

# Micronutrient Bioavailability and the African Soil Information Service

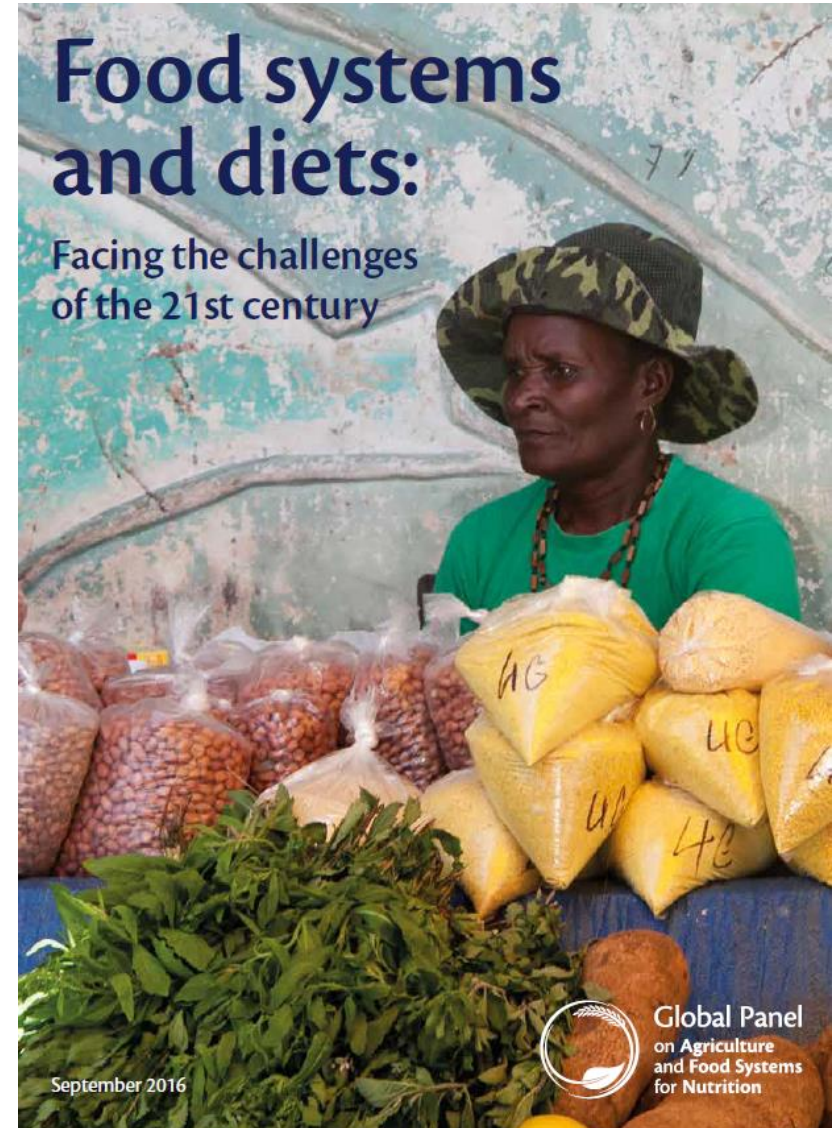
Steve McGrath

Sustainable Agriculture Sciences



# Soil – Food Chain – Humans (and animals)

- Background
- GeoNutrition examples
- AfSIS developments
  
- Antimicrobial resistance
- Soil microbiome



# A growing nutritional crisis

- Malnutrition : stunting, wasting, deficiencies of essential vitamins and minerals, and obesity.
- Overweight, obesity and diet-related chronic diseases such as diabetes and hypertension
- More than 2 bn people lack vital micronutrients (e.g., iron, zinc, selenium, vitamin A) which affects their health and life expectancy.
- 25% children <5 y today are stunted, with diminished physical and mental capacities. Undernourished mothers are having babies who will be left with life-long impairments.

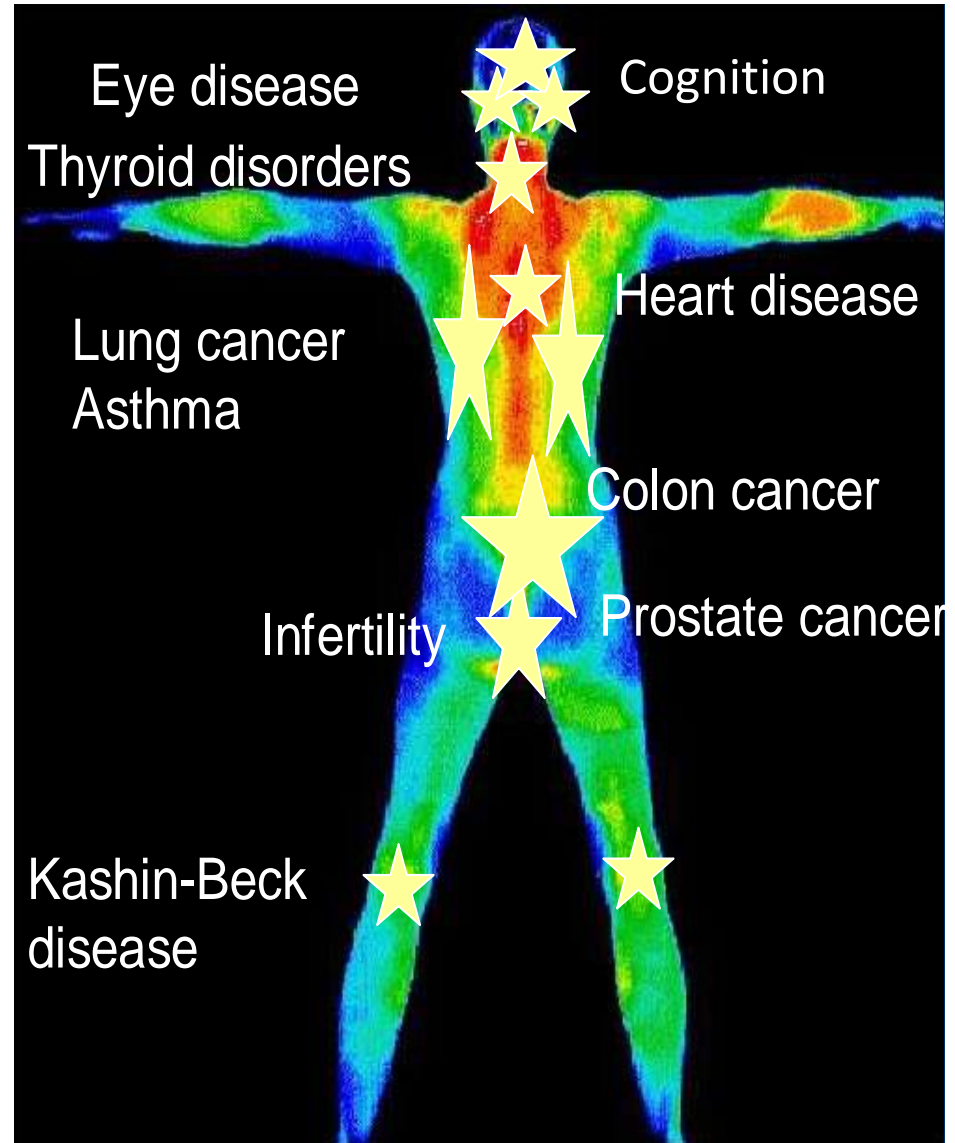
# Food systems and diets

- Malnutrition no.1 risk factor in the global burden of disease
  - Food systems are not delivering healthy diets
  - Potential interventions
    - Fertiliser (agronomic biofortification)
    - Genetically biofortified crops
    - Alter diet
    - Dietary fortification (supplementation)
    - Iodised salt
- 
- 1. Selenium example
  - 2. AfSIS/iSDA developments
  - 3. Ongoing GeoNutrition projects

