FERARI
FERTILIZER RESEARCH & RESPONSIBLE IMPLEMENTATION

IFDC

IFDC Modelling and Mapping Information System

IFDC 2023

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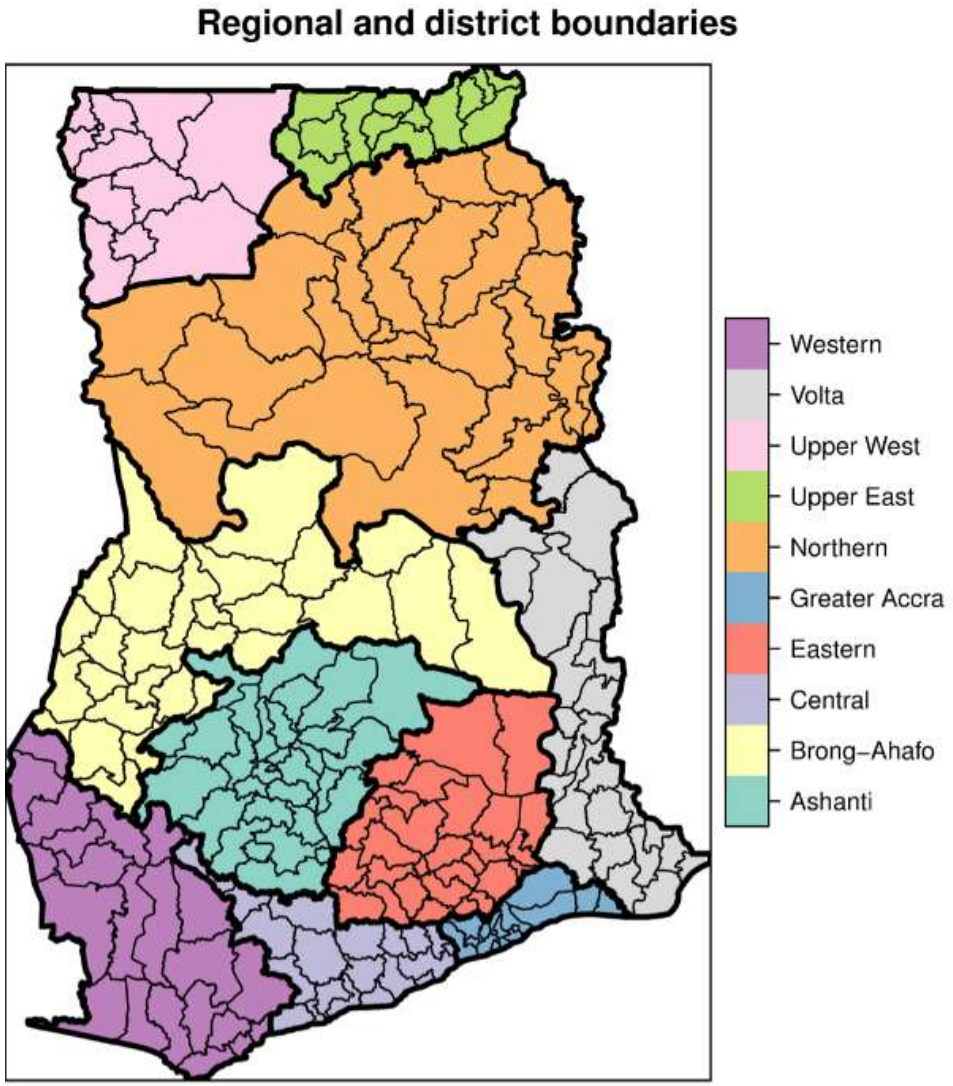
Why spatial analyses

- Where to use what fertilizer products and amounts
- Fertilizer products and use specified for
  - Soil properties (chemical and physical) / soil type
  - Crops
  - Weather
  - (Socio-economic factors)
- Targeting plant fertilization for yield, human nutrition and health
- Optimizing (agronomic/economic) nutrient use efficiency of fertilizers
- Optimizing logistics
  - Fertilizer value chain optimization
  - Marketing optimization
- Assessment regional and national production volumes
  - For import-export policies
  - For impact assessment
- For most of these purposes, maps at a resolution of 1km*1km could be sufficient.
  - (We may aim for 100m*100m)

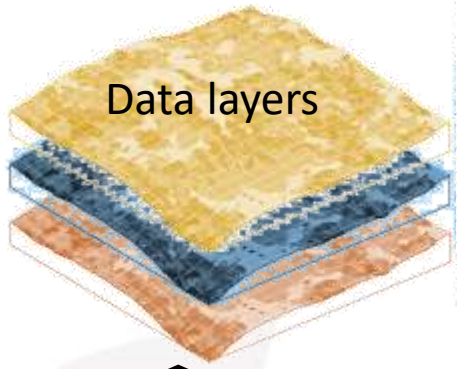


IFDC – Modelling and Mapping Information System

Legacy data
(Fertilizer – yield responses)

New data (trials)
(Fertilizer – yield responses)

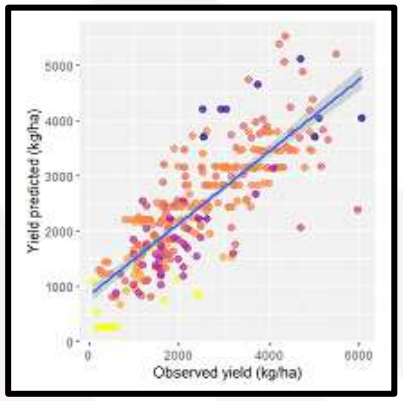
IFDC fertilizer - crop response database
(national, supra-national (e.g. West Africa), Continental African)



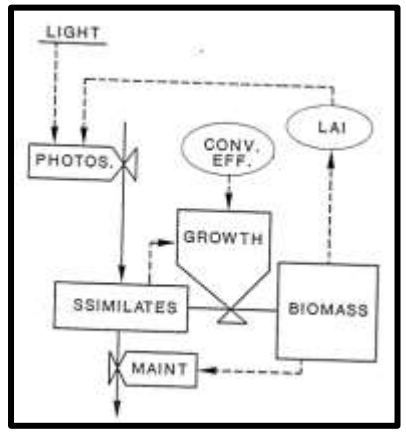
Legacy auxiliary variable data

New auxiliary variable data

IFDC co-variate layers
(weather, soil, landscape, close/remote sensing, ….)



