communities in the Commune of Tchaourou”*. Paul Sabiboum has completed his coursework and is about to start field data collection.

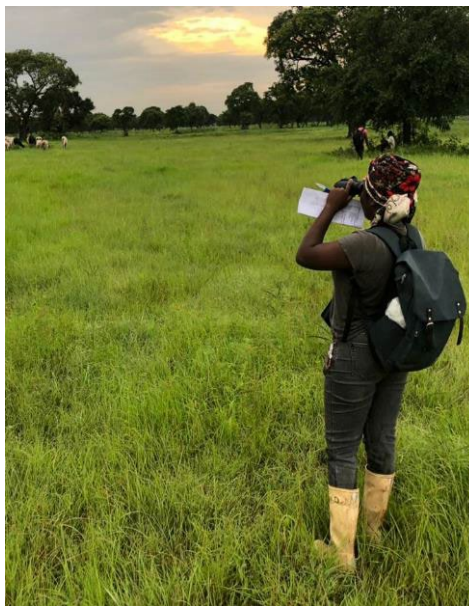


# Summary - Findings

- **Land use mapping** shows a shift from food crops to cash crops. Income from cash crops supports household food security.
- **Expansion of cashew cultivation** has altered traditional land use and reflects local land ownership and adaptation strategies.
- **Land tenure changes** reduce flexible land access for women and youth
- **Patterns of land use** reveal a connection between capitalist production and patriarchal gender relations
- **Environmental pressures** and land enclosures have reduced herd sizes, affecting pastoral livelihoods
- **Livelihood diversification** has increased as a response to changing tenure systems and is gendered
- Local strategies, such as **marking trees and oral history**, supplement land administrative technologies.

## Objectives

- Characterize and identify the challenges of mixed crop-ruminant farmers in northern Ghana
- Determine the nutritional quality of the pasture vegetation throughout the year
- Characterise and quantify feed resources available at farm level
- Monitor the livestock management of sedentary farmers for possible improvement options



## Approaches

- Individual interviews and focus group discussions
- Grazing behaviour monitoring and pasture biomass quantification
- Animal performance recording (body condition, reproduction, milk offtake, mortality)
- Modelling and scenario development (OPERAS; GLEAM)



## Insights

- Despite biomass yields of 4 to 7 t DM/ha annually, feed scarcity and animal theft remain major challenges for livestock keepers
- Crop residues and rangeland biomass are still communally exploited, though animal densities remain high year-round
- Milking of cows is not widely practiced, resulting in low offtake
- Supplementary feeding is uncommon, both for small and large ruminants
- Farmers are interested in intensifying feeding practices to improve livestock performance

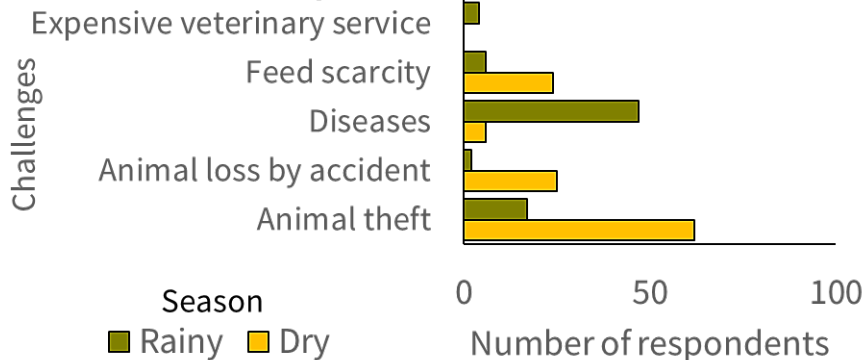


Photo: Hassann Kalla

DecLaReDecision support for strengtheningand resilience in the face of global challenges

# Agroforestry/crop production/nutrients

Deogratias Kofi Agbotui, Geronime Marlene Houeto, Amisu Mohammed,  
Vincent Kodjo Avorny, Andreas Buerkert