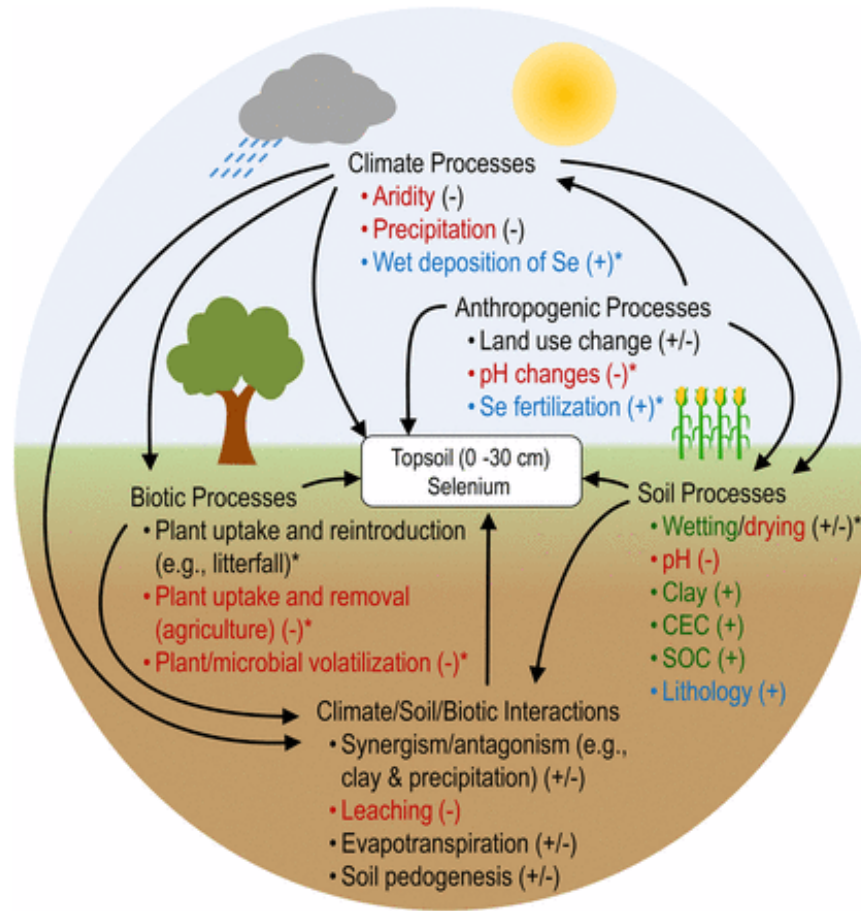
# 1. Selenium

## Increased health risks associated with low Se status:

- Mortality
- Poor immune function
- Impaired thyroid function
- Male infertility
- Increased risk of cancer??
- Cardiovascular disorders (e.g. Keshan disease)
- Animals:  
fertility, white muscle disease

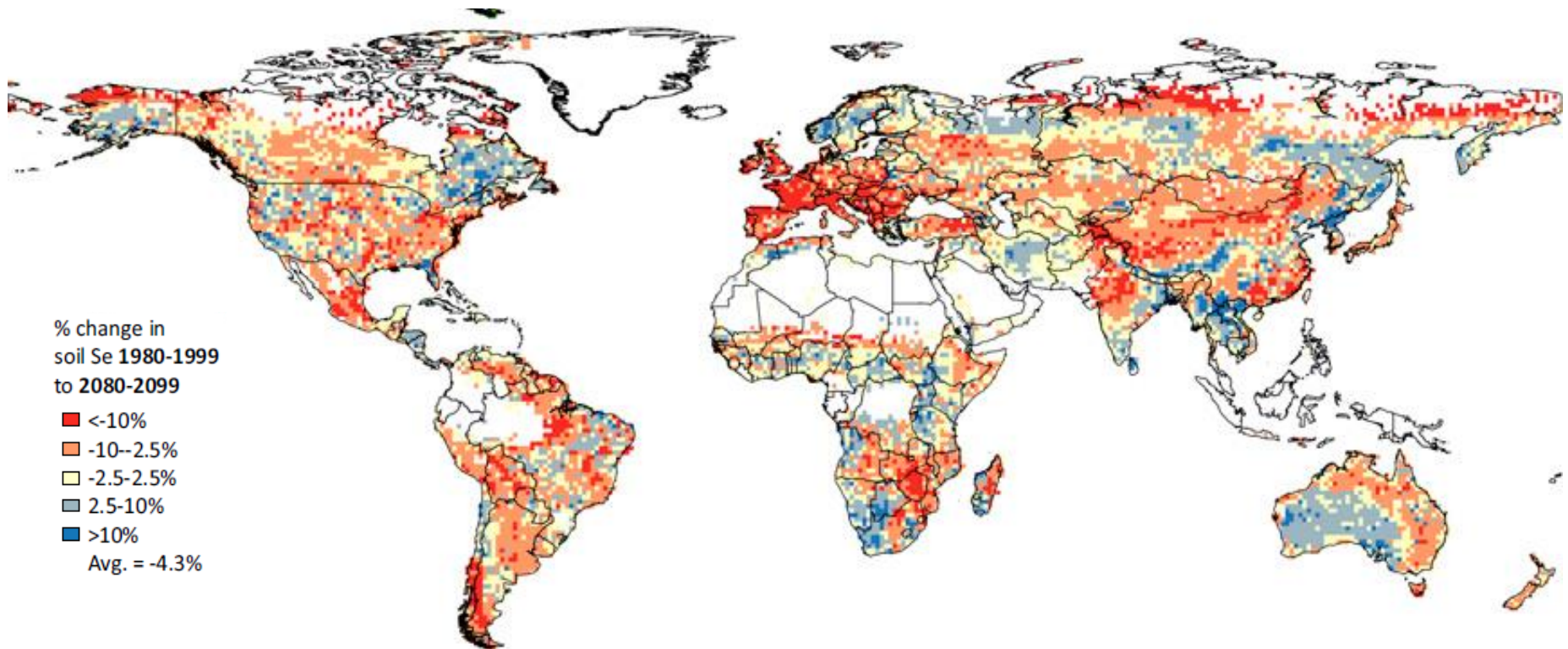


# Potential factors affecting Se bioavailability – assessed



Jones et al, PNAS, 2017, 114, 2848–2853.

