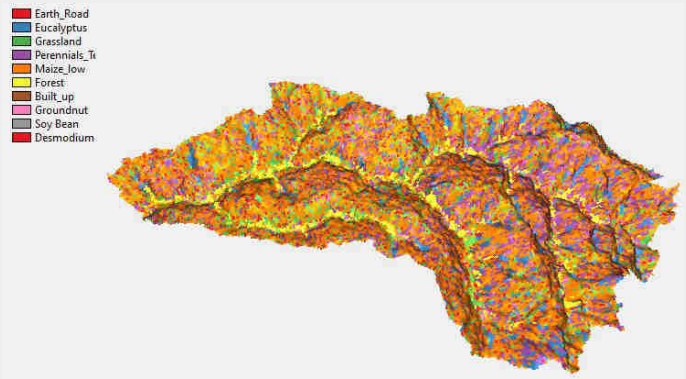
Exploring sustainable farming options for Sabatia landscapes
Model scenarios for the Innovation Platform in Sabatia, April 2017



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University of Eldoret & Catholic University of Leuven
Kenyatta University

Introduction

Previous activities of CONNESSA in Sabatia

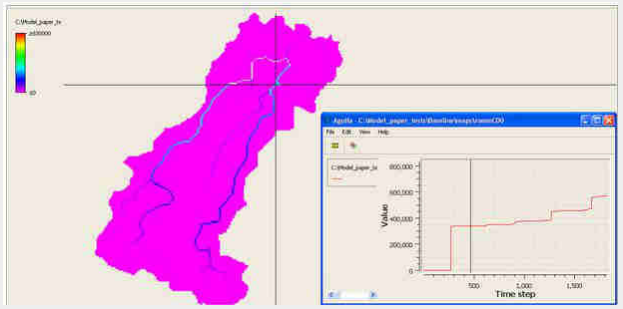
- Innovation platform in January 2017 by FibL: Land use scenarios suggested by participants included planting more legumes, making better use of manure, plant more trees, construct reservoirs
- Fertiliser and manure experiments on farmers' fields by the Universities of Eldoret and Leuven 2015-6: Reaction of different planting systems to higher inputs

Objectives during this Innovation Platform

- Assess consequences of some of these scenarios on farming and on the environment in Sabatia, if they were applied in a larger area and for a longer time (e.g. 5 or 10 years)
- Present results of a landscape model used to simulate our scenarios
- Discuss the outcomes of the simulations
- Feedback how realistic the simulated results are, so that we can improve the model
- What additional scenarios should be tested?

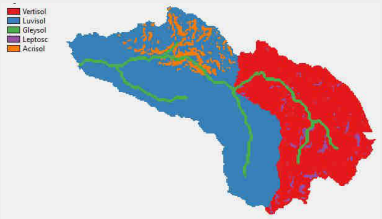
Model description and inputs

- The model calculates how plants grow and soils change in a landscape over time
- The landscape is subdivided into squares (pixels) and changing soil and plant characteristics are calculated for every pixel and every day

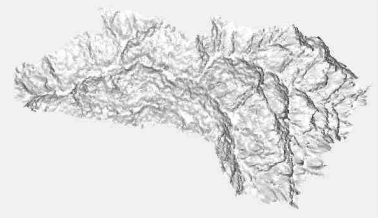


Surface runoff on a specific day and pixel

- Scenarios can be run over several years



Different soil types and topography need to be considered



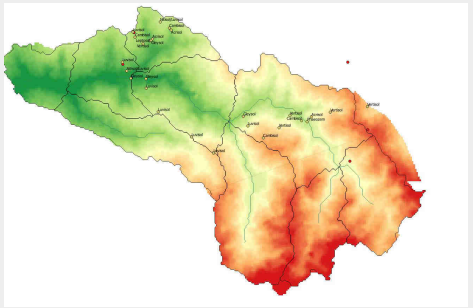
- Weather data* for every day are needed
- Information on plant growth is needed