UNI KASSEL  
VERSITÄT | ÖKOLOGISCHE  
AGRAR  
WISSENSCHAFTEN

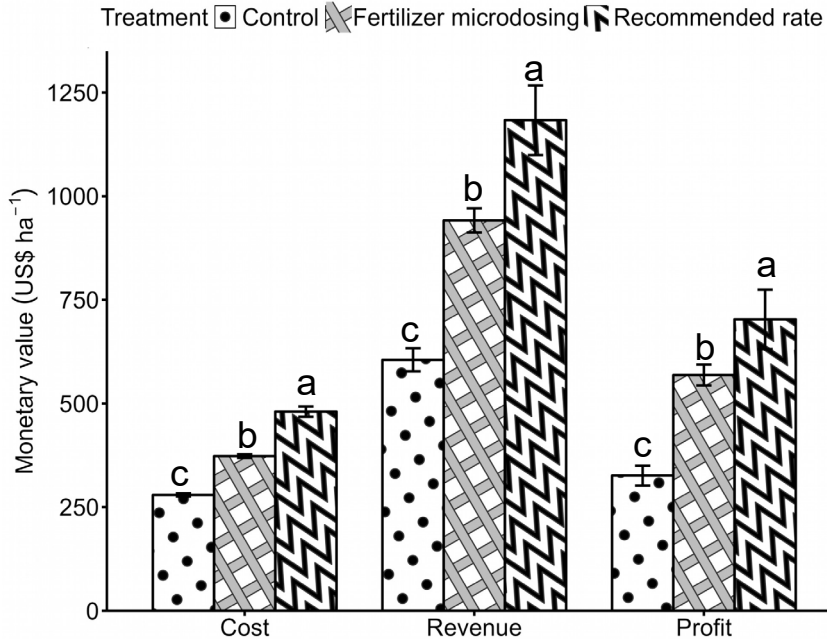


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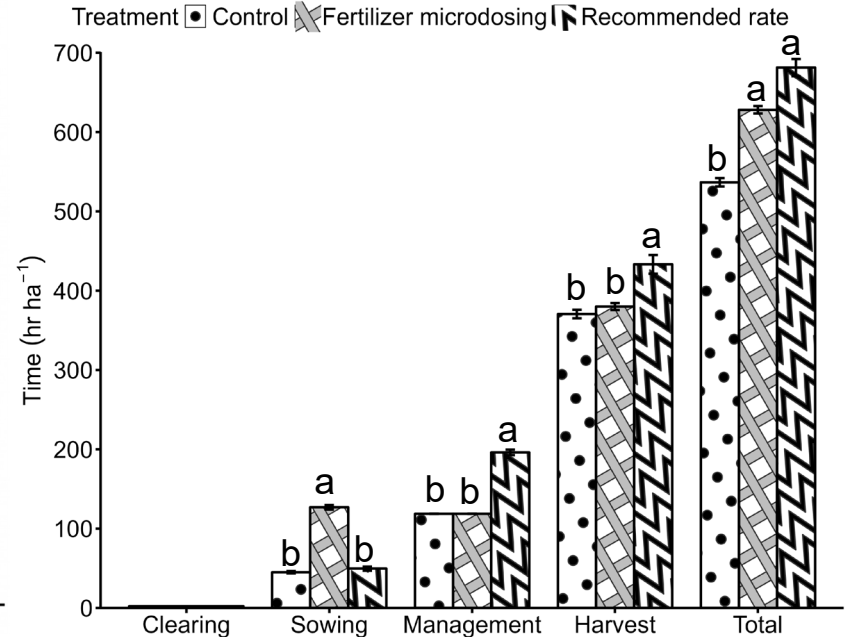