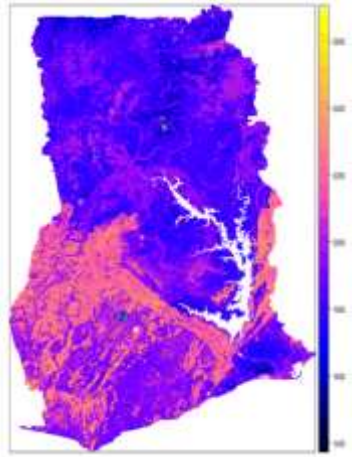
Advanced statistics
Crop-soil modelling
Machine learning



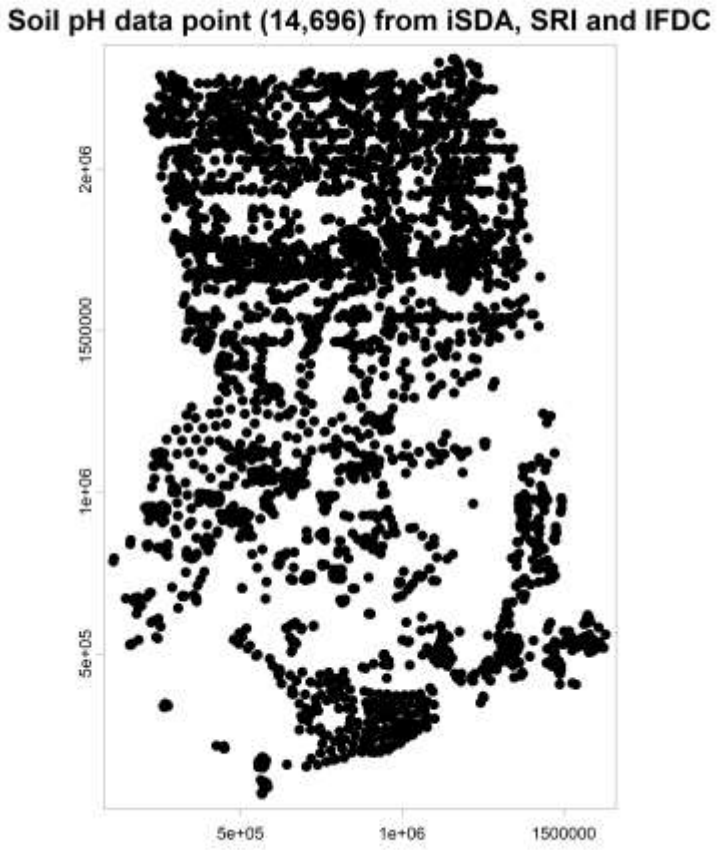
Local / Cyber infra-structure

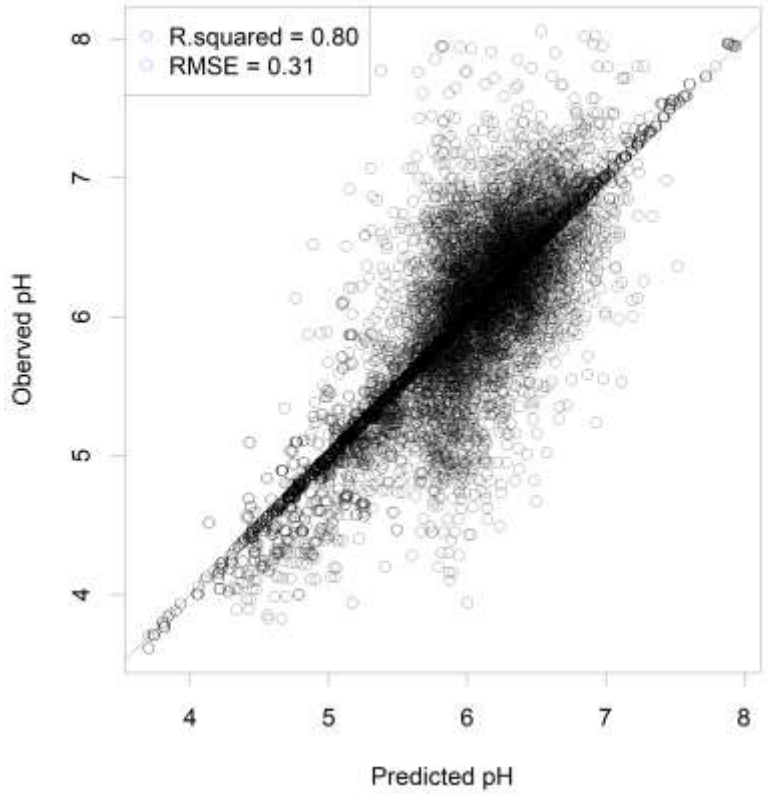
Anticipated: Socio-Economic data

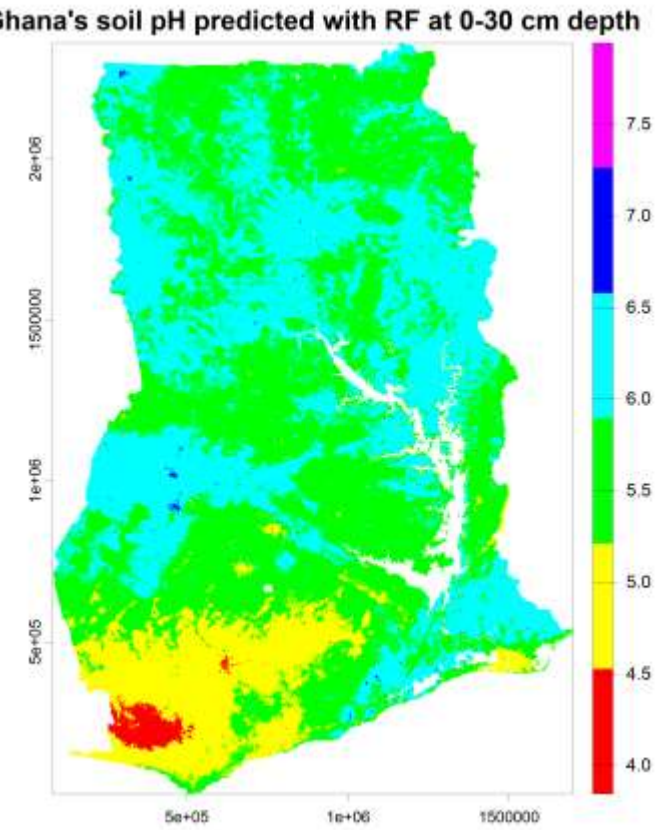
- Location/crop specific recommendations
- Fertilizer requirements
- Yield predictions
- Production volumes