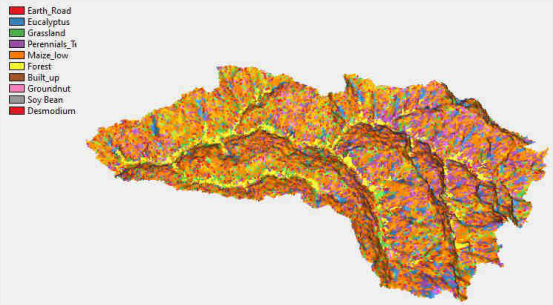
* Rainfall, air and soil temperature, reference evapotranspiration and solar radiation

Field information collected for the study

- Soil samples along two transects to see how different soil types are distributed in the landscape
- Land use information from satellite images
- Weather data from Shamakhokho 2015-6
- Management information from the University of Eldoret plots (planting dates, fertiliser application, manure application, planting distances)
- Plant growth information from the University of Eldoret plots (N, P, K contents, biomass, yields)

Alex, kannst Du bitte eine Abbildung zu einem Ja
Shamakhokho Regen und Lufttemp mit Jahresan





Model applications and capabilities

What the model can do:

- We can test how plants and soils behave under different land use, management or weather conditions, e.g.:
- How does maize grow when different amounts of manure / fertiliser are applied?
- Does soil erosion decrease when maize is planted in rotation with a legume cover crop (and by how much)?

… and what it is not made for:

- Predict exact yields for specific plots
- Predict land use change (farmer decisions)