# Profitability and labour time



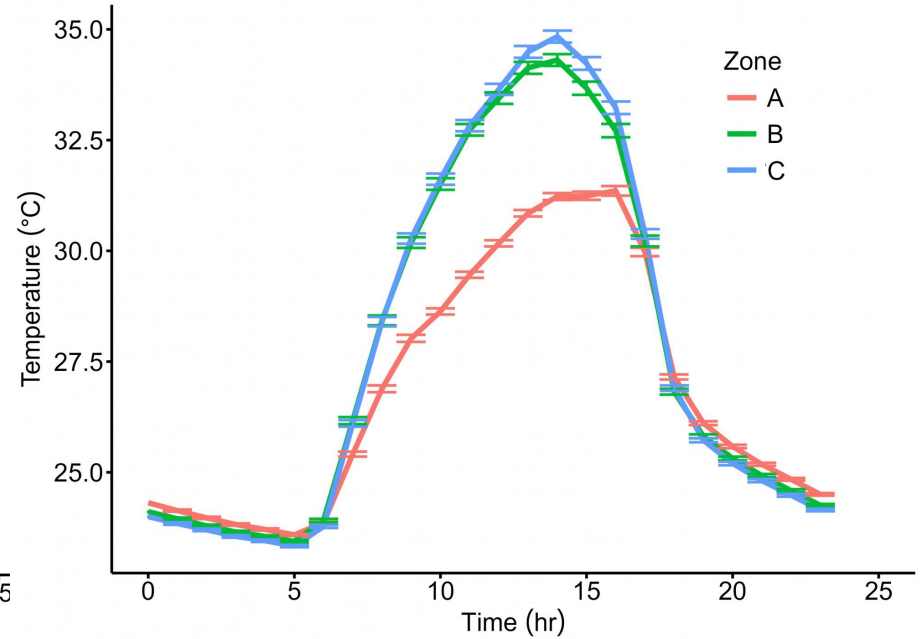
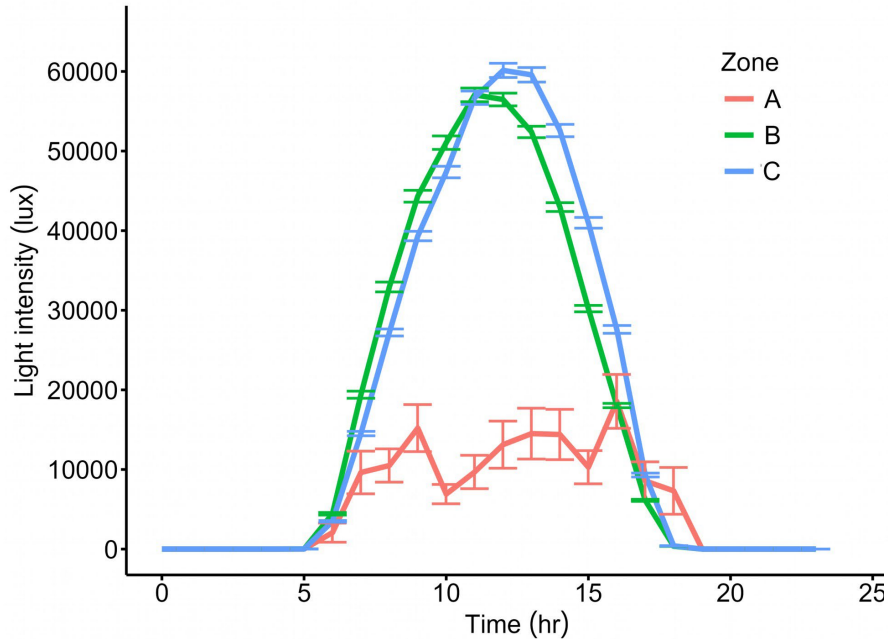
- C profit was 54% lower than RR
- FM profit was 19% lower than RR



- Sowing time in FM was 1.5x higher than the others
- FM total time = RR total time