Machine Learning for Soil Mapping



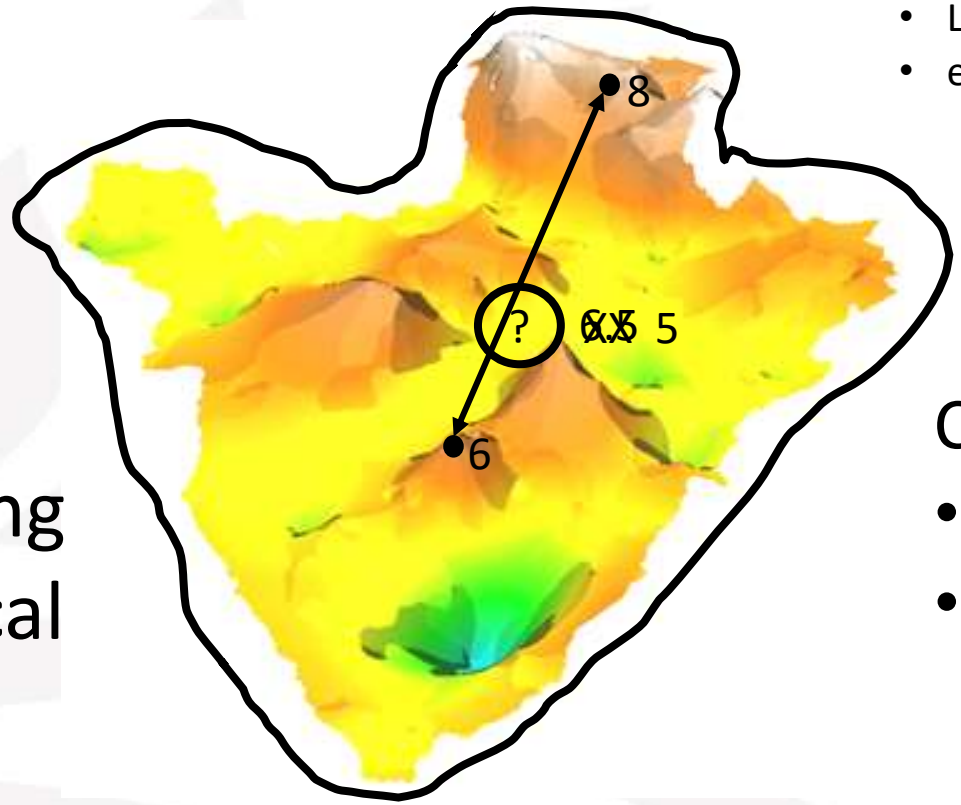


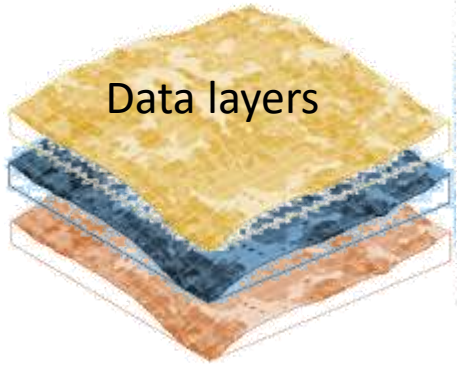


How do we make spatial maps?

- Soil data points
- Co-variates
  - Rainfall
  - Temperature
  - Relief
  - …

- More soil data points improves the map
  - Till an optimum
- Accurate co-variates
  - The more weather stations the better
  - Digital elevation maps
  - Land use maps
  - etc





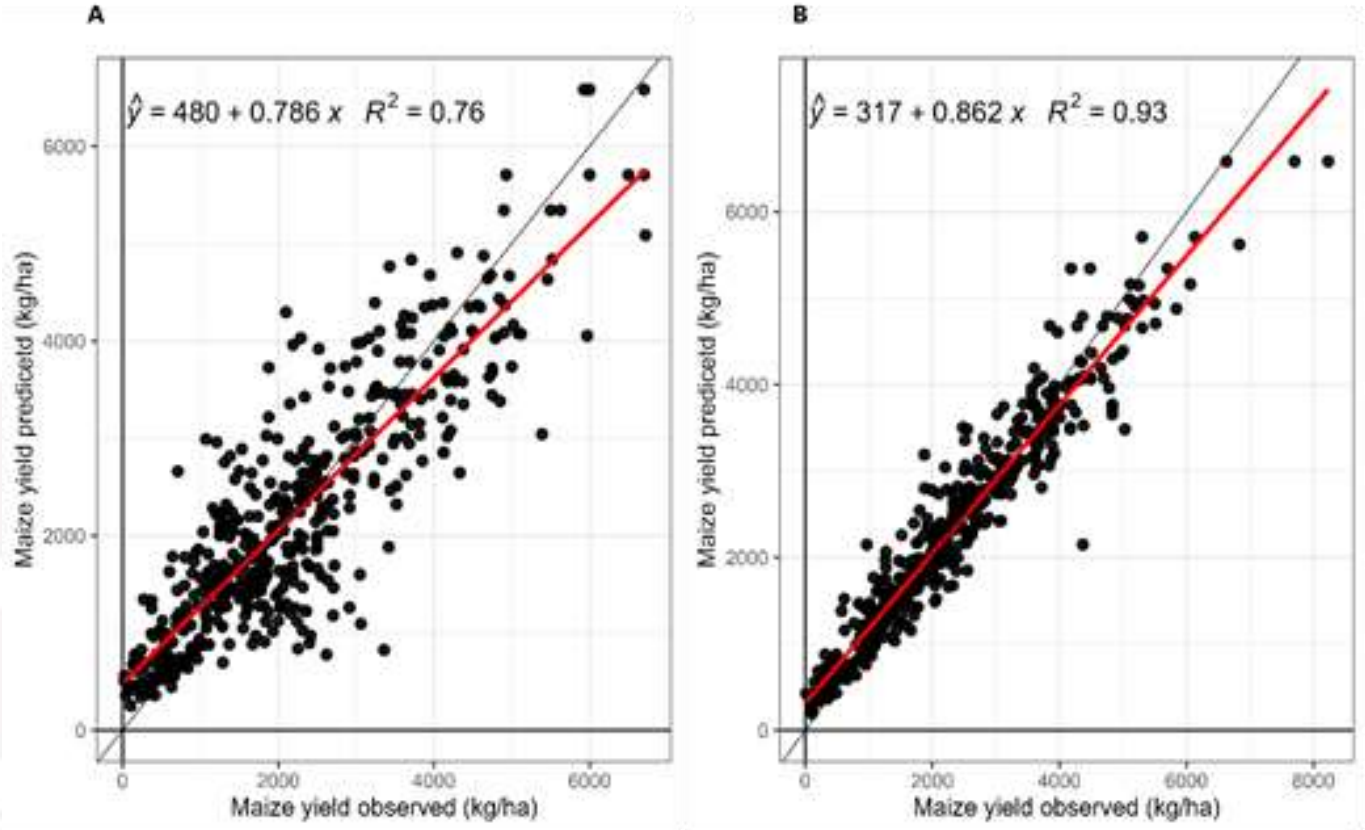
Machine learning and geostatistical methodologies

Collecting data will never stop

- Make a baseline map
- Adjust version with increasing data points

Fertilizer recommendations – what information is needed?

- **Fertilizer – Yield Response**
  - 978 data points
  - Yield(s) = f (Elev + Rain + Tmax + Corg + Norg + POlsen + pH + Rzd + Sand + Clay + Silt + FN + FP + FK) (s) + ε(s)
  - Explain ± 80% of variability



- **Crop yield is determined by**
  - Soil chemical properties = nutrients for plants (±25%)
  - Soil physical properties = water for the plants (±25%)
  - Weather conditions = rainfall, temperature, … (±25%)
  - Other … (management)

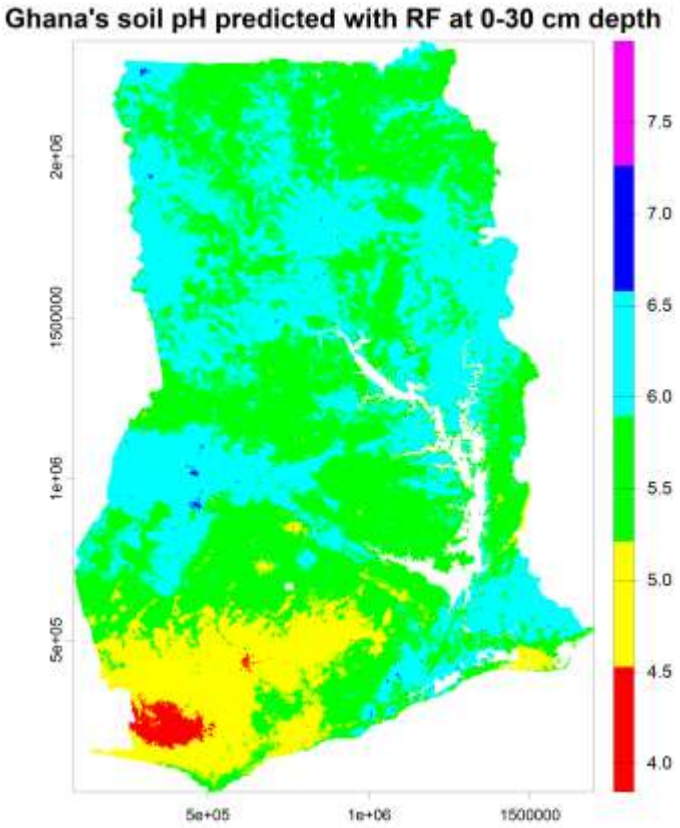
Kouame, K.K.A. Bindraban, P.S., Kissiedu, I.N., K., Atakora, W.K., El Mejahed, 2022. Identifying drivers for variability in maize yield in Ghana. Agricultural Systems (Accepted)