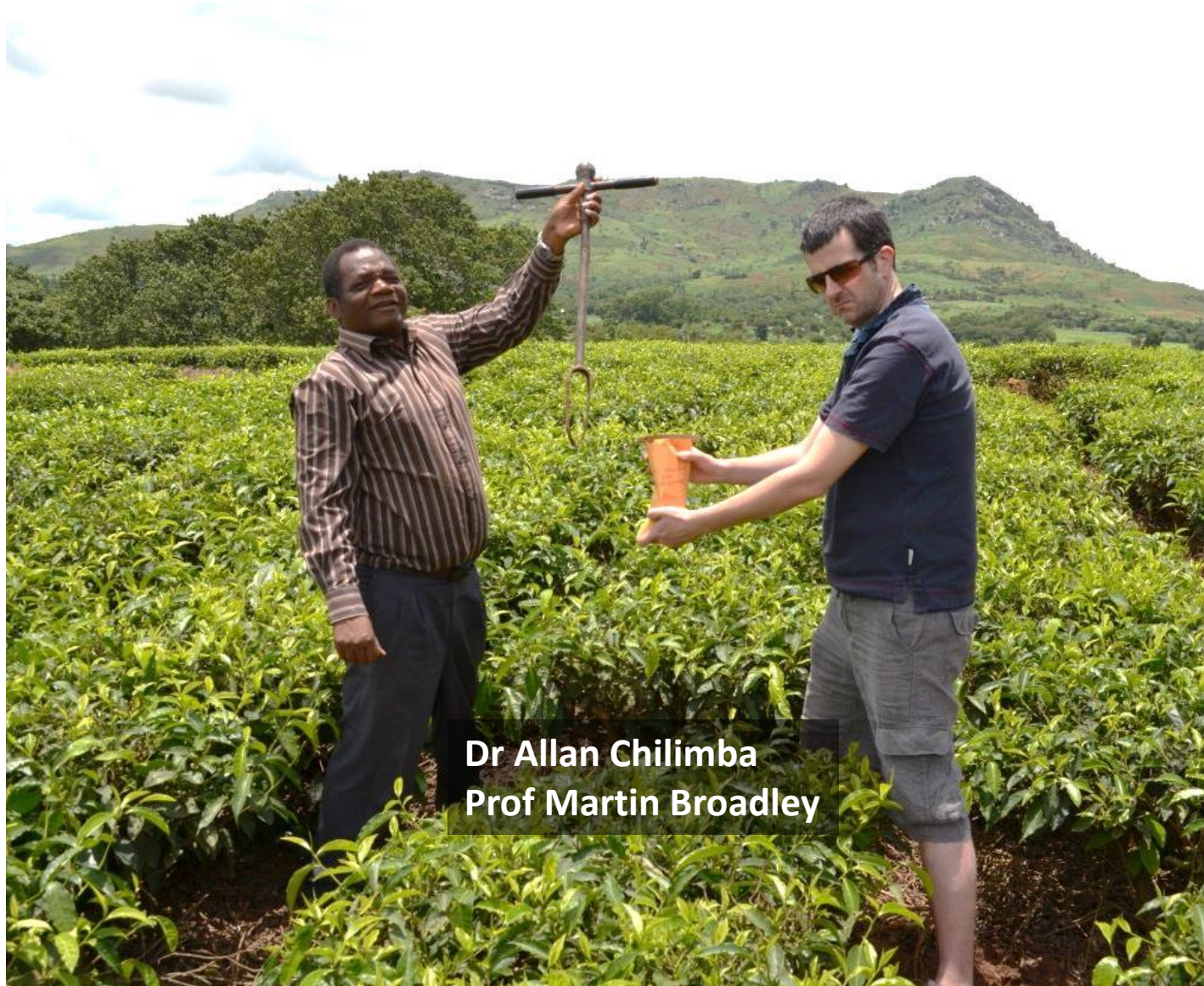
# Predicted change in topsoil Se concentrations



Jones et al, PNAS, 2017, 114, 2848–2853.

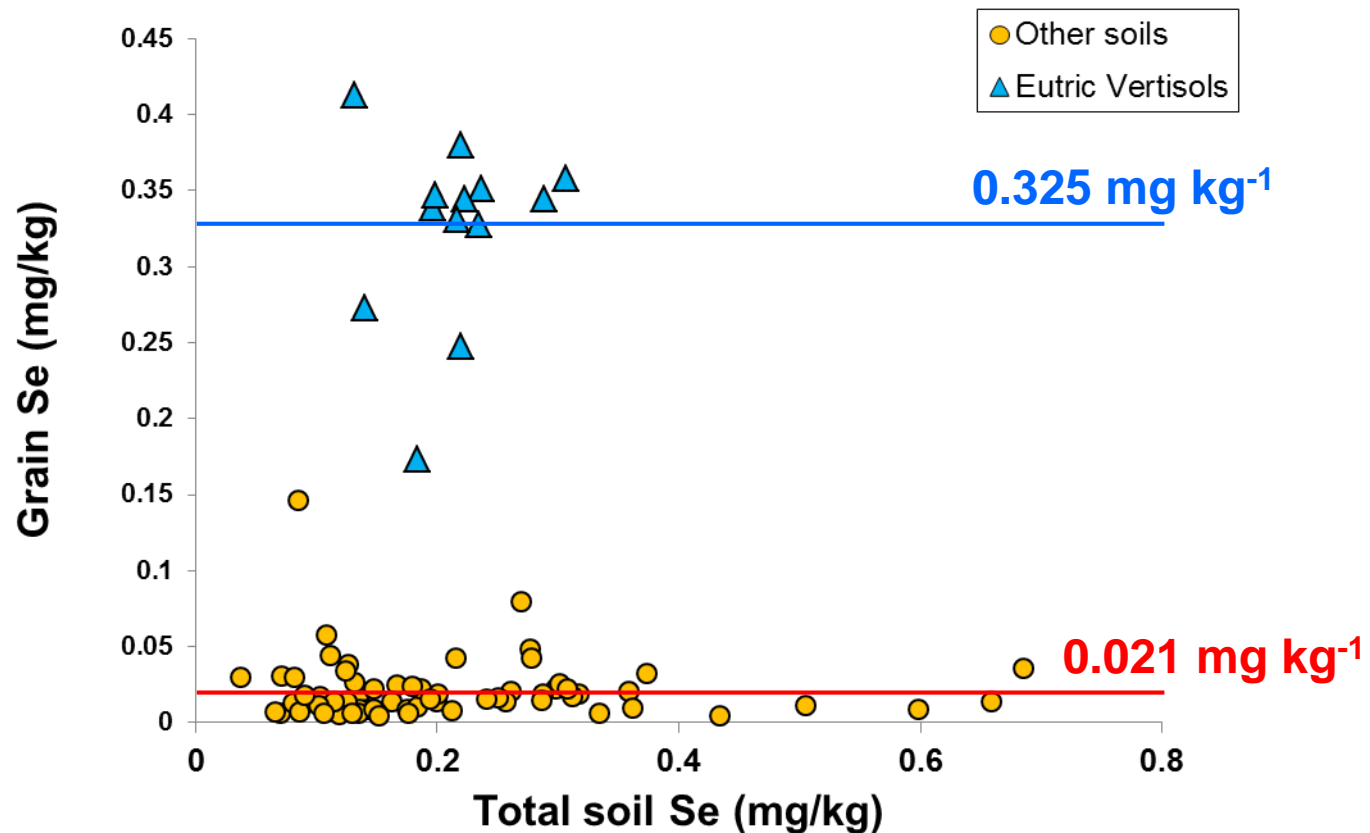


## Selenium supply in Malawi: soil and grain surveys



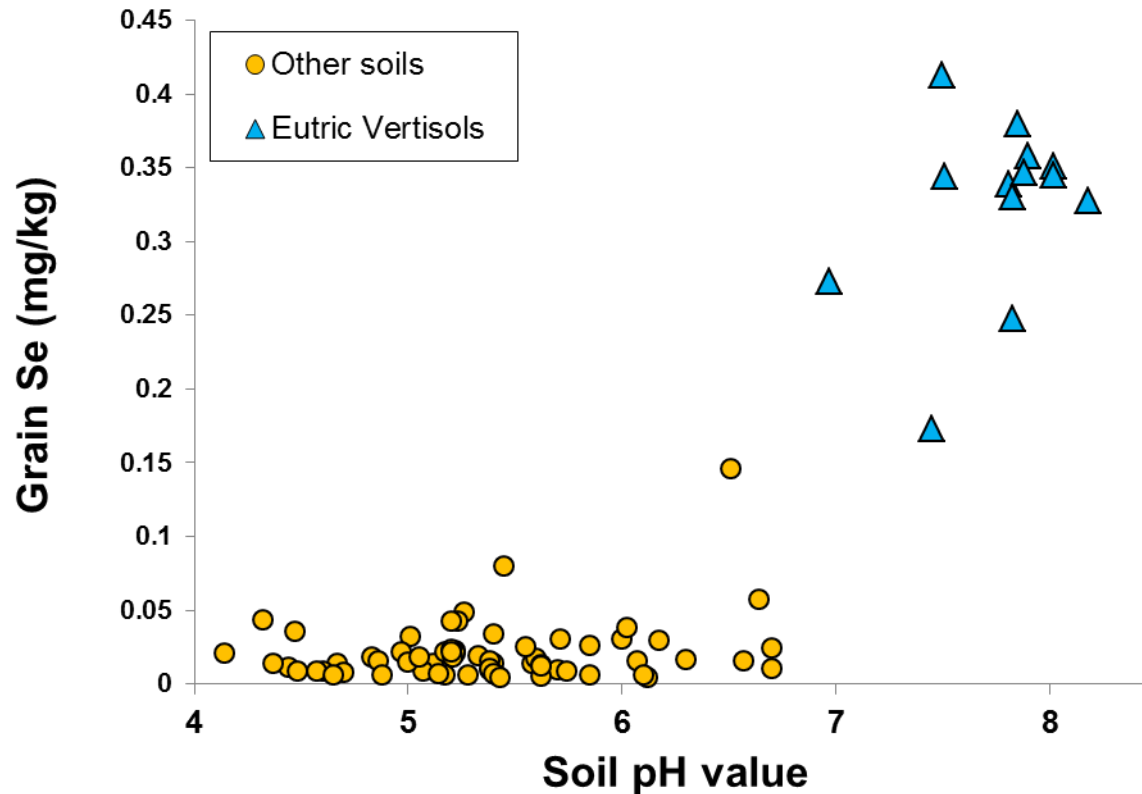
**Dr Allan Chilimba**  
**Prof Martin Broadley**