# Shea tree canopy light and temperature reduction

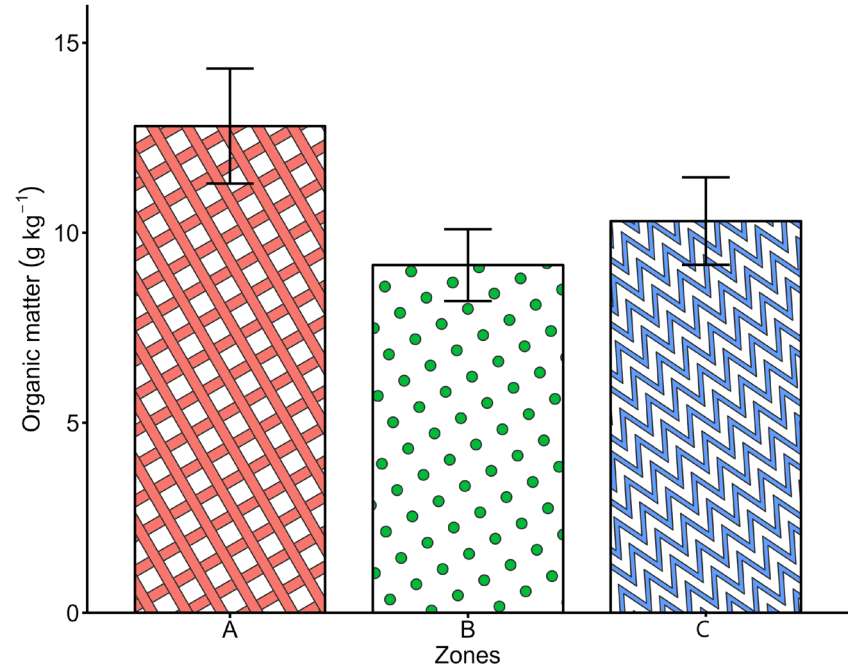
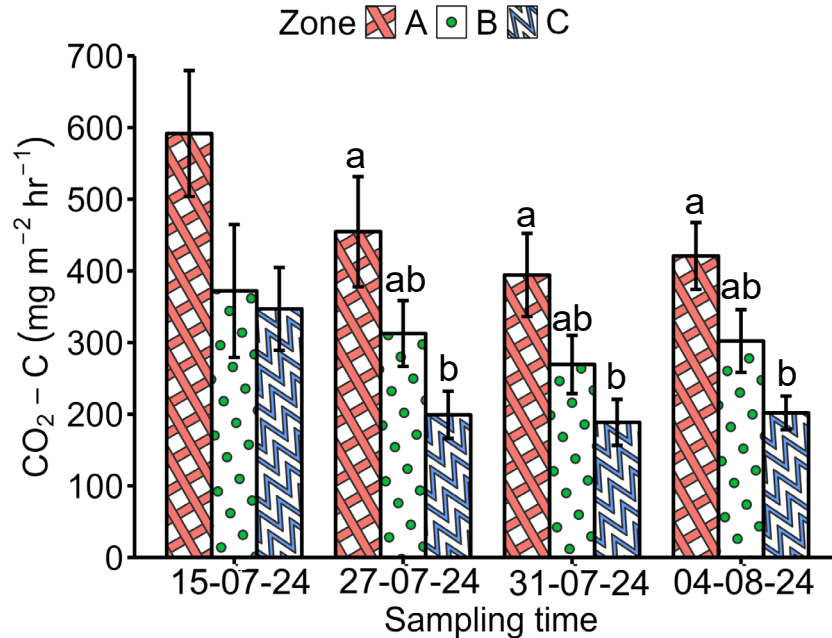