Fertilizer recommendations – spatial analyses

- Soil map
  - One of the ESSENTIAL data layers, but NOT ENOUGH, to arrive at fertilizer recommendations
- Auxiliary data for fertilizers recommendations
  - Weather data, Landscape data, land use, (socio-economic, management)
- Fertilizer – yield responses: large spatial variability
- Fertilizer recommendation maps needed

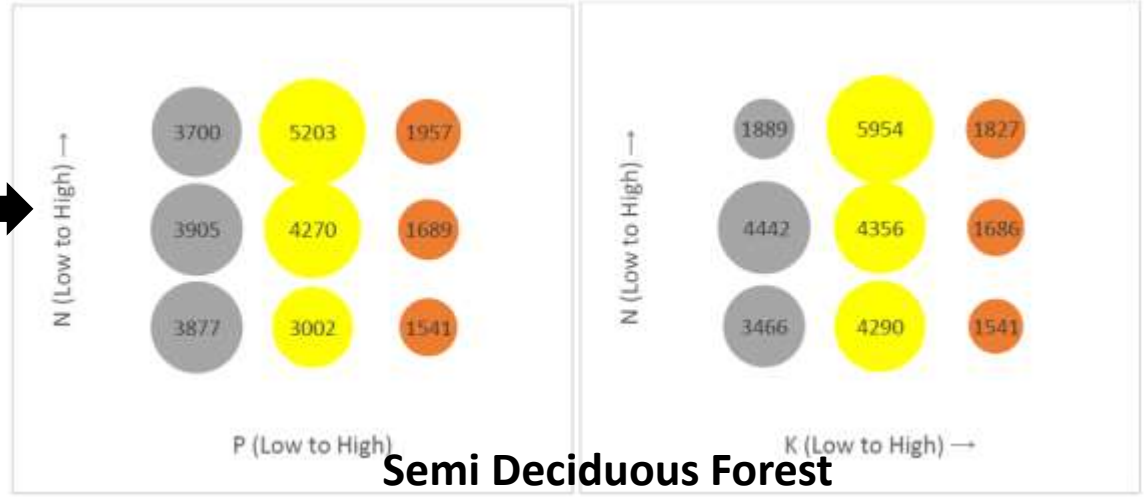
- Optimizing logistics
  - Fertilizer value chain optimization
  - Marketing optimization

- Assessment regional & national production volumes for Fertilizers and Food
  - For import-export policies & business
  - For impact assessment
- …

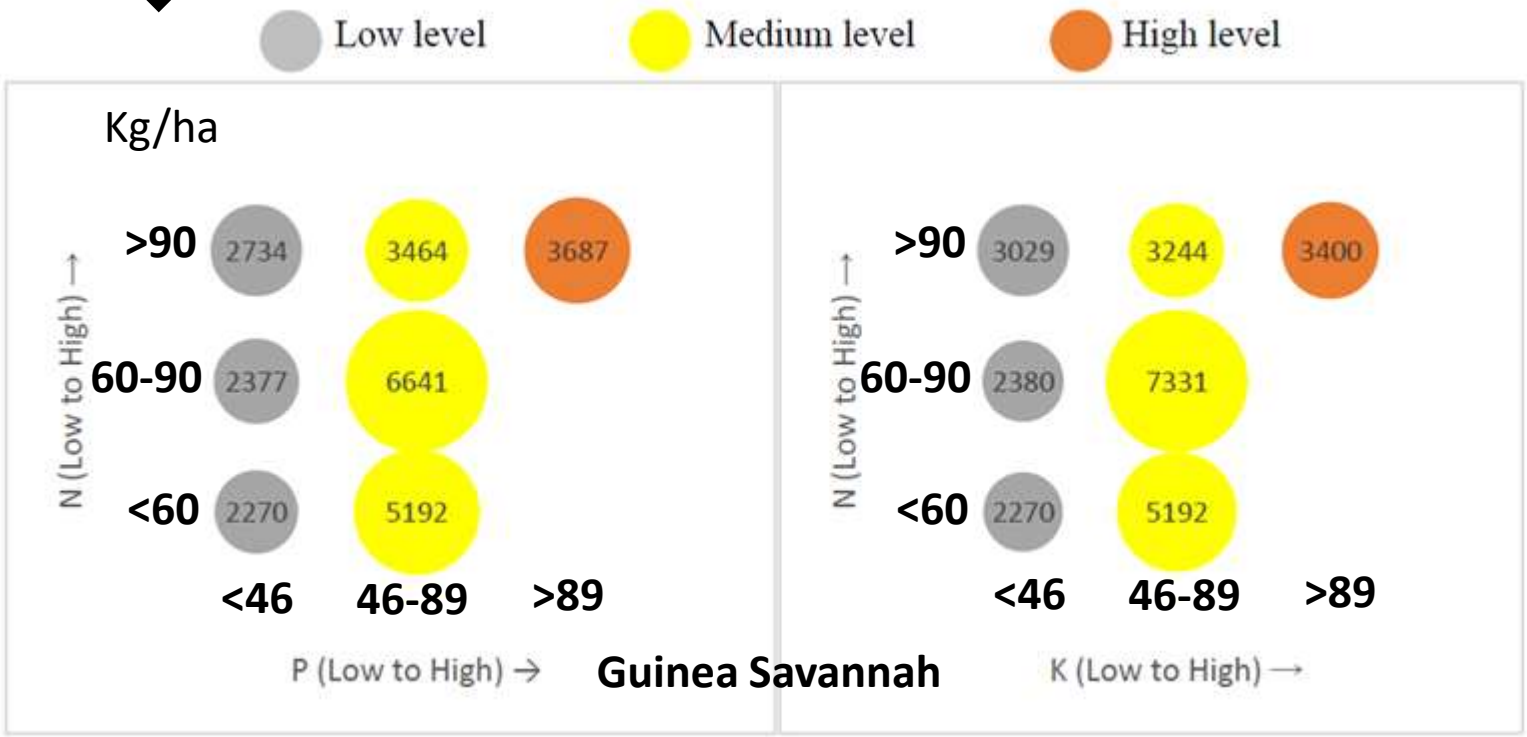


NPK composition

- Higher N rates in Semi-Deciduous Forest (but max yields lower)
- Medium levels of P and K
- More is not better (for yield)
- Lower optimal rate for N in Guinea Savannah (max yields high)