# Selenium supply in Malawi: maize-grain survey



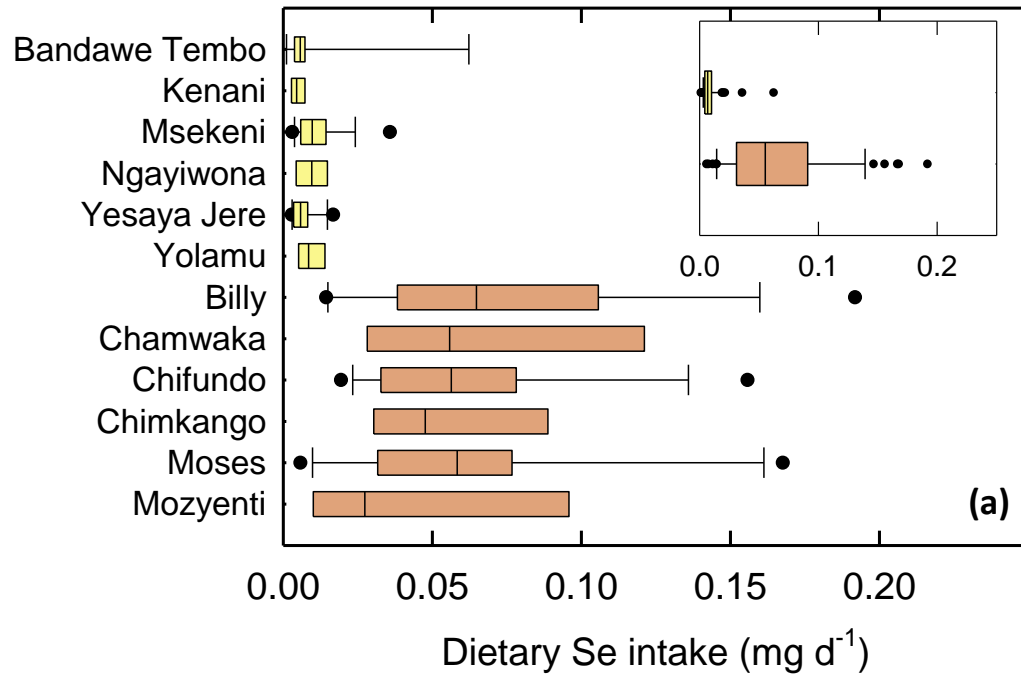
Chilimba ADC, Young SD, Black CR, Rogerson KB, Ander EL, Watts M, Lammel J, Broadley MR (2011). Maize grain and soil surveys reveal suboptimal dietary selenium intake is widespread in Malawi. *Scientific Reports*, 1, 72.

## Selenium supply in Malawi: maize-grain survey



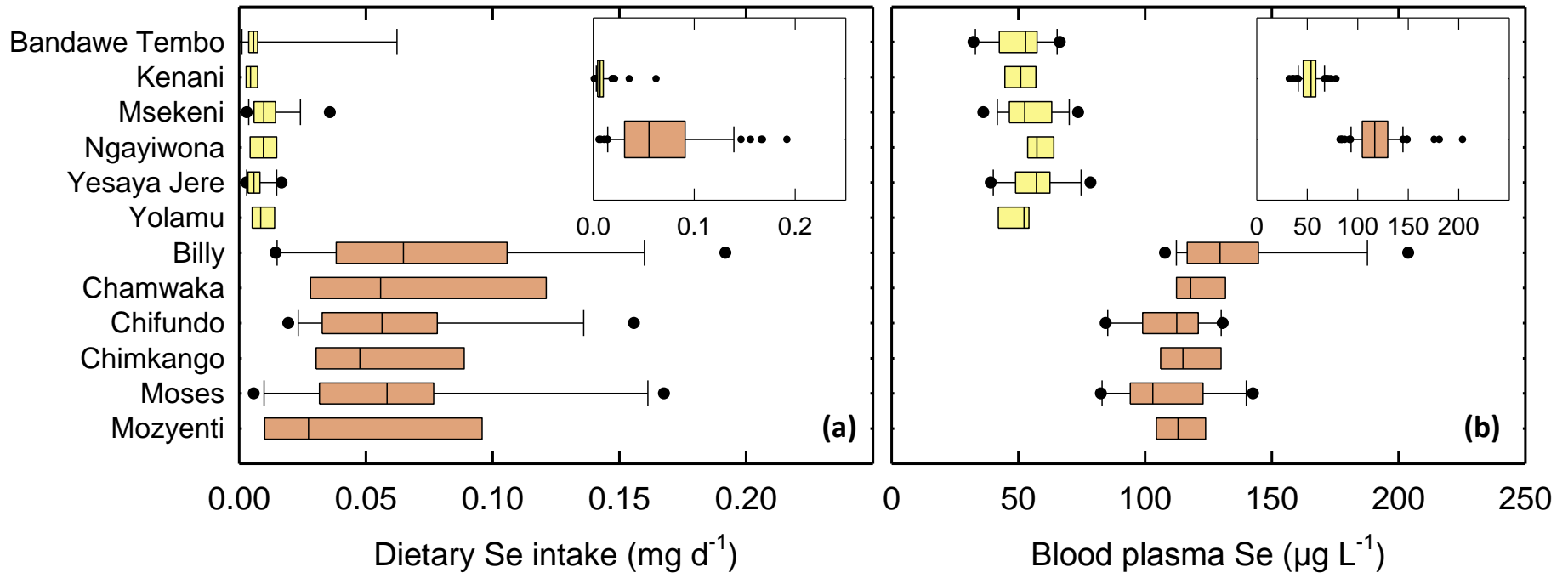
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# Soil geochemistry linked to selenium intake...