- Shade reduces light intensity by 40,000 lux between 12-13 noon

- Shade reduces temperature by 3°C between 12-13 noon



# CO<sub>2</sub>-C emission and organic matter



- High organic matter made CO<sub>2</sub>-C higher in Zone A

- High organic matter in Zone A due to litterfall and fine root turnover

# The DecLaRe DSS – Landing web page

DecLaRe



## DecLaRe Toolbox For Eastern West Africa

How to use



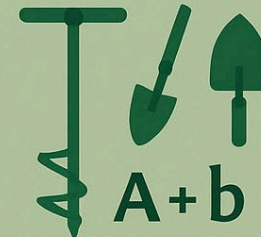
Land  
Evaluation



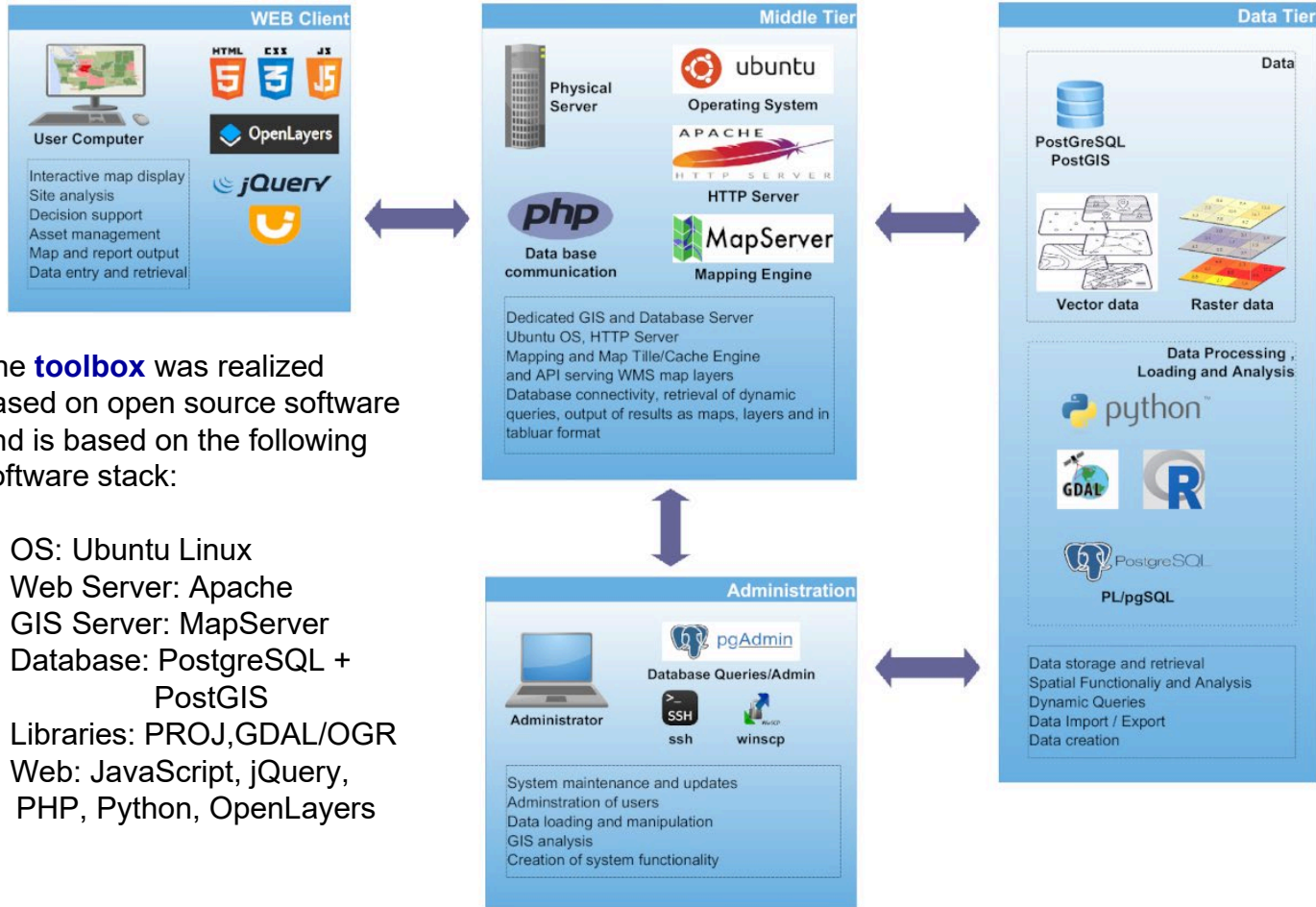
Spatial  
data



Other tools



# DecLaReToolbox



The **toolbox** was realized based on open source software and is based on the following software stack:

- OS: Ubuntu Linux
- Web Server: Apache
- GIS Server: MapServer
- Database: PostgreSQL + PostGIS
- Libraries: PROJ, GDAL/OGR
- Web: JavaScript, jQuery, PHP, Python, OpenLayers

## **Land Evaluation Tool**

- Based on the framework for land evaluation by the FAO
- Calculation of crop suitability (maize, cassava, cotton) at a scale of 250 m
- Region-specific analysis with adjustable inputs

## **Suitability for micro-dosing application (FM)**

- Evaluates site-specific fertilizer application
- Focus on smallholder farming systems

## **Micronutrient Chain Tool (in development)**

- Identifies areas at risk of human micronutrient deficiency
- Connects geology & soil to food-chain nutrient flow

## **Additional Tools (open to collaboration)**

- Your tool here ...

# Land Evaluation Tool

- Based on the framework for land evaluation by the FAO
- Calculation of crop suitability (maize, cassava, cotton) at a scale of 250 m
- Region-specific analysis with adjustable inputs

**DecLaRe Geospatial Tools**

**Legend**  
 Maize (ph,p\_average\_mm,awc,per\_organic\_carbon)  
 Not included in calculation  
 Not Suitable (N)  
 Marginally Suitable (S3)  
 Suitable (S2)  
 Very Suitable (S1)

**Select map layers**

Base Map

Data Layers

Select data to display:

- Open Street Map
- Administrative Boundaries
- Research Data, Work and Sites
- Soil and Geology
- Soil Profiles
- Land Evaluation Tool Results
- Maize (ph,p\_average\_mm,awc,per\_organic\_carbon)

[Clear All Layers](#)

**Land Evaluation Calculation Guide**

Pre-Information

Area Selection (required)

Upload your own data layers (optional)

Select Crop and Adjust Calculation Input and Classification (crutial)

**Step 3**

I. Please select for which crop you like to calculate suitability:

Maize

II. Please select the input layers. Four well-established default layers are preselected for crop evaluation. You can also set a multiplication factor on each layer to change the weight of each (use the numeric input field right to the checkbox to add values between 0 and 100).