Semi Deciduous Forest



Guinea Savannah

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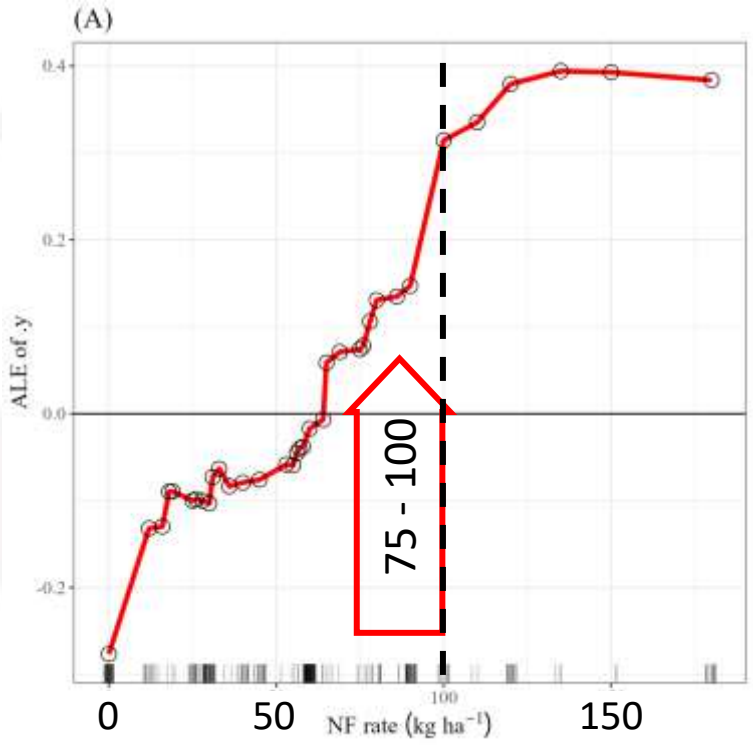
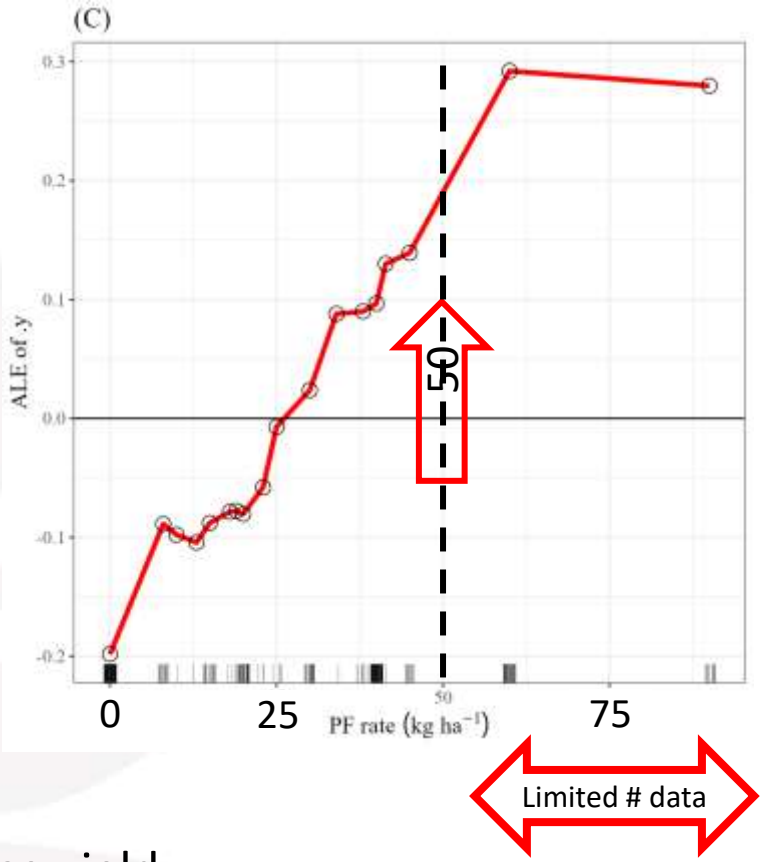
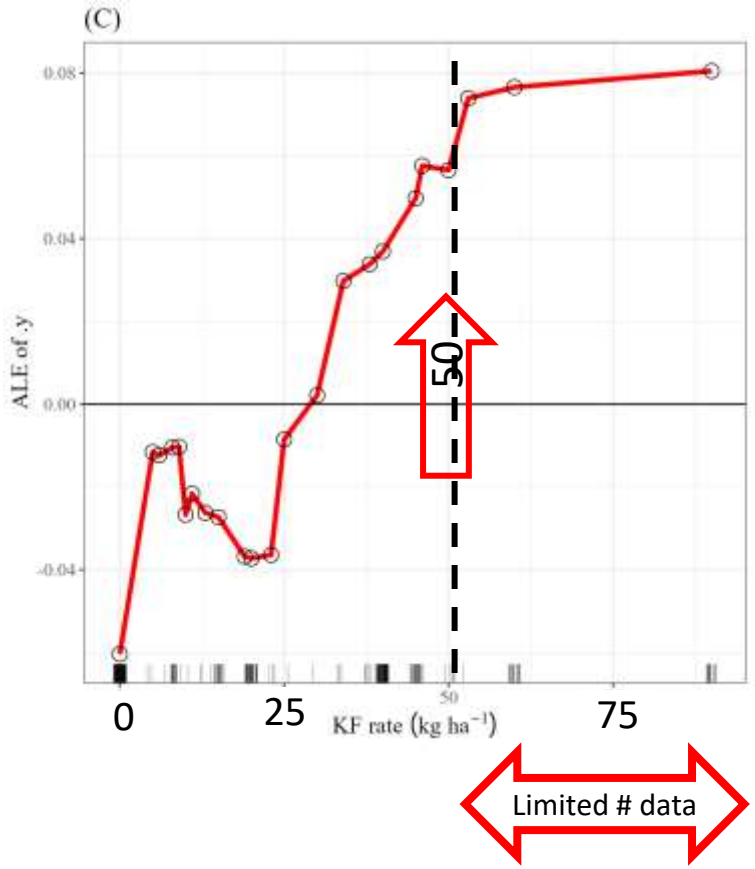
Statistical rational for recommendation rates