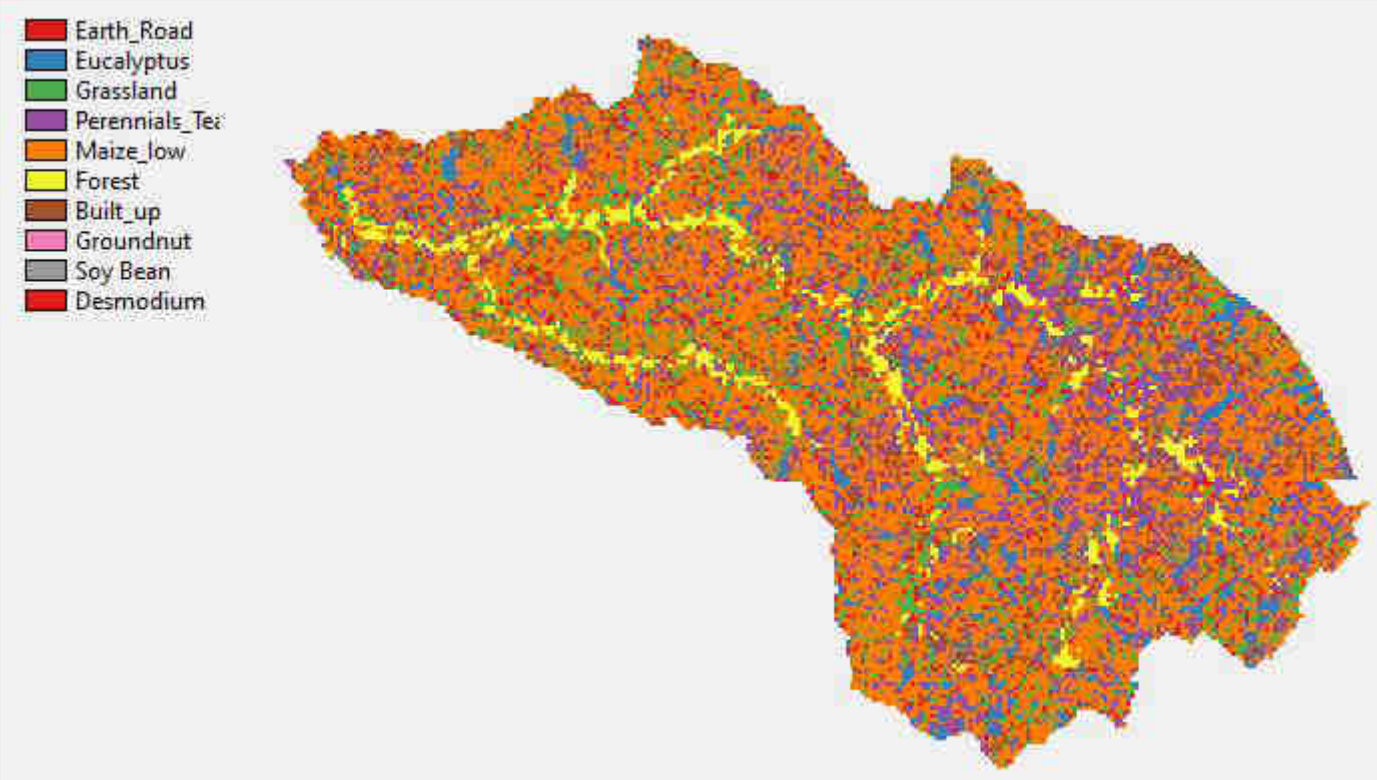
Discussion on field data

We would like to build on your knowledge of the area to improve our simulations:

- Can you locate your farm or an important landmark on the map (see next slide)?
- Please describe the different soil types in the area – what are their characteristics and where do they occur?
- Is rainfall in Shamakhokho representative for Sabatia?
- Does rainfall vary strongly within Sabatia?
- Where in the landscape do you expect best and worst maize growth under equal management?

Model results are only as good as the model inputs. Here we present a first approximation. During this Innovation Platform we hope to collect ideas how to improve simulations in a second round.

Discussion on field data



Land use Sabatia 2017, supervised classification 30x30 m pixel from 10 m resolution satellite image

Model validation

How do we know that the model calculates correctly?

1) We fine-tuned the model to produce the maize yields observed on the experimental plots (calibration)
2) We then compared results of the calibrated model to another, independent, set of yield data (validation). We used field data on plant growth from the experimental plots by the universities of Eldoret and Leuven to check whether the model calculates the correct yields:

- Maize yields under full fertiliser input for 2015 (wetter year)
- Maize yields under full fertiliser input for 2016 (drier year)