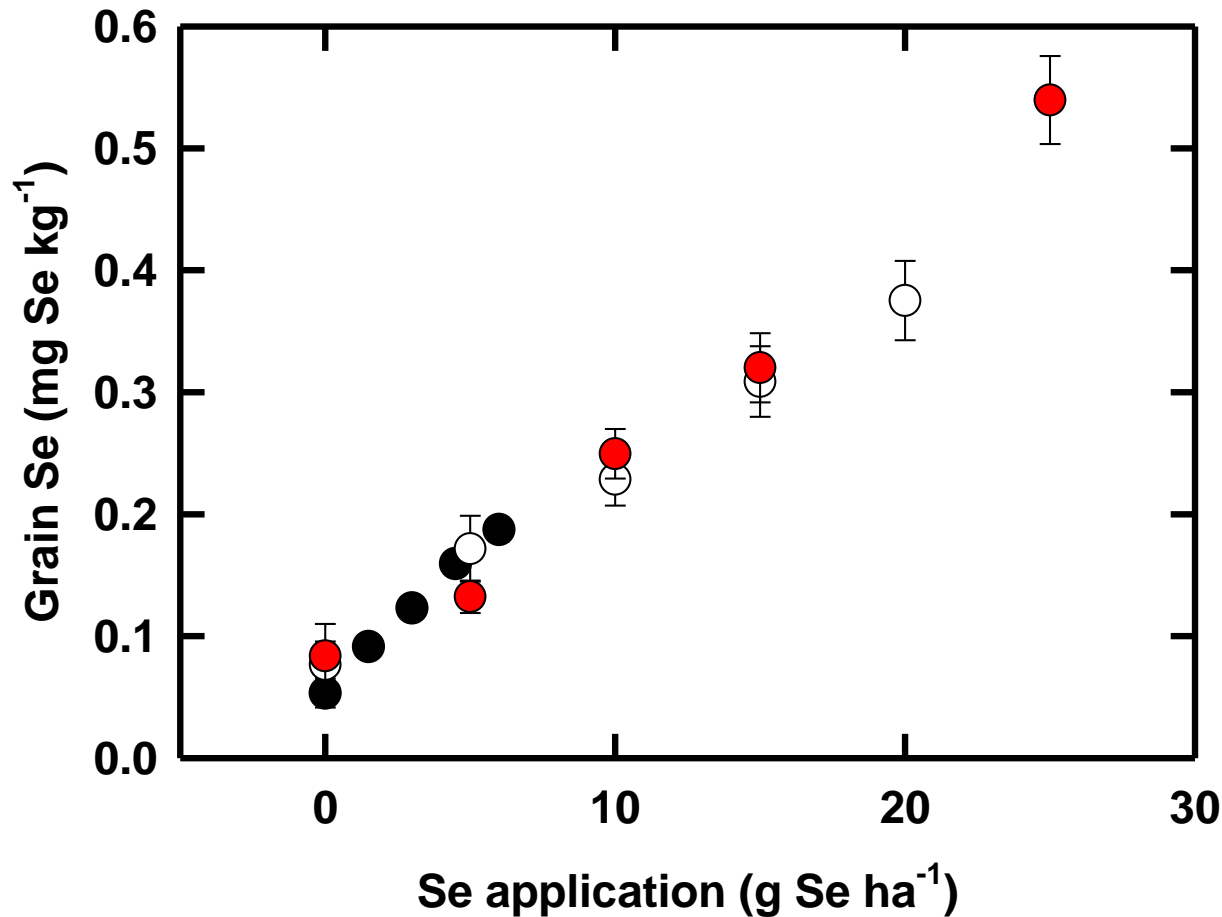
# Soil geochemistry linked to selenium intake...

...and status



= GeoNutrition!

# Agronomic biofortification Malawi: results summary



● Liquid drench  $y = 0.019x + 0.061$

○ CAN+Se (granular)  $y = 0.015x + 0.085$

● NPK+Se (granular)  $y = 0.022x + 0.056$

**~0.02 mg Se kg<sup>-1</sup> grain / g<sup>-1</sup> Se ha<sup>-1</sup>**

UK wheat – just as low/responsive to Se

## 2. AfSIS/iSDA

Geospatially explicit information

# Africa Soil Information Service (AfSIS)

[africasoils.net](http://africasoils.net)



ROTHAMSTED  
RESEARCH

Rothamsted led from Nov 2016-18

ICRAF, EI, ISRIC,

Ethiopia, Tanzania, Ghana & Nigeria national SIS

Now: **iSDA** Ltd – innovative Solutions for Decision Agriculture  
Company recently set up in UK, 2018



***Supply a wide range of decision makers (governments, industry, service providers, farmers) with business relevant soil, crop, and land information services for specific use cases***

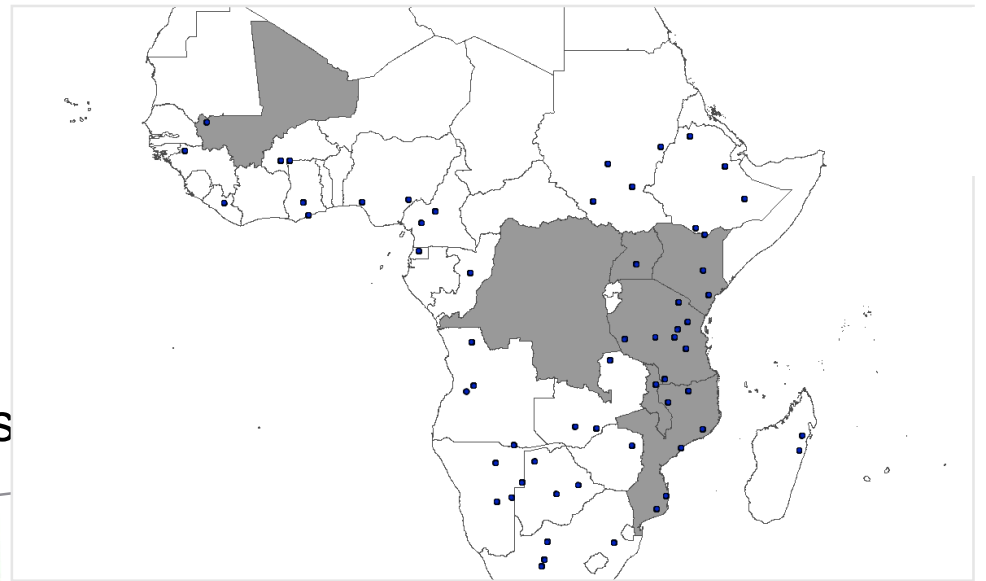


THE EARTH INSTITUTE  
COLUMBIA UNIVERSITY



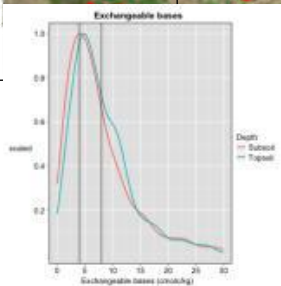
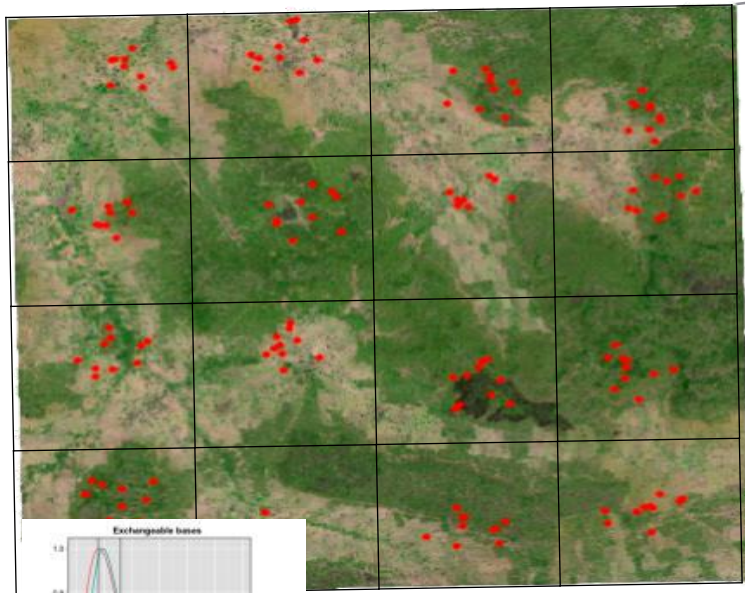
BILL & MELINDA  
GATES foundation



