Agricultural inputs, yields, and farmers' perceptions of soil fertility in Sub-Saharan Africa

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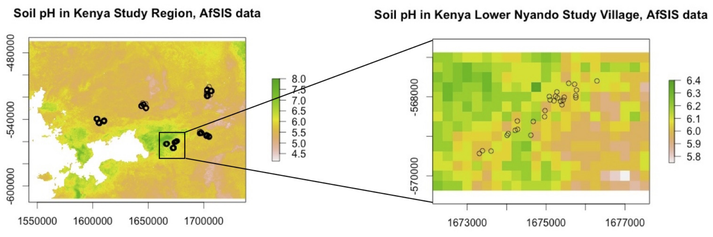
Research questions

- **Question 1:** What can we learn from survey data about how farmers in Sub-Saharan Africa (SSA) form perceptions of soil fertility? Do agricultural inputs and/or outputs vary with farmers' perceived soil quality and soil type?
- **Question 2:** How well do farmers' subjective perceptions correspond to objective measurements of soil fertility?
- **Question 3:** Can the new high resolution and publicly available soil data provide sufficient information to obviate the expensive and time-consuming collection of detailed plot-level data?

Study area and data

- **Kenya**: 509 maize plots in main growing season of 2011 across 308 households in the western highlands + soil analysis from largest maize plot, mid-infrared spectroscopy (Berazneva, 2015);
- **Tanzania**: 2,360 maize plots in main growing season across 1,566 households, nationally representative sample (use household-level sampling weights), 2010-2011 wave of the Tanzania National Panel Survey;
- **Africa Soil Information System (AfSIS)**, 250m spatial predictions based on point data sets in combination with a large number of covariates (Hengl et al. 2015).



Note: X and Y-axes are latitude and longitude in UTM WGS84.

Kenya: subjective vs. objective soil fertility

Variable	Carbon (C) (% w/w)	Nitrogen (N) (% w/w)	pH 1–14	CEC (meq/100g)
Soil quality, mean (st.dev.)				
Good (n=67)	2.56 (1.54)	0.17 (0.12)	5.85 (0.54)	25.26 (18.56)
Average (n=173)	2.42 (1.19)	0.16 (0.08)	5.81 (0.49)	24.29 (14.13)
Bad (n=68)	2.32 (0.98)	0.15 (0.06)	5.78 (0.54)	23.59 (23.59)
*Tukey-Kramer test, * if p-value* < 0.05				
Good vs Average	1.15	1.51	0.75	0.63
Good vs Bad	1.59	1.77	1.20	0.90
Average vs Bad	0.75	0.62	0.68	0.45
Soil type, mean (st.dev.)				
Sandy (n=75)	2.27 (1.41)	0.15 (0.09)	6.02 (0.50)	24.23 (12.72)
Loam (n=166)	2.34 (1.04)	0.16 (0.08)	5.68 (0.49)	21.89 (14.28)
Clay (n=57)	2.86 (1.41)	0.19 (0.09)	5.90 (0.50)	30.65 (18.23)
*Tukey-Kramer test, * if p-value* < 0.05				
Sandy vs Loam	0.57	1.11	6.96*	1.61
Sandy vs Clay	3.94*	3.75*	1.92	3.50*
Loam vs Clay	3.99*	3.29	4.10*	5.47*

Kenya: farmers' perceptions, inputs, yield

Variable	Chemical fertilizer 1=yes	Herbicides, pesticides 1=yes	Organic resources 1=yes	Conditional fertilizer kg/ha	Maize yield t/ha
Soil quality, mean (st.dev.)					
Good (n=124)	0.50 (0.50)	0.19 (0.40)	0.64 (0.48)	137.97 (113.24)	2.07 (1.70)
Average (n=262)	0.56 (0.50)	0.14 (0.34)	0.66 (0.48)	144.08 (136.84)	1.73 (1.51)
Bad (n=123)	0.55 (0.50)	0.08 (0.27)	0.67 (0.47)	120.37 (127.59)	1.38 (1.30)
*Tukey-Kramer test, * if p-value* < 0.05					
Good vs Average	1.59	2.12	0.53	0.44	2.90
Good vs Bad	1.18	3.63*	0.69	1.09	5.10*
Average vs Bad	0.21	2.12	0.28	1.76	3.05
Soil type, mean (st.dev.)					
Sandy (n=124)	0.42 (0.50)	0.97 (0.30)	0.64 (0.48)	149.45 (154.40)	1.44 (1.45)
Loam (n=283)	0.60 (0.49)	0.14 (0.35)	0.67 (0.47)	128.07 (125.15)	1.83 (1.60)
Clay (n=88)	0.57 (0.50)	0.17 (0.38)	0.65 (0.48)	149.49 (119.37)	1.85 (1.41)
*Tukey-Kramer test, * if p-value* < 0.05					
Sandy vs Loam	4.73*	1.83	0.95	1.46	3.37*
Sandy vs Clay	3.06	2.17	0.23	0.00	2.69
Loam vs Clay	0.68	0.86	0.58	1.44	0.10

- Only maize yields differ by both soil quality and soil type;
- Some evidence that application of herbicides and pesticides differs by perceived soil quality;
- Use of chemical fertilizer inputs differs by soil type.