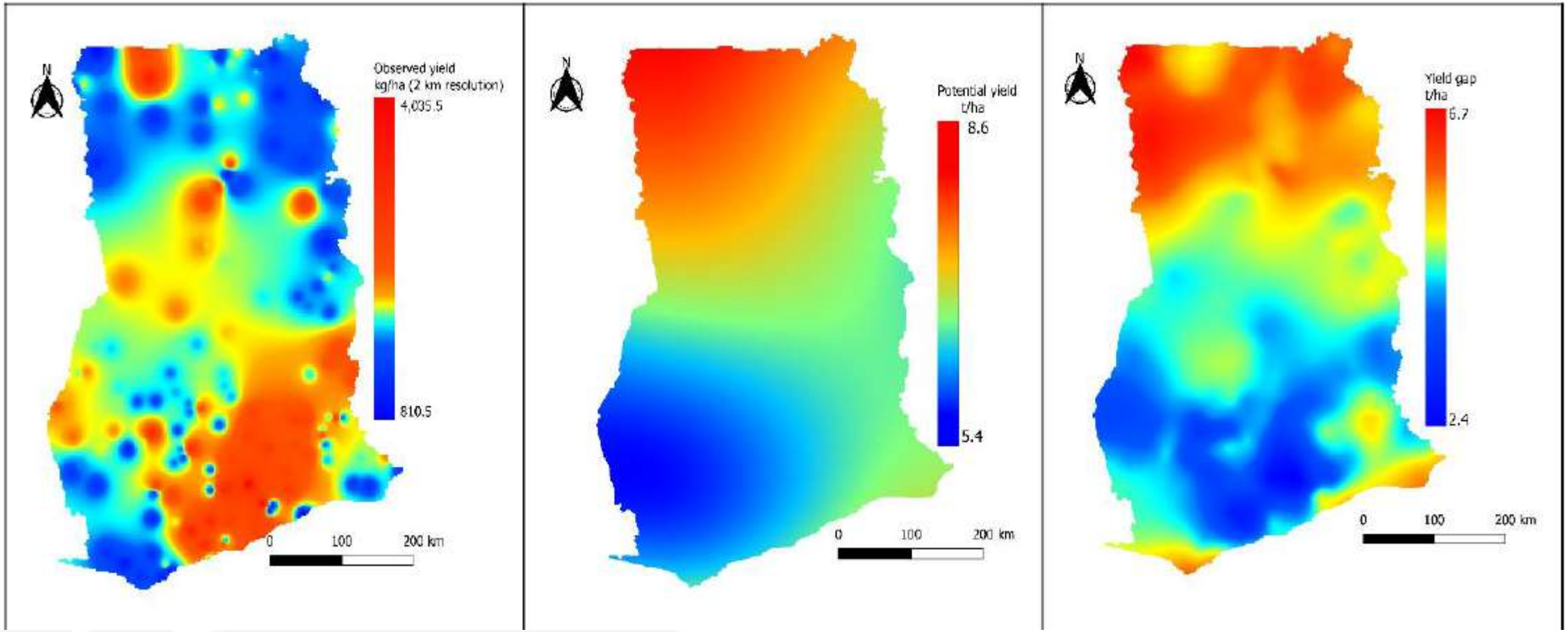




- Based on 1074 data points
- N rates up to 100 kg/ha increase yield
- P rates up to 50 kg/ha give highest responses
- K is essential to exceed 30 kg and maximal around 50 kg/ha

ALE: Accumulated Local Effect; Average variable influence of the prediction of a machine learning model.

Initial spatial yield and yield gap analysis



Boullouz, M., Bindraban, P.S., Kissiedu I.N., Kouame, A.K.K., Devkota, K.P., Atakora, W.K., 2022. An integrative approach based on crop modelling, geospatial and statistical analysis to quantify and explain the maize (Zea mays) yield gap in Ghana. Front. Soil Sci. 2: 1037222. https://www.frontiersin.org/articles/10.3389/fsoil.2022.1037222/full

"Generic" NPK recommendation - PRELIMINARY

1 bag = 50 kg

"Generic" application rates [N, P (P_2O_5) and K (K_2O)]: ±75 : ± 50 : ± 50 kg/ha Maize/Rice (no urea for soya)

- GS: Option N:P_2O_5:K_2O ratio ≈ 11-21-22 (5 bags/ha) (or 10:20:20) + Urea: 50 kg/ha (2 bags/ha)
- DF: Option N:P_2O_5:K_2O ratio ≈ 11-21-22 (5 bags/ha) (or 10:20:20) + Urea: 50 kg/ha (3 bags/ha)

- Guinea savanna 73 – 52.5 – 55 NPK per ha → **initial recommendation to be detailed**
- Deciduous Forest 96.5 – 52.5 – 55 NPK per ha → **initial recommendation to be detailed/reduced**

Current government recommendation (maize / rice)

- Guinea savanna 90 – 60 – 60 kg NPK per ha
- Transitional/ Deciduous Forest 100 – 40 – 40 kg NPK per ha

- Our analyses confirm the current recommendation rates
- Yet, the associated yield should be about 5-6 t/ha
  - Yield gains in Guinea Savanna from 1 to 4-6 t/ha gap: (3-5 t/ha gain)
  - Yield gains in Transitional/Deciduous Forest from 3-4 to 5-6 t/ha gap: (2-3 t/ha gain)

- Current farmer yields between 1.5-2.5 t/ha
- Auxiliary farm measures needed to increase fertilizer use efficiency at these recommended rates

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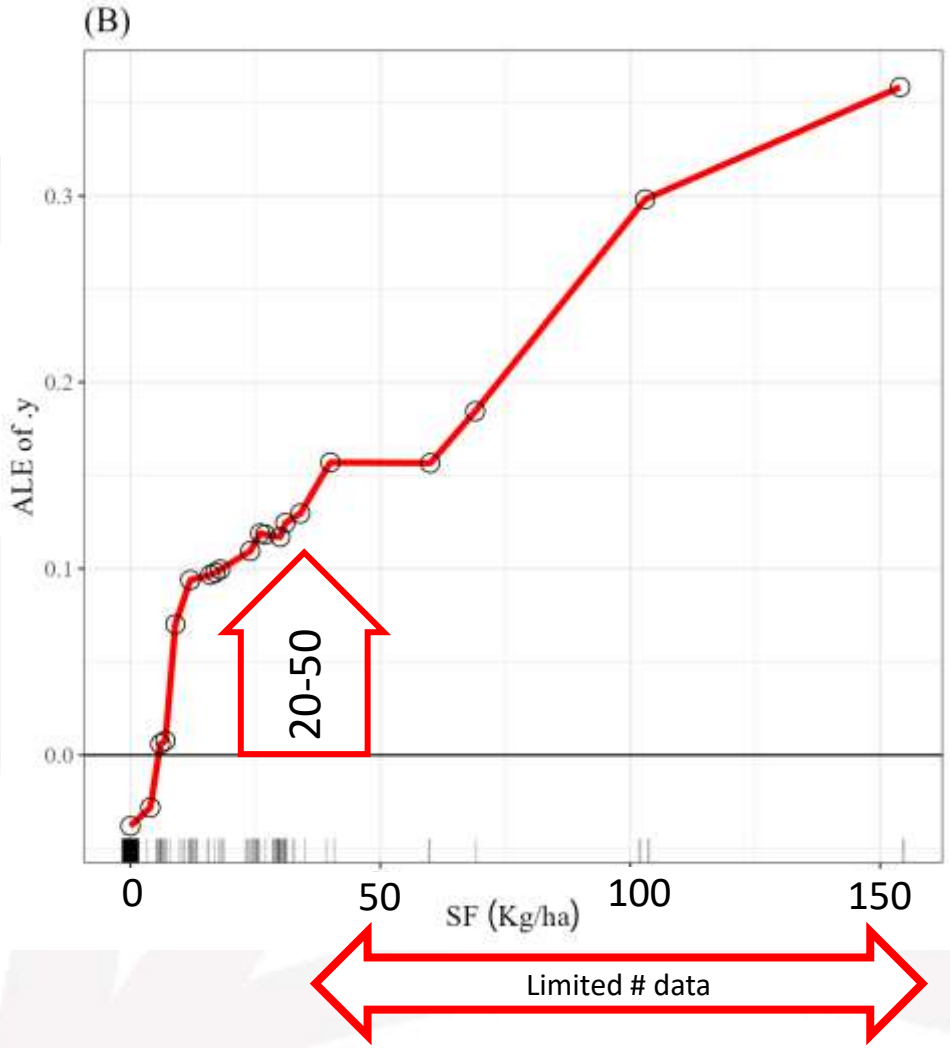
Further Rationale for S



- Based on 1074 data points
- S rates between 20-50 kg/ha give high responses

Sulphur (relative to NPK)

- Farmers estimate yield with S to be higher

Maize
NPK with S proved to be more effective in increasing yields than NPK (Adzawla et al.)