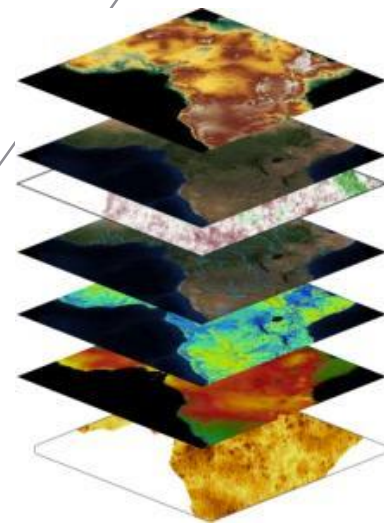


# Sentinel sites

## Randomized sampling schemes



Prevalence, Risk factors, Digital mapping



Coupling with remote sensing

Consistent field protocol



Soil spectroscopy



# Calibration of dry spectral instruments

PLANT



FERTILISER



SOIL

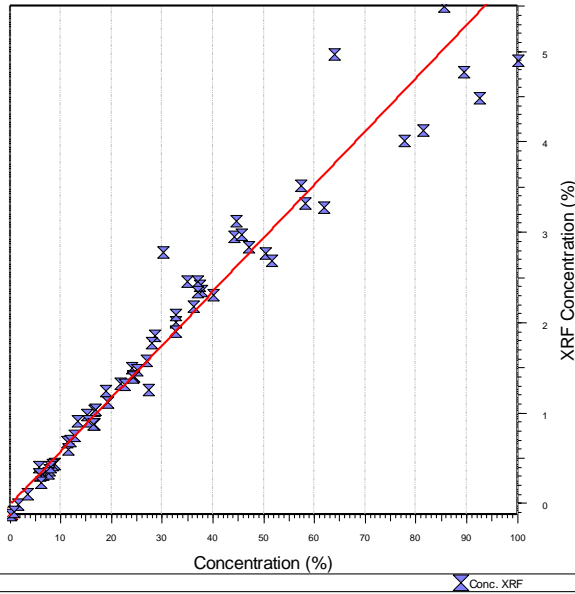


# Calibration of the XRF

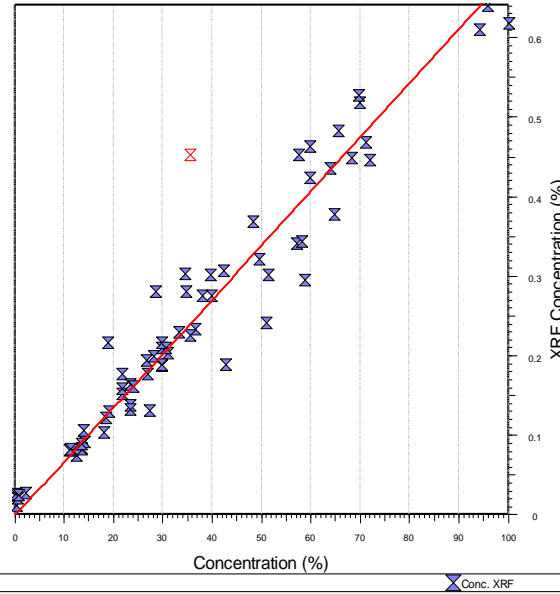
Plant, soil, fertiliser and organic manures

Plant standards (n = 67) analysed using ICP-OES/ICP-MS and XRF:

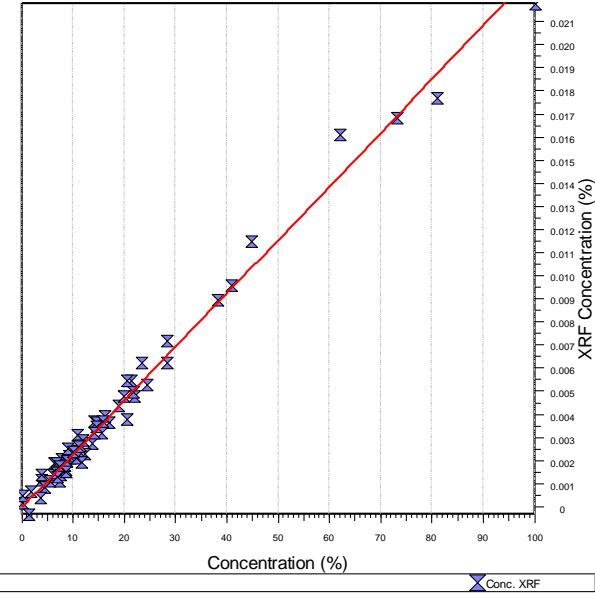
potassium-  $r = 0.95$



phosphorus-  $r = 0.94$



zinc-  $r = 0.99$



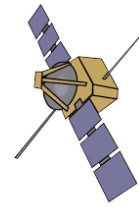
# AfSIS lab Arusha, Tanzania



amo



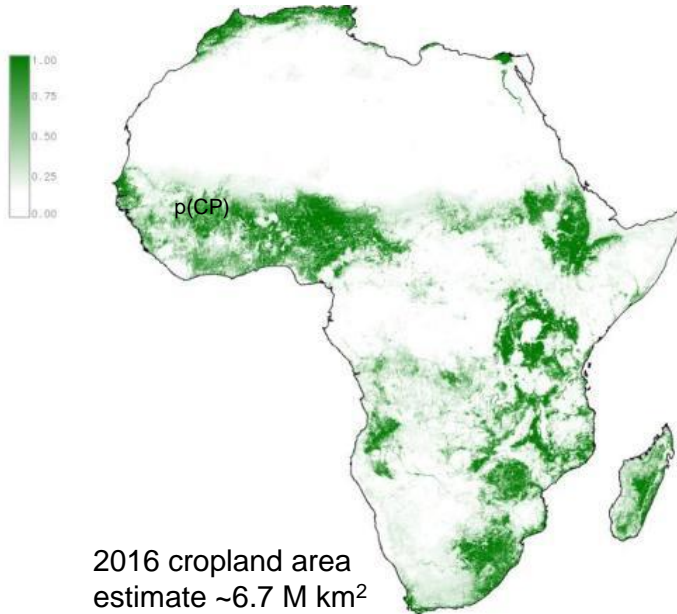
# Africa 2016 cropland area



Africa Soil Information Service  
africasoils.net

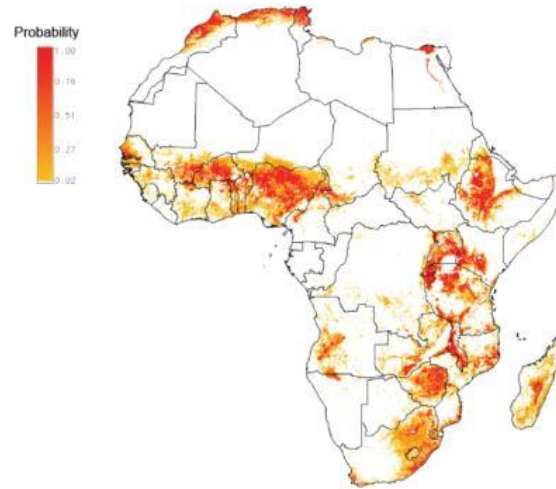


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2016 cropland area  
estimate ~6.7 M km<sup>2</sup>  
(of the total 30 M km<sup>2</sup>,  
African continent)

### 2015 Africa rural settlement probabilities



GeoSurvey - crowdsourcing



Cropland present?

Yes  No  Don't know

Woody cover greater than  
60 percent?

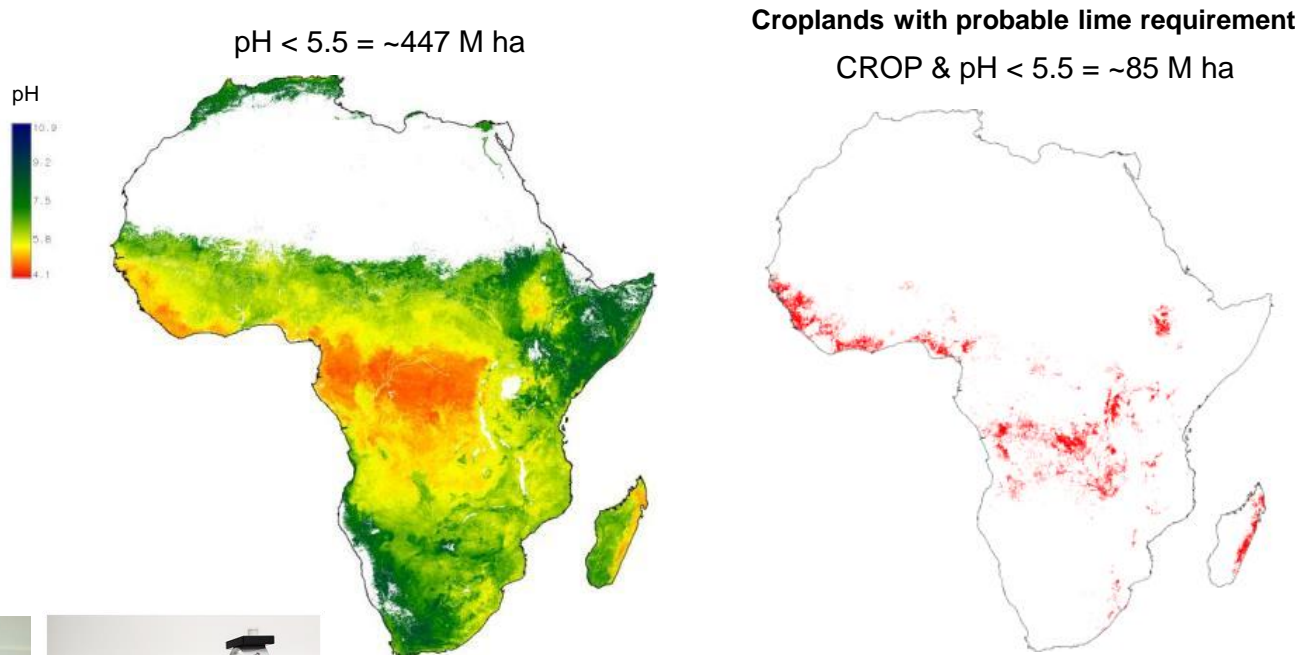
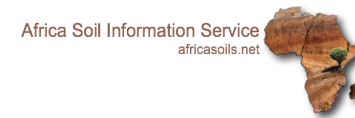
Yes  No  Don't know