- 1 Soil pH (\*10) (H20) [data value range 46-89]
- 1 Average Precipitation Growing Season (mm/growing season crop specific) [data value range 200-1100]
- 1 Soil Available Water Capacity (Liter/m<sup>2</sup>) [data value range up to 760]
- 1 Soil Organic Carbon Content (decigrams per kilogram/permille) [data value range up to 120]

III. To change your choice click on the check boxes and/or press the "Add Input Layers" button and follow instructions.

[Add Input Layers](#) [Remove Non-default Layers](#)

IV. Adapt crop parameterization by pressing the "Adapt Classification" button and follow the instructions.

[Adapt Classification](#)

1 : 367,784



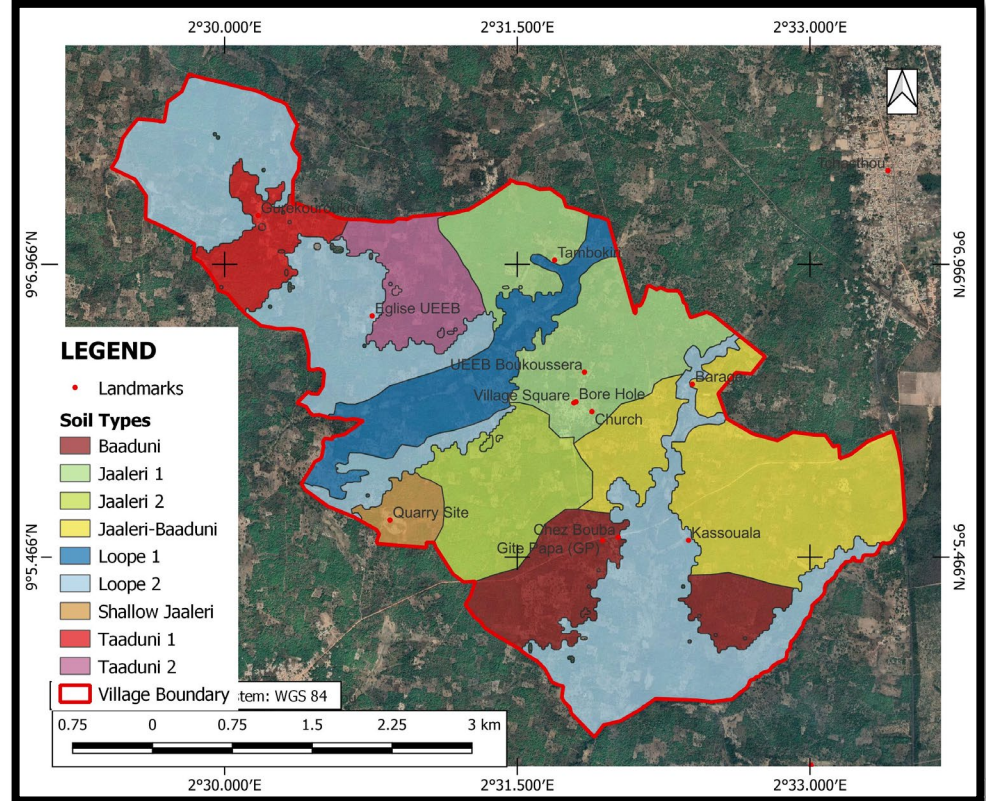
# Participatory soil mapping aided by gamma spectroscopy

## Participatory Soil Mapping Process



- The participatory approach helps to bridge the language/knowledge divide between rural farmers and researchers