Tanzania: farmers' perceptions, inputs, yield

Variable	Chemical fertilizer 1=yes	Herbicides, pesticides 1=yes	Organic resources 1=yes	Conditional fertilizer kg/ha	Maize yield t/ha
Soil quality, mean (st.dev.)					
Good (n=1,106)	0.17 (0.38)	0.09 (0.29)	0.15 (0.36)	146.90 (158.32)	1.18 (1.35)
Average (n=1,101)	0.18 (0.38)	0.09 (0.29)	0.14 (0.35)	146.29 (143.73)	1.11 (1.35)
Bad (n=153)	0.26 (0.44)	0.10 (0.30)	0.15 (0.35)	97.04 (96.78)	0.94 (1.19)
*Tukey-Kramer test, * if p-value* < 0.05					
Good vs Average	0.40	0.30	0.62	0.06	1.72
Good vs Bad	3.85*	0.14	0.20	2.86	2.93
Average vs Bad	3.62*	0.29	0.11	2.81	2.06
Soil type, mean (st.dev.)					
Sandy (n=360)	0.20 (0.40)	0.07 (0.25)	0.16 (0.37)	133.46 (127.32)	1.01 (1.34)
Loam (n=1,603)	0.17 (0.38)	0.10 (0.29)	0.15 (0.36)	147.11 (160.79)	1.15 (1.33)
Clay (n=374)	0.21 (0.40)	0.10 (0.30)	0.10 (0.31)	129.90 (112.93)	1.10 (1.34)
*Tukey-Kramer test, * if p-value* < 0.05					
Sandy vs Loam	1.68	2.71	0.76	1.01	2.64
Sandy vs Clay	0.48	2.40	3.30	0.21	1.30
Loam vs Clay	2.20	0.36	3.34*	1.28	0.92

- Higher share of plots with 'bad' soil quality get chemical fertilizer, but application rate is higher for plots with better soil quality.
- Application of organic resources differs by soil type.

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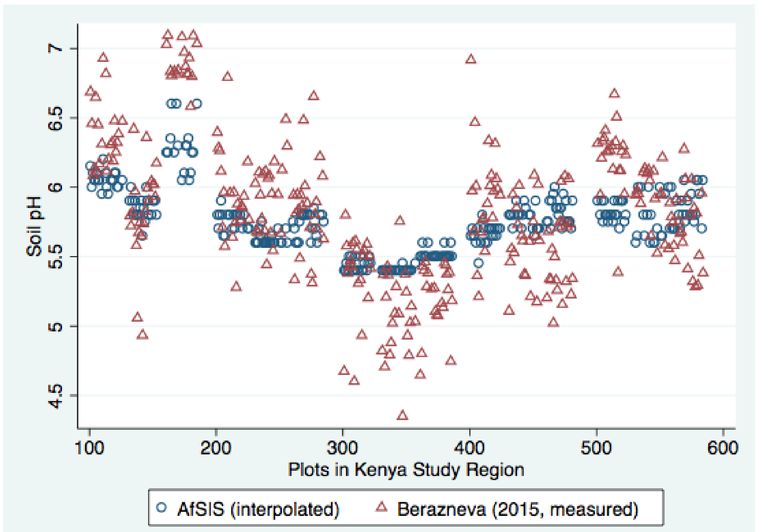
AfSIS vs. Berazneva (2015) data

- AfSIS (interpolated) data show less variation than Berazneva (2015, measured) data within villages;
- The average carbon and nitrogen soil content differs by data set at both the village and sample level (we reject t-tests of the equivalence of means between the two data sets);
- Mean soil CEC, a stable indicator of soil fertility, is not statistically distinguishable between data sets at the sample level.



Preliminary findings

- **Question 1:** Similar to Marenya, Barrett, and Gulick (2011) and Karltun et al. (2013), we find some evidence that farmers base their perceptions of soil quality on maize yield.
- **Question 2:** Farmers' reported soil type is a reasonable predictor of objective soil fertility indicators (carbon, nitrogen, pH, and CEC).
- **Question 3:** Difference at household, village, and sample levels justifies collection of plot-level soil data despite availability of AfSIS data.

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