Buildings present?

Yes  No  Don't know

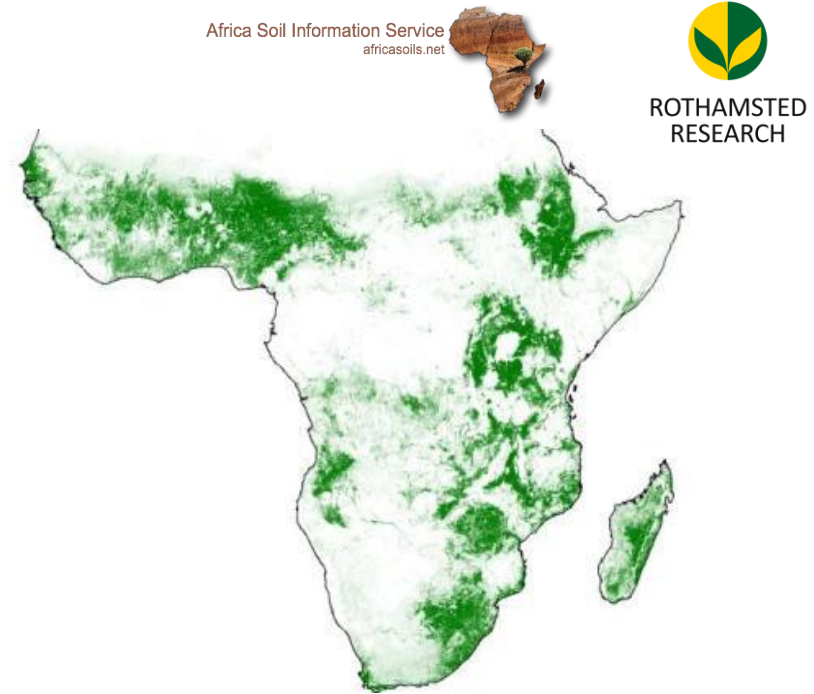
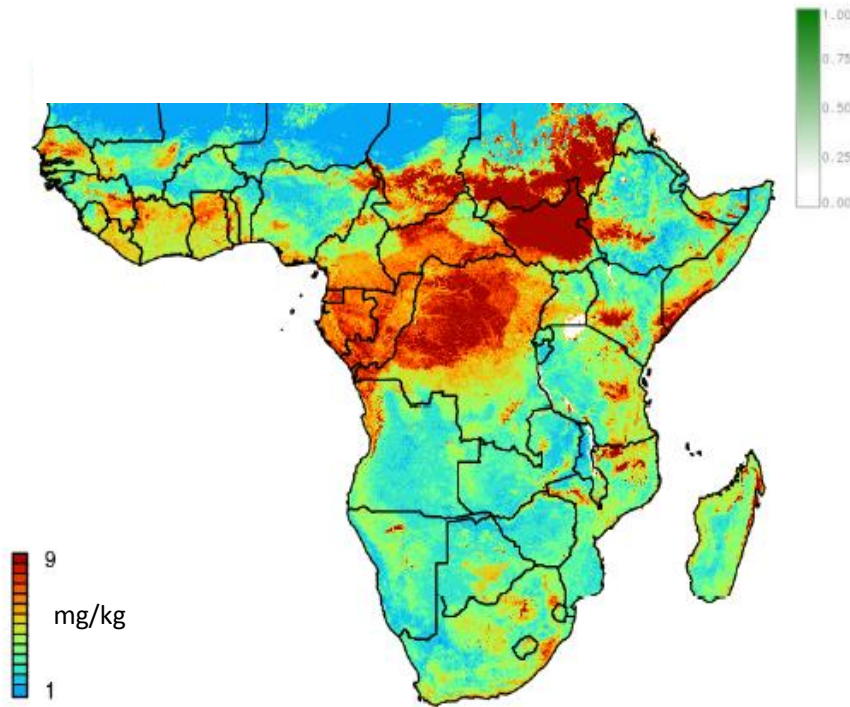
Keep me open  
[Close this bar](#)

# Predicted topsoil (0-20 cm) pH

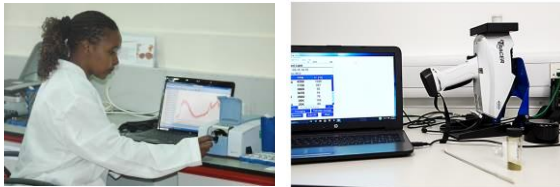


GeoSurvey – crowdsource  
MobileSurvey – sampling app  
Dry spectroscopy techniques

# Predicted topsoil (0-20 cm) extractable Zn



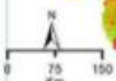
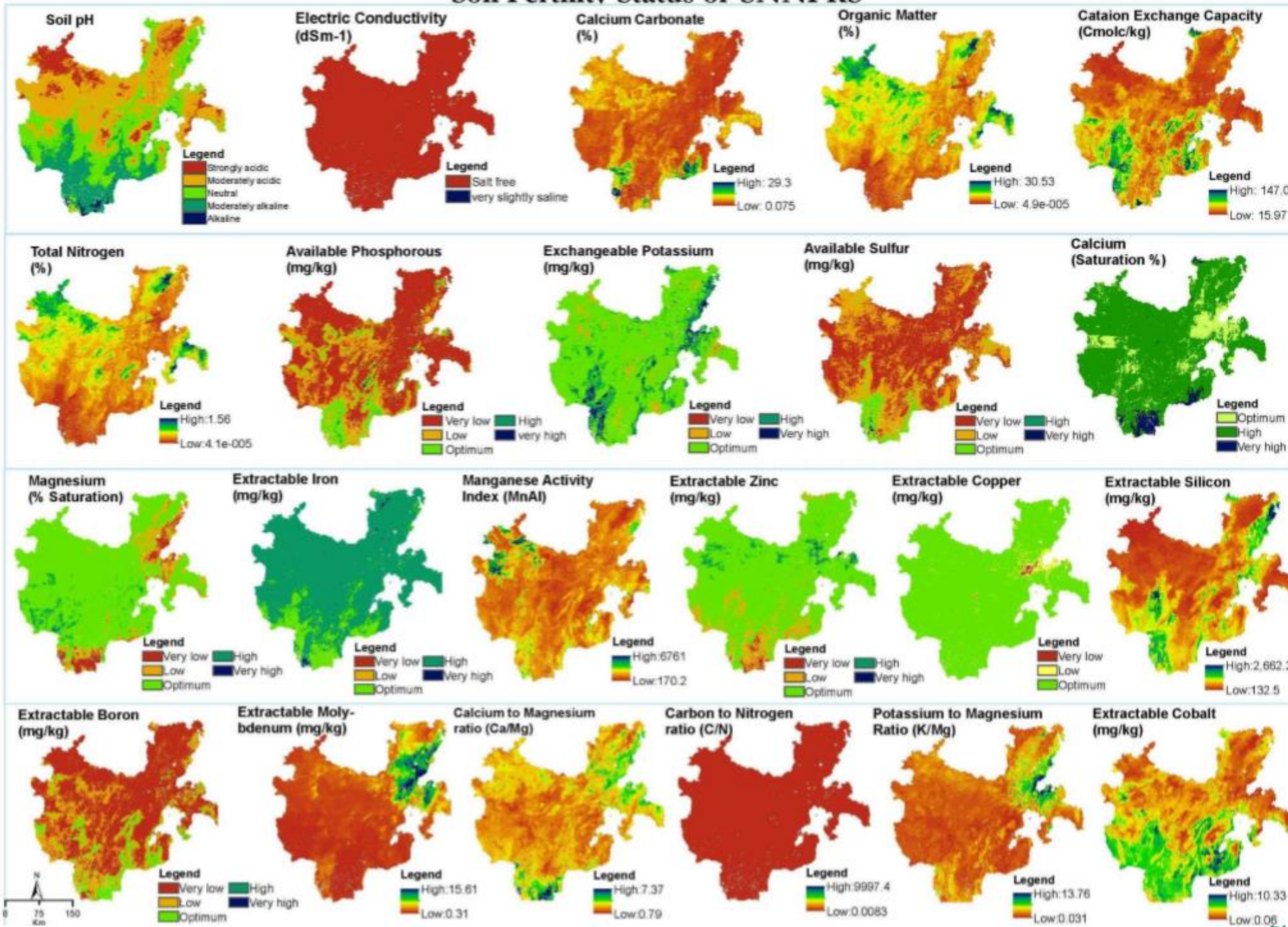
Blue or light blue – critical for crop growth