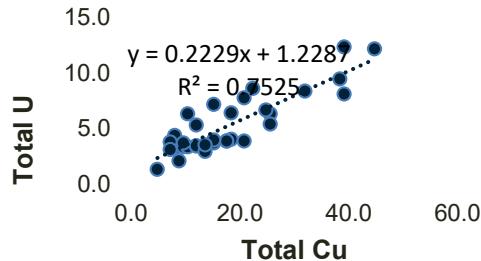
## Preliminary Soil Map of Boukoussera





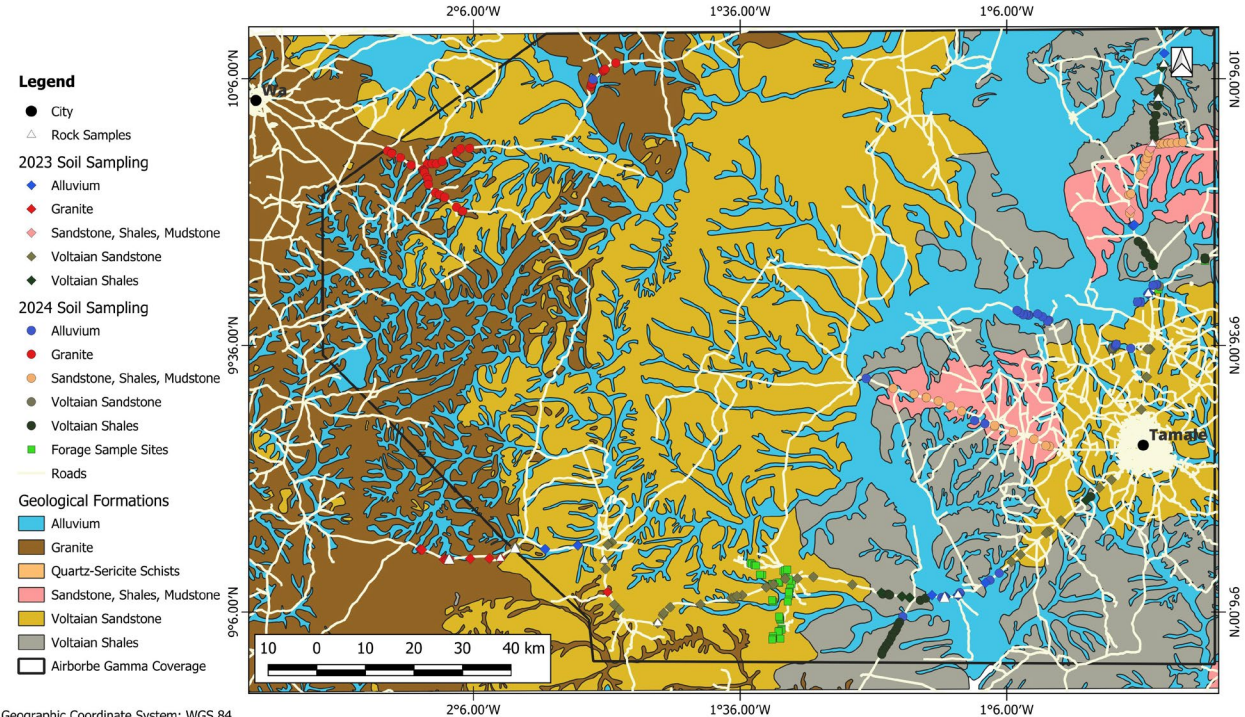
# Micronutrient chain assessment in Northern Ghana

- 93 soil and rock samples were collected in 2023.
- In 2024,
  - Up to 30 soil samples were taken per geological formations (at 3 depths)
  - Forage also taken at 55 sites in the region.
- Statistical analysis of available data is ongoing



- The chart shows a very strong correlation between U and Cu

Sample Sites on Different Geological Formations in Northern Ghana



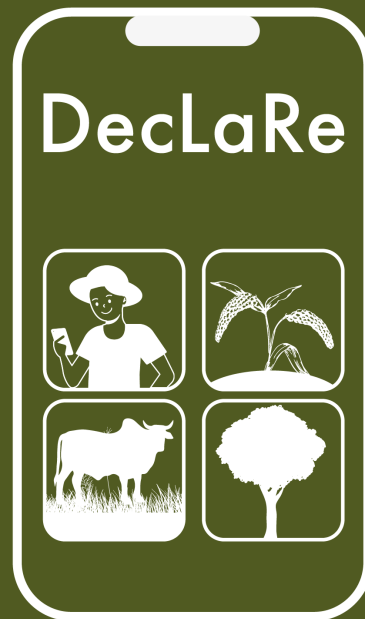


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Resilience in the face of global challenges