- Maize yields without fertiliser 2015
- Maize yields without fertiliser 2016

Alex, kannst Du bitte entsprechende Abbildungen zu Biomasse und Erträgen einfügen und die jew Statistik dazu (r2, RSME, EF)?

Baseline: The current situation (2015-16)

Main cropping system:Sole-cropped maize.
Further relevant land uses: Tea, trees, grassland.
Rainfall (2015 > 2016).

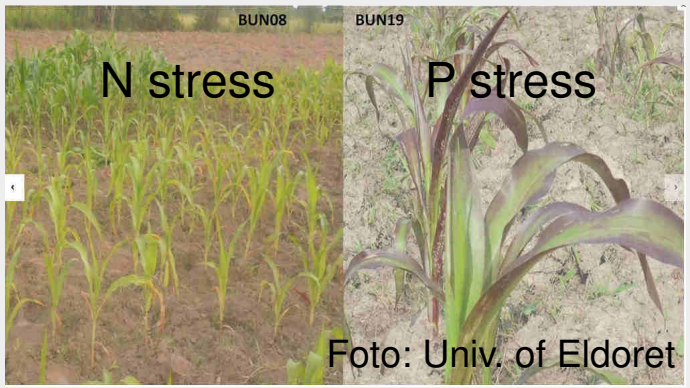
1) [Describe the rainfall in this year and compare it to Shamakhokho data]

2) Map with spatial yields of control treatment (explain what the legend means) [Does this match own experiences? Try to relate yields to landscape and soils]

3) Have symptoms of NP or water stress been observed in the field?

4) Is soil erosion an issue in the area [outputs have not been calibrated!]?

1) Spatial maize yields for 2015-6
2) Map output of soil erosion



Scenario 1: Increased area under legumes

Scenario description:

- Increase legumes (common and soy bean) by 25% of all cropped fields at t
  cost of maize plots
- Crop rotation maize – legumes instead of sole maize on 25% of cropped pl
- Intercropping maize and legumes (Desmodium) on 25% of cropped plots

Questions:

- Are total maize yields increasing?
- What is the quantity of legume yields?
- Is soil erosion decreased through the effect of the legume cover?
- How do soil N and P contents change without inputs (more demand but les
  loss)?