- S increases yield by 0.5-1.5 t/ha

Maize
NPKS gave 1.5, 0.9, and 0.4 t ha^{-1} more in SS, GS, and DF, respectively, compared to NPK (Bua et al.)

- Yield trials → inconsistent effect of S_{soil} / S_{foliar} works sometimes
- Analyses by Kouame → S emerges as important
- Trials Kassim → large S effect on Yield

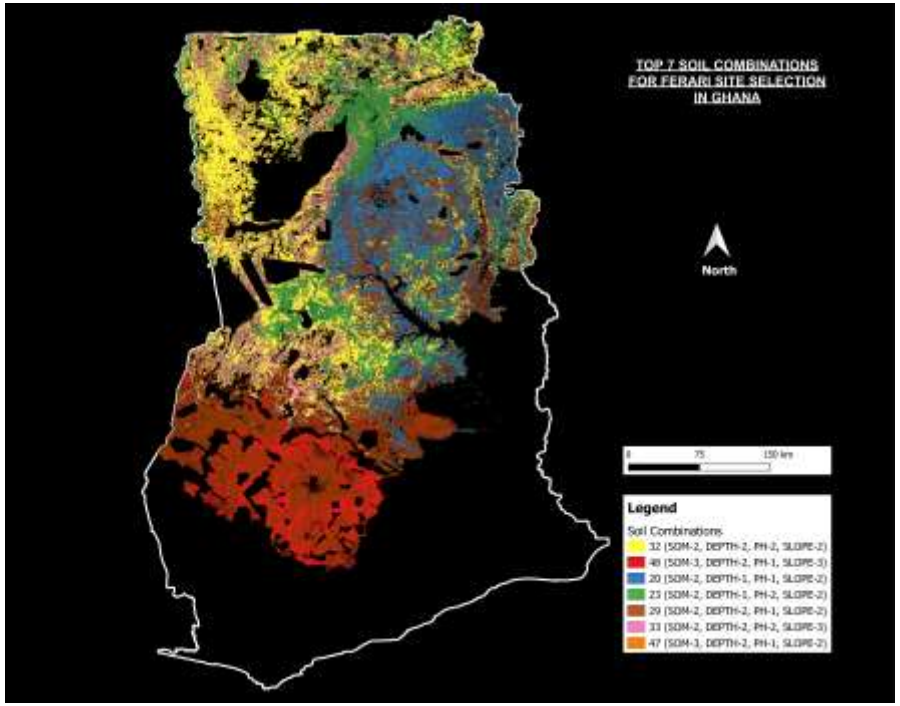
S application increase yield by 0.5-2 t/ha (Maize), 0.5 (Soya) (Kassim et al.)

- S rate ≥ 20 kg /ha

- S has higher impact on yield in the North (1.5 t) than in the South (0.5t)
- S important in the North to close the yield gap

(NPK)**S** trials in 2023

- Confirmation trials in 2023
  - These trials on the 7 largest representative soils?



- 1.2 M ha maize Ghana
  - ➔ NPKS: 11-22-21-5S: 5M bags + 2.4M bags Urea
  - ➔ Production increase: 1.2 Mha * 1.0 t/ha = 1.2 Mtons Maize (in addition to current 3Mt)
  - ➔ Total added value (1 ton maize = 3k GHS): 3600M GHS ~ 360M$
  - ➔ ± 600k farmers (cost:benefit ~ 1:2) ➔ Income increase ~ 300$ (assumed cost 150$/ha)

NB. ± 50 maize farmers household consumption; 50% market oriented

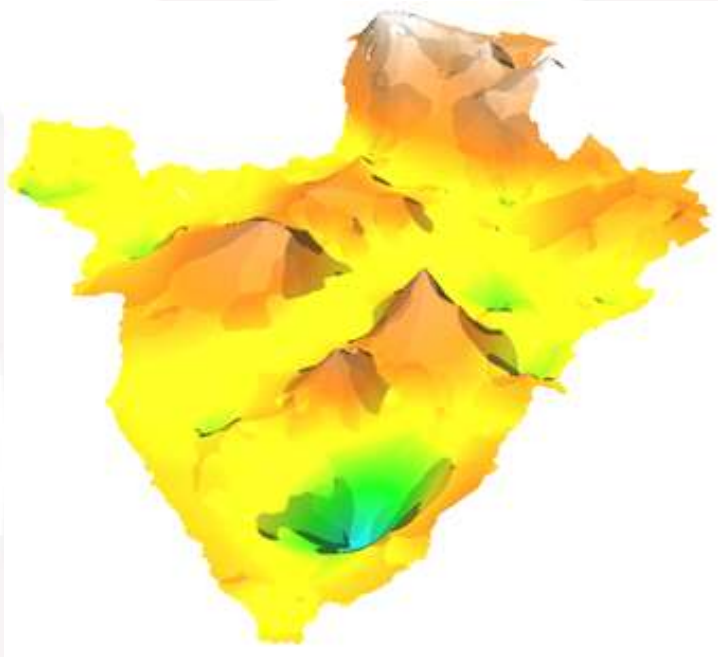
Farmers use ± 150-300 kg fertilizers /ha

