Agronomy at scale
Principles and approaches with examples from ACAI

Pieter Pypers, 22-11-2016
What is “agronomy at scale”?

Definition:

“agronomy” = “the science of soil management and crop production”

“at scale” = “at the required size to solve the problem”
The problem?

• Increasing recognition of variation in response to interventions

• Need for local adaptation of ISFM components

How can we advise farmers?
Why “working at scale”? 

Objectives

• **Embrace** (quantify and understand) **variation**

• **Build models** (predict the next farmer’s response)

• **Provide customized advise** (poor the model into a decision support tool)
Acai addresses questions identified by development partners

- Fertilizer blending
- **Fertilizer recommendations**
- Best planting practices
- Cassava intercropping
- **Scheduled planting**
- High starch content

What fertilizer, at what rate and following which regime should I apply to achieve a target yield / revenue gain?

When should I plant / harvest to achieve a maximal (starch) yield at a target harvest / given planting date?
An appropriate sampling frame to allow inter-/extrapolation of results:

- Unbiased
- Representative
- Sufficiently large
- Cost-effective
An appropriate sampling frame to allow inter-/extrapolation of results:

- **Unbiased**
- **Representative**
- **Sufficiently large**
- **Cost-effective**

**GIS-assisted approach**

**Climatic factors**
1. Annual mean temperature (1960-1990) (1km)
2. Annual mean precipitation (1960-1990) (1km)
3. Mean precipitation driest quarter (1960-1990) (1km)
4. Seasonality (Coefficient of Variation) precipitation (1960-1990) (1km)
5. Mean precipitation wettest quarter (1960-1990) (1km)
6. Mean temperature coldest quarter (1960-1990) (1km)
7. Seasonality (Coefficient of Variation) temperature (1960-1990) (1km)
8. Mean temperature warmest quarter (1960-1990) (1km)

**Soil factors**
9. AfISIS Cation exchange capacity for 5-15 cm depth (250m)
10. AfISIS Exchangeable acidity for 5-15 cm depth (250m)
11. AfISIS Electrical conductivity for 5-15 cm depth (250m)
12. AfISIS Exchangeable Magnesium for 0-20 cm depth (250m)
13. AfISIS Exchangeable Sodium for 0-20 cm depth (250m)
14. AfISIS Sum of exchangeable bases for 5-15cm depth (250m)
15. AfISIS Total nitrogen content for 0-20 cm depth (250m)
16. AfISIS soil organic carbon for 5-15 cm depth (250m)
17. AfISIS pH value for 5-15 cm depth (250m)
18. AfISIS Sand content for 5-15 cm depth (250m)
19. Enhanced Vegetation Index (2000-2014) (EVI) (250m)
20. Average MODIS Reflectance Red Band (2000-2014) (250m)
21. Average MODIS Reflectance Blue Band (2000-2014) (250m)
22. Fraction of Photosynthetic active Radiation (FPAR) (2000-2014) (250m)
23. Gross Primary Production (250m)
24. Net Primary Production (250m)

**Remote Sensing Products**
An appropriate sampling frame to allow inter-/extrapolation of results:

- Unbiased
- Representative
- Sufficiently large
- Cost-effective
Field trials

Multi-locational field trials to test and develop best agronomic interventions:

- **Objective:** treatment $\times$ environment interactions
Field trials

Multi-locational field trials to test and develop best agronomic interventions:

- **Objective:** treatment × environment interactions

- **Well-reasoned observation and measurement scheme**
Efficient field trial design

An appropriate design to extract maximal value from investments in trials:

- **Objective(s)**
- **Control**
- **Factor levels**
- **Interactions?**
- **Replication**
- **Balance**
- **Power**

Multiple objectives:
1. Yield response to nutrient inputs
2. Response curves
3. Data for model parametrisation

Nutrient Omission Trials in Tanzania
Predict the performance across the entire target intervention area:

- Determine **variance at different scales**
- Extract **BLUPs**
- Relate BLUPS to **GIS covariates**
- **Cross-validate** prediction models
- Geospatial modelling techniques
Statistics and geospatial modelling

Predict the performance across the entire target intervention area:

Example: Nutrient Omission Trials in Tanzania

GY ~ treat -1 + (treat|cluster:site) + (treat|cluster)
Predict the performance across the entire target intervention area:

- Measures of **autocorrelation**
- **Machine learning** techniques
- Covariance function and **semivariogram**
- Spatial prediction and **kriging**
- Spatial regression and **linear mixed effects models**
- (spatially-correlated) **error structures**
- **Covariate prediction models**
Soil and plant analyses

Faster (and cheaper) methods to assess soil and plant measurements:

- vis-NIR spectroscopy
- XRD
Learn from characterizing farmers’ current practices:

- Ranges in environmental / management-related parameters
- Clustering
- Relationships
- Hypothesis generation
- Refine field trial designs
Field surveys and characterisation studies

Learn from characterizing farmers’ current practices:

Example: Cropping calendar in Tanzania
Field surveys and characterisation studies

Learn from characterizing farmers’ current practices:

Example: Variation in starch content in harvested roots
Crop and nutrient uptake modelling

Crop modelling for two reasons:

- **Focus and accelerate field trial testing**
- **Predict crop performance for site-specific recommendations**

**QUEFTS**

**Nutrient norms**

**Components of DSSAT**

**DSSAT Foundation**

**DSSAT: Decision Support System for Agrotechnology Transfer**

Modular structure: separate components by scientific disciplines

With an interface to add crop models
Data management system

Data input and storage infrastructure:

ODK collect

submit collected data

ODK aggregate

set of automated routines to export, verify and clean

.long file

.csv file

long-term storage for all subsequent activities

GIS database

Agronomy database

processed data relevant to M&E

ME&L database

Repository

Trial summaries
Open access

API

API

Result tracker progress reports
Provide extension agents and farmers with site-specific recommendations:

- **Co-develop** with clients / end-users
  - Decide on the **format**
  - Understand the **situation**
  - Narrow down the **question**

- Collect / infer required **input**

- Process and provide **advice**
Validation activities

Validate and co-develop DSTs with target development agents:

- Feedback on format
- Feedback on performance
- Improve and update \((V_0, V_1, \ldots, V_F)\)
Summary

Agronomy at scale involves:

• GIS-assisted **sampling frames**

• Field trials with **effective experimental designs**

• Statistics and **geospatial analyses**

• **Surveys** to learn about inherent variation

• **Fast and accurate** (but less precise) measurements

• **Crop modelling** to accelerate field testing

• Efficient **data management** systems

• Focus on **decision support tools** and **validation** exercises