Modelled changes:

- Compare areatotals and plot-wise yiel

Plausibility of model results and points fo

Scenario 2: Intensified use of manure

Scenario description:

- Double number of LSU (corresponding to ≥ 1 cow + 2 calves per 5 ha), zero grazing, manure collection and distribution improves quality
- Calliandra as fodder planted on the edges of the fields. 1 LSU unit will require 4km of hedges @ 4 m = 1.6 ha (?!)

Implementation in the model:

- Increase manure (sensitivity analysis), increase manure quality (check what is limiting and increase elemental amount)
- Translate into LSU and reserve corresponding area to Calliandra at the cost of maize

Questions:

- Are maize yields increasing to compensate for reduced area?
- Can sufficient amounts of fodder (Desmodium + maize stover + grassland) be produced?

Modelled changes:

-

Plausibility of model results and points for further discussio

Assumptions for scenario 2:

Weiss & St Pierre (2007)*
Data for lactating dairy cows fed a variety of diets:

- Daily excreta 140 lb
- Wet faeces 95 lb
- Urine 45 lb
- Water 87.5% = 122.5 lb
- DM = 17.5 lb = 8.75 kg / day.

Assume factor 0.75 for a tropical livestock unit, this corresponds to 6.56 kg DM / day

Manure composition, analysed by the University of Eldoret 2015:
Total C 5.33%, total N 0.27%, P 0.4%, K 2.06%. C and N appear underestimated and were from Pettygrove et al. 2010**: C 36%, N 2.1%.
Lignin was estimated 13% and polyphenols 10%

Visible maize yield improvements from 5 Mg / ha manure upwards, this would correspond to yearly solid excreta of 2.1 LSU

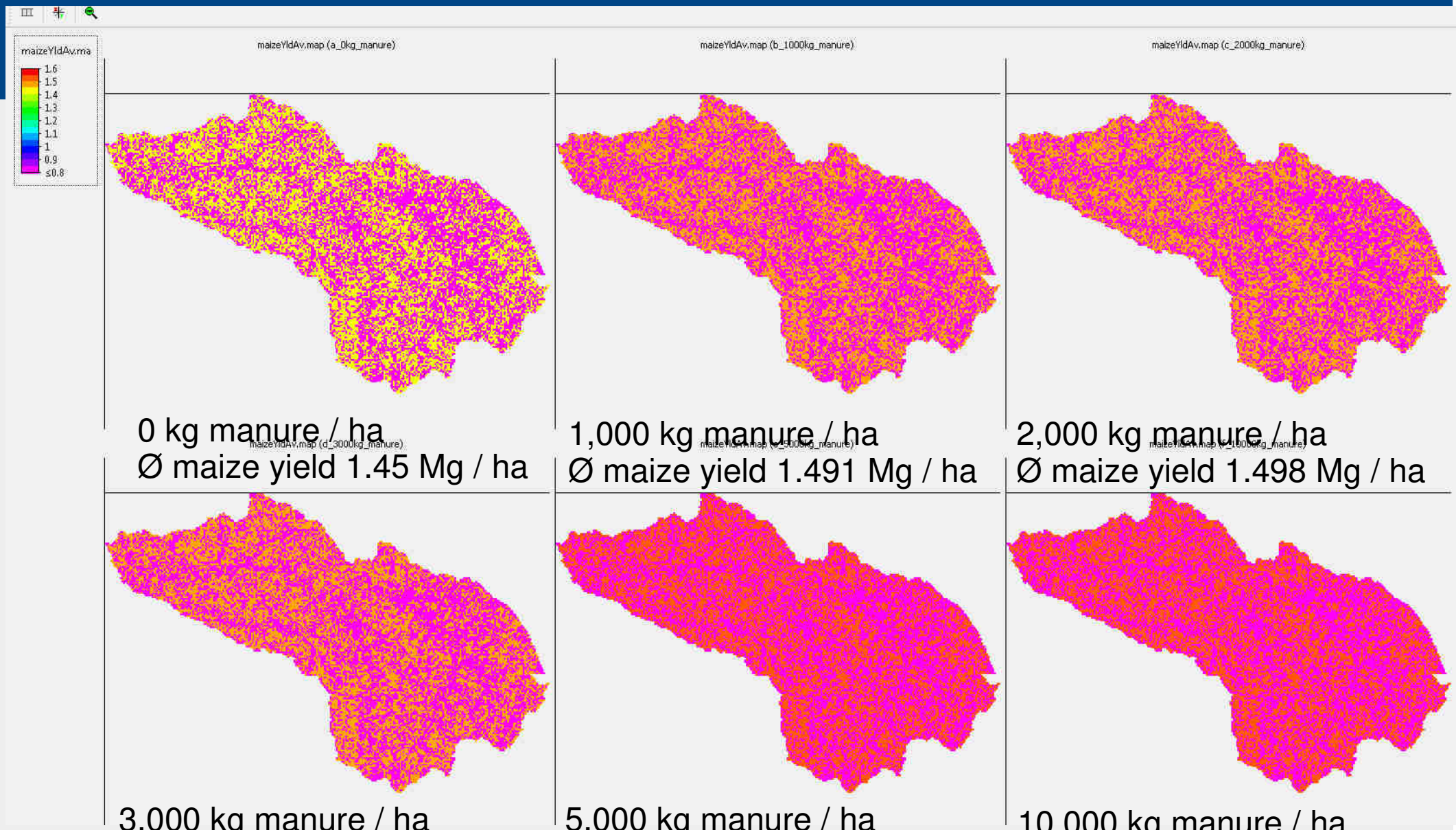
Assuming that 1 LSU requires 1.6 ha of Calliandra (4 km hedge á 4 m width) and that farmers don't plant Calliandra within the maize plot, we need to plant 3.2 ha Calliandra for every ha of maize to produce sufficient fodder