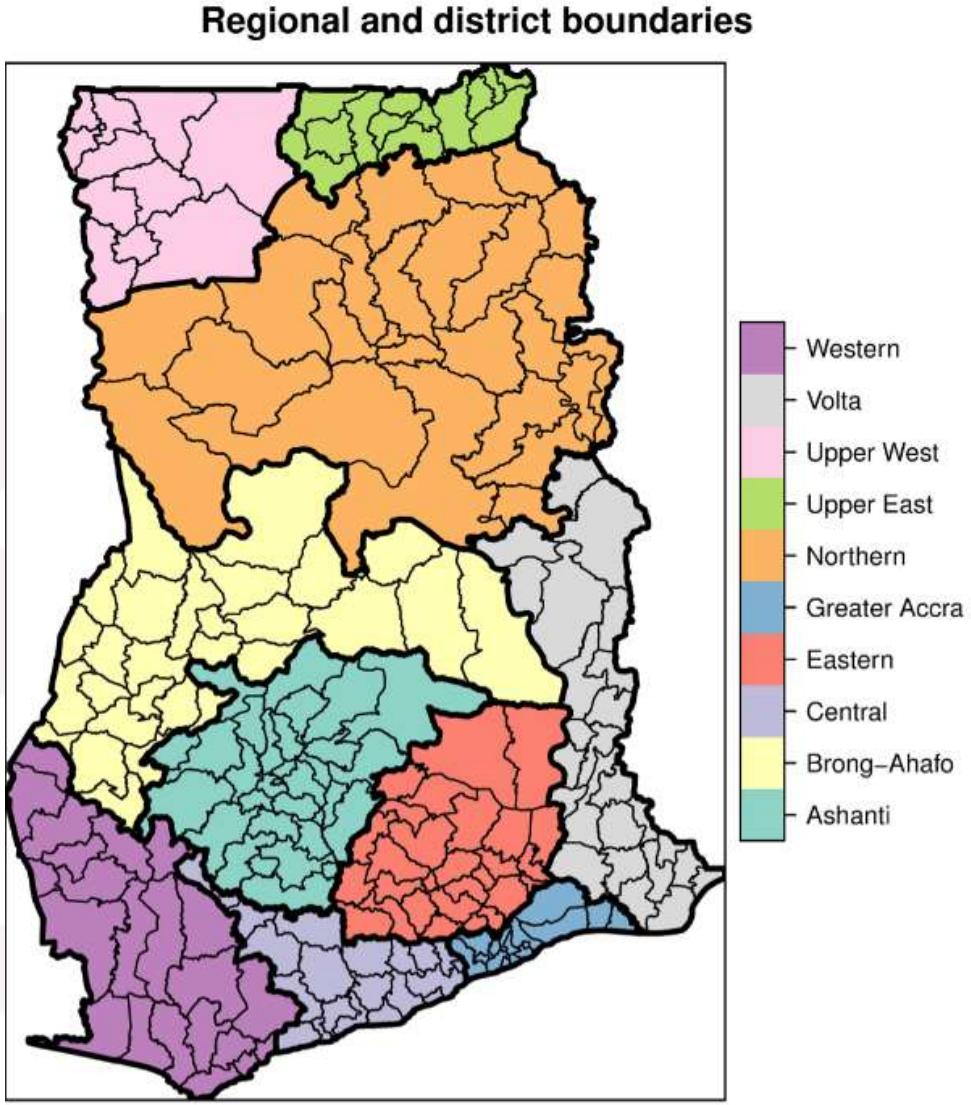
Ultimate fertilizer recommendations

Target: e.g. Maize yield = 3 t/ha

≡

NPKS recommendation rates





Soil-Crop Modelling and Mapping Services

OUR **EXPERTISE** ON **YOUR** SIDE

The use of mineral and organic fertilizers is essential for agricultural intensification. To maximize its effectiveness, we can tell you **where to use what fertilizer product, in what amounts, for what crop yield level**. We specify this information on spatial maps based on:

- Soil chemical and physical properties
- Crop type and varietal characteristics
- Climatic conditions
- Socio-economic and farm management conditions

TRAINING AND EDUCATION IN **REALISTIC** FERTILIZER **RECOMMENDATIONS**

We have developed methodologies that combine theoretical knowledge with practical experience (Crop Modeling, Digital Soil and Yield mapping, Yield Prediction and Forecasting, along with on-station, on-farm, farmer managed trials and farm surveys) to arrive at realistic fertilizer recommendations. Together with our partners we train and educate young scientists in this expertise.

WHY **CHOOSE US?**

Our approach comprises solid theoretical tools supporting cropping systems and practical and concrete means to help in operational decision-making on the field/farm and supporting strategic decision-making.

- We are a network of experienced and resourceful personnel with diverse backgrounds to meet your needs.
- Most recommendation about fertilizer use are based on soil chemical characteristics.
- Our research shows that soil physical characteristics, like the amount of water the soil can hold, weather conditions, crops characteristics and farmer management determine the crop yield also.
- There is a great discrepancy between theory and practice that we bridge with our approach.
- We consider all factors holistically to arrive at more realistic recommendations for using plant nutrition (organic and inorganic) more effectively for improving soil health and higher farm yields.

THE **ADVANTAGES**

Our information enlightens private fertilizer and food sector, NGO's, R&D institutes, donors, government, farmers. Our services can help:

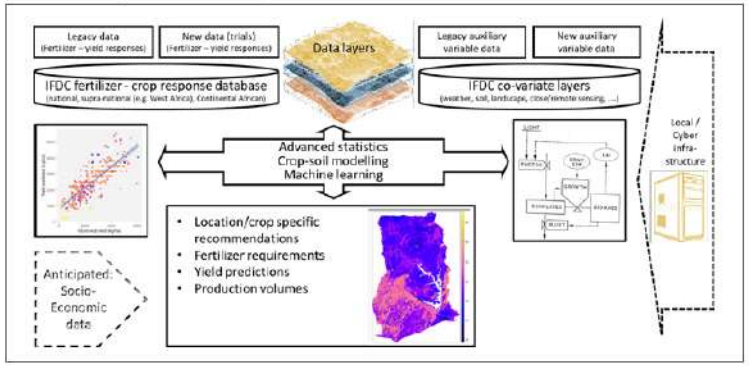
- **Governments** to know where to support what fertilizer products
- **Fertilizer traders** to reduce distribution costs by spatially optimizing their logistics with right volumes
- **Fertilizer industry** to increase the effectiveness (nutrient use efficiency) of their fertilizers
- **Farmers** to increase their crop yields and income
- **Farmers** to increase their economic incentives to use fertilizers
- **R&D organizations** to target their research efforts
- **Donors and NGOs** to spatially prioritize their interventions

Additional benefits to society that you can claim as well are:

- Reduced losses of fertilizer nutrients to the environment
- Less need for farmers to clear new natural lands that degrade soils and biodiversity
- Improved nutritional quality of the crops that helps to improve human health
- Estimation of regional and national production volumes for food and fertilizer traders and import-export policies

THE **MAPPING** ADVANTAGE

- We use the most advanced scientific methods to produce our spatial information with maps at a resolution of 1km*1km or 500m*500m. Maps of 100m*100m can be produced if so desired.



LINKING **SCIENCE** TO **PRACTICE**

- We conduct on-station, on-farm and farmer-managed trials to develop and test our recommendations. Our socio-economic survey helps us to understand farmer's behavior and decision makings on agricultural practices.

FARM **ANALYSIS**

- Crops respond very differently to fertilizer management in different locations. Even within the field of the farmers there are spots with high and low yields. We use drone observations to find out the cause of these differences.

TRAINING AND **EDUCATION**

The most fundamental building block for development is the training and education of our youth. Together with Universities and partner institutions, IFDC supports building a next generation of agricultural scientists in advanced modelling and mapping.

IFDC
Developing Agriculture from the Ground Up

OUR **PASSION**

Our team wants to enhance resilience and productivity of farming systems for food security and poverty alleviation. No more hunger! We break the cyclical poverty among farmers!

OUR **TEAM**

IFDC partners with universities and research institutions to bring together our brightest young minds in:

- Advanced statistical methods, including machine learning, for mapping and prediction
- Crop-soil simulation modelling
- Close and remote sensing
- Conduct of on-station, on-farm and farmer-managed trials
- Socio-economic surveys and analysis

IFDC

Since 1974, the International Fertilizer Development Center (IFDC) has delivered agricultural solutions to help end hunger and poverty in developing countries.

The organization achieves its vision of a food-secure and environmentally sustainable world by conducting quality research, improving on-farm productivity, developing market systems, and supporting enabling environments.

IFDC specializes in taking concepts from the lab to the field, performing research, testing, and piloting to scale out products and practices.

CONTACT

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IFDC-M&M
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