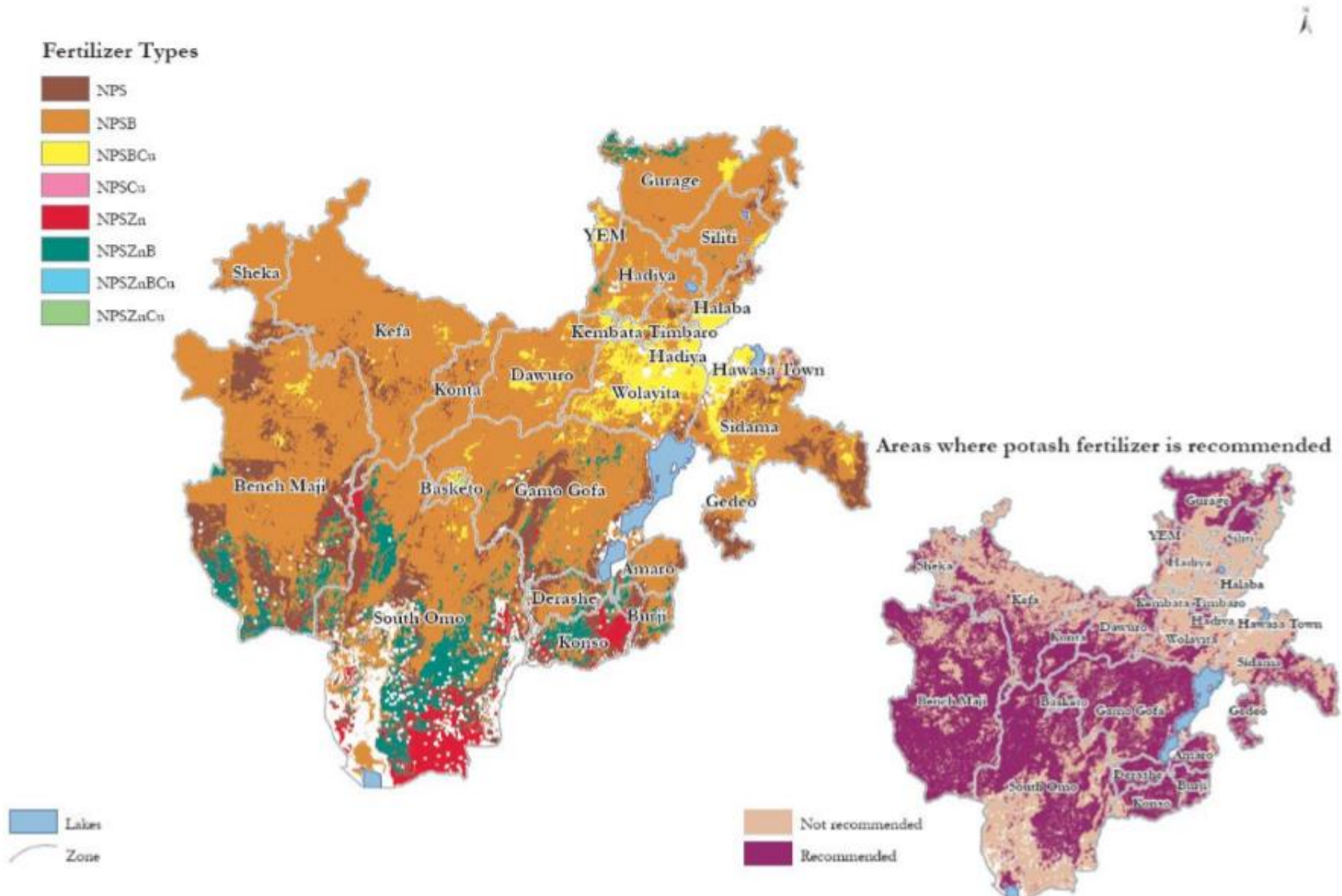
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# Soil Fertility Status of SNNPRS



# Fertilizers recommended for SNNPRS



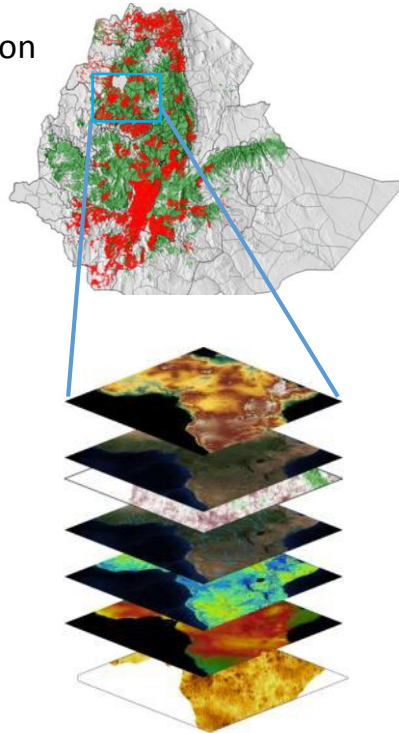
**In Dendi woreda (Oromia, Ethiopia), wheat crop (variety *Danda'a*) fertilized with DAP + Urea, micronutrients and sulfur outperformed the other plot with the same crop and variety fertilized with DAP and Urea only (2013)**



# 3. GeNutrition

## Geo:

- Geospatially resolved information
- Geography
- Geochemistry
- Crops
- Climate etc
- Data layers:



- Human biomarkers
- Dietary intakes
- Diet
- Crops
- Soil properties n
- Soil properties 3
- Soil properties 2
- Soil properties 1



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British  
Geological Survey  
NATURAL ENVIRONMENT RESEARCH COUNCIL



The University of  
Nottingham

Ethiopia (AAU, ATA)

Malawi (DARS, MoH, CHSU, LUANAR)

1 **GCRF** Pilot areas, mapping, linkages  
Global Challenges Research Fund

2 **BILL & MELINDA  
GATES foundation**

Most cropland,  
Mapping, linkages,  
intervention studies



**BBSRC**  
bioscience for the future

# Conclusions

- Biofortification method – depends on the nutrient of interest
- Micronutrient content depends on variety, soil conditions, climate
- Need diagnostics, and spatially explicit recommended interventions
- Collaboration

# Acknowledgements



Ethiopia (AAU, ATA)

Malawi (DARS, MoH, CHSU, LUANAR)