Assuming that additionally to Calliandra, cattle feeds on maize stover (X Mg /ha) and intercropped Desmodium (X Mg /ha), Calliandra could be reduced to X ha per ha maize.

Is this feasible given that average farm area is 5 ha? Hoigher yields of maize do not compensate for additional area consumed by fodder plants. Additional value of fodder plants? Long-term improvement of the soil? Does 6-years run show soil / yield recovery?

* Weiss, W.P. and St-Pierre, N.R. 2006. Factors Affecting Manure Excretion by Dairy Cows. Penn State Dairy Cattle Nutrition W
** G.S. Pettygrove et al. 2010. Dairy Manure Nutrient Content and Forms. University of California Cooperative Extension. Manure Technical Bulletin Series. http://manuremanagement.ucdavis.edu

Average yield on all maize pixels in year 1



0 kg manure / ha
Ø maize yield 1.45 Mg / ha

1,000 kg manure / ha
Ø maize yield 1.491 Mg / ha

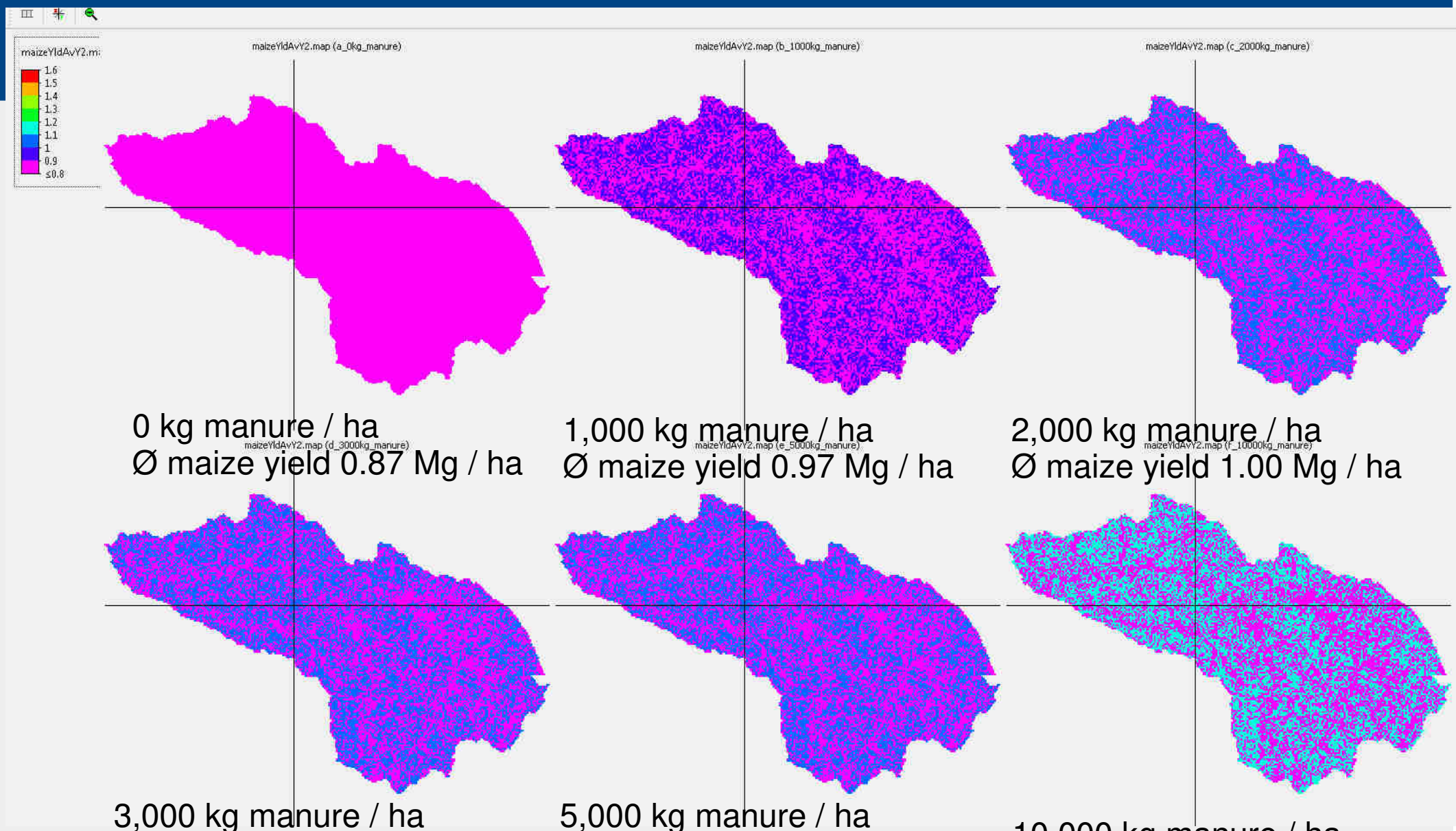
2,000 kg manure / ha
Ø maize yield 1.498 Mg / ha

3,000 kg manure / ha
Ø maize yield 1.50 Mg / ha

5,000 kg manure / ha
Ø maize yield 1.54 Mg / ha

10,000 kg manure / ha
Ø maize yield 1.56 Mg / ha

Average yield on all maize pixels in year 2, markedly below year 1, manure effect more pronounced



0 kg manure / ha
Ø maize yield 0.87 Mg / ha

1,000 kg manure / ha
Ø maize yield 0.97 Mg / ha

2,000 kg manure / ha
Ø maize yield 1.00 Mg / ha

3,000 kg manure / ha
Ø maize yield 1.02 Mg / ha

5,000 kg manure / ha
Ø maize yield 1.05 Mg / ha

10,000 kg manure / ha
Ø maize yield 1.19 Mg / ha

Scenario 3: Increased water availability from ponds

Scenario description:

- Dams and ponds double water availability and allow irrigation of 1/10 acre per farm. Used for vegetable production (dry season) close to the water points.
- One water point per km^2, allowing irrigation of 5% of the arable land.

Implementation in the model:

- Create ponds in depressions (1 per sqkm) and collect rain water
- Locate vegetable plots in the surroundings
- Grow vegetables (soy bean) under unlimited water supply

Questions:

- Is water stress relevant for plants? In all years?
- Can maize yields be boosted by irrigation?

Modelled changes:

- Vegetable yields
- Maize yields

Plausibility of model results and points for further discussion:

- Is there any dry season in Sabatia?

Scenario 4: Expanding tree cover

Scenario description:
10% of all LU tree cover (AF or forest) on poor soils and slopes
Alternative to tea plantations
Implementation in the model:

- Calculate tree + tea area * 0.1
- Replace corresponding area of tea with Eucalyptus

Questions:

- Soil erosion?
- Wood yield?

Modelled changes:
Plausibility of model results and points for further discussion: