Responses to Climate Change:

What Can We Learn from East Africa?

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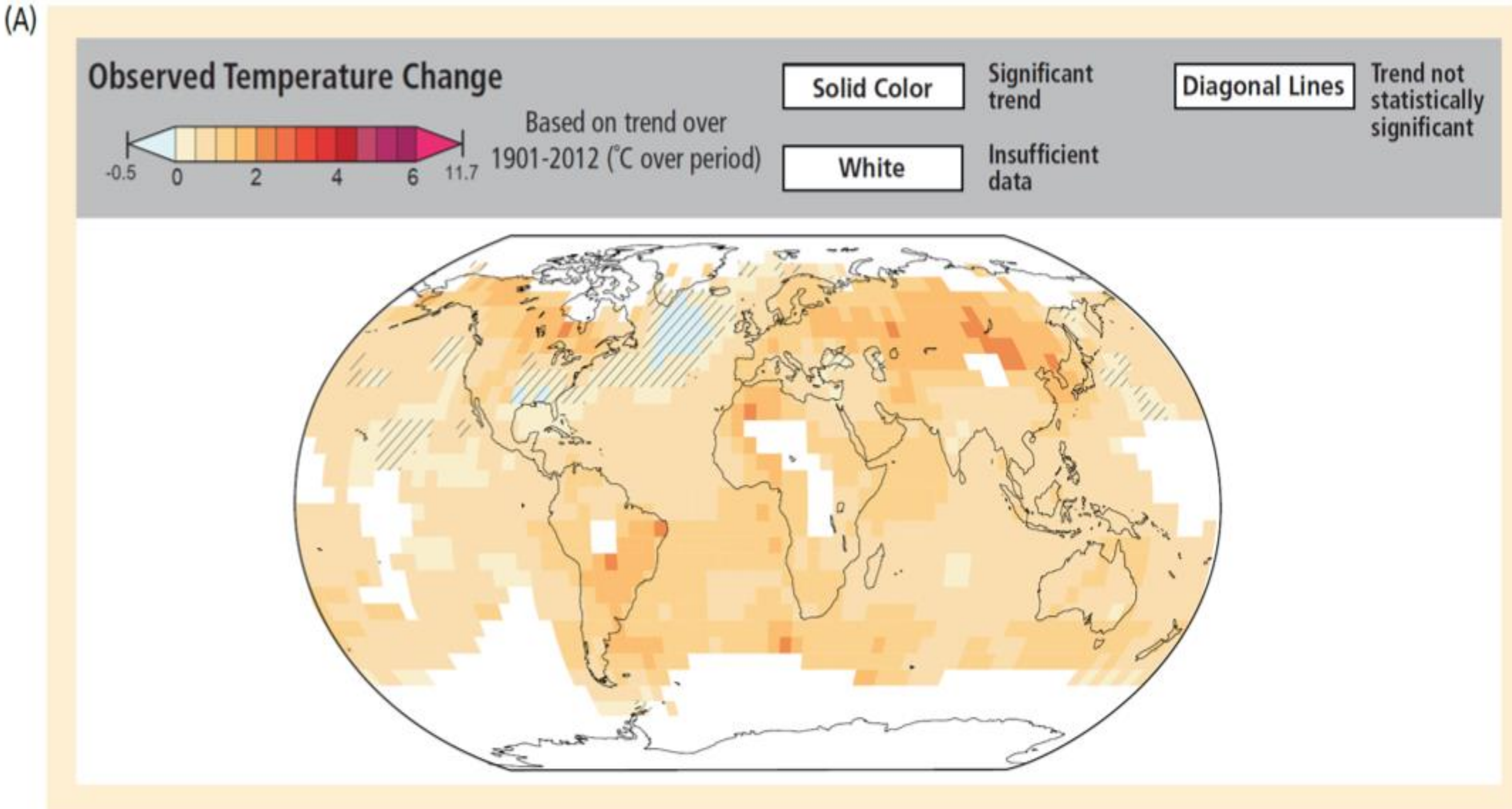
Outline

- Climate change impact on the agricultural sector
- Empirical Evidence: macro and micro
- Adaptation in SSA Revenues and risk exposure
- New developments behavioral experiments on risk and impatience
- Conclusions

Findings



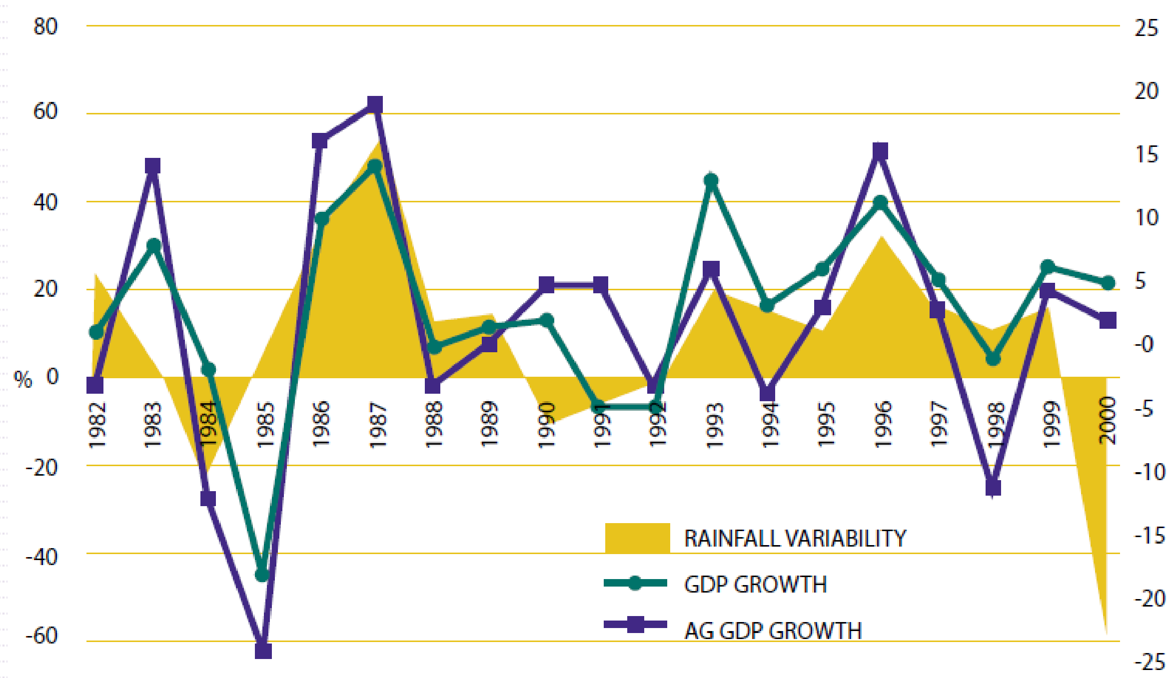
IPCC, 2013

Findings

-Agriculture-dependent countries have already suffered the negative impact of climatic factors (Mendelsohn et al., 2006)

-Poor economic performance and growth rate for African nations (Barrios et al., 2010, Dell et al., 2012)

-Agriculture the key mechanism



Ethiopia's economic growth and climate variability
Source: World Bank, 2010

Findings

- Development, poverty reduction and growth prospects are closely related to the performance of agriculture.
- African countries cannot bypass a agricultural revolution to successfully launch economic transformations (Diao et al., 2010)

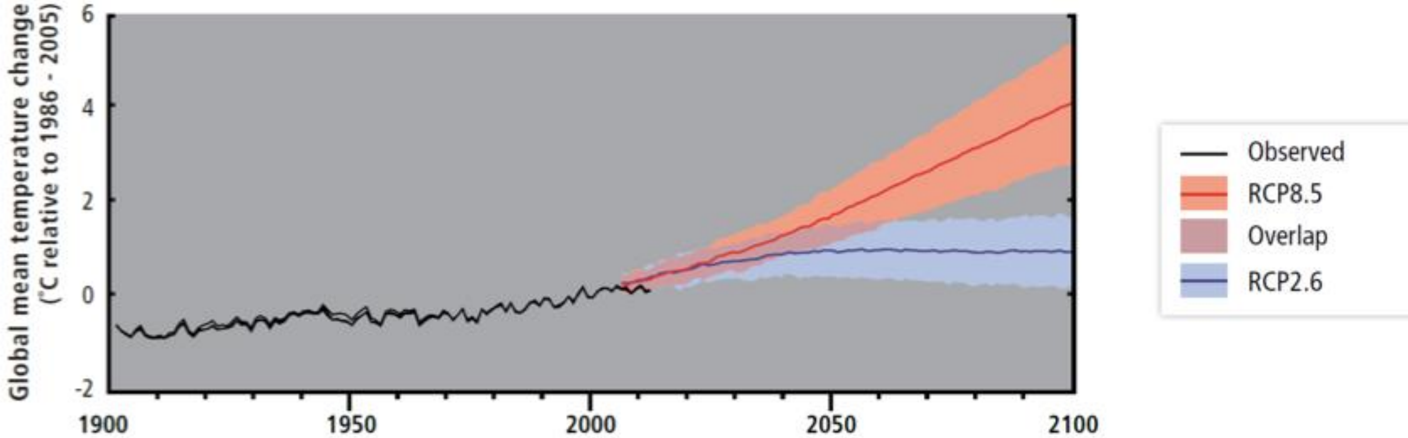
Findings: Commodity Price Shock and Civil Conflict

- More extreme events are likely to have crucial implications on prices on commodites
- Colombia: sharp fall in coffee prices during the 1990s lowered wages and increased violence (Dube and Vargas, 2013)
- Ethiopia: Social unrest associated with variability of food prices (Bellemare, 2015)

Weather patterns are changing

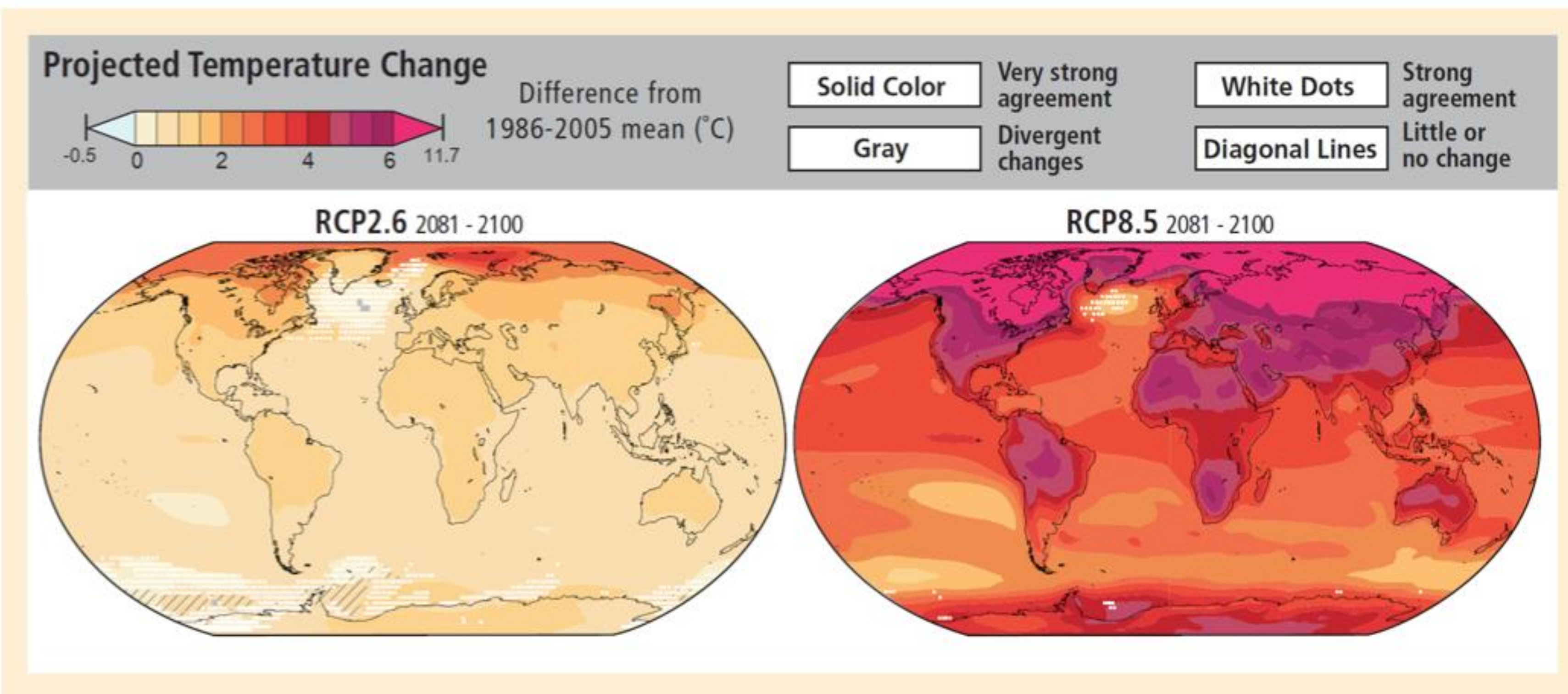
- It is plausible that a warmer earth would produce more and stronger El Niño (ENSO)
- High variability of El Nino has important implications for price of agricultural commodities
- ENSO appears to account for almost 20% of commodity price inflation movements over the past several years
- ENSO also has some explanatory power for world consumer price inflation and world economic activity, 10% to 20% of movements Brunner (2002)
- Increase the likelihood of crop failure

IPCC, 2013



Global mean temperature change
(°C relative to 1986 - 2005)
6
4
2
0
-2
1900
1950
2000
2050
2100
Observed
RCP8.5
Overlap
RCP2.6

(C)



Projected Temperature Change
-0.5
0
2
4
6
11.7
Difference from
1986-2005 mean (°C)
Solid Color
Very strong agreement
Gray
Divergent changes
White Dots
Strong agreement
Diagonal Lines
Little or no change
RCP2.6 2081 - 2100
RCP8.5 2081 - 2100

Can we do without adaptation?

- **No**
- The identification of climate change adaptation strategies is vital in sub Saharan Africa and elsewhere

1. Autonomous adaptation => micro level and pay offs
2. What is the impact on outcomes of interest of farmers' decision to adopt some strategies in response to changes in temperature and/or precipitation?
3. What are the driving forces behind farmers' decisions to adapt to climate change?

Policy perspective

- Understanding adaptation to climate change is of paramount importance
- How the set of strategies implemented in the field by farmers (e.g., changing crops, adopting new technologies or, soil conservation measures) in response to long term changes in environmental conditions are chosen and how they affect productivity or revenues (Di Falco et al. 2011)
- Same framework

Economic Implications of Adaptation to Climate Change

(Di Falco et al. 2011; Di Falco and Veronesi; 2013; Di Falco and Veronesi, 2014)

Issues for quantitative analysis

- Systematically different between adapters and non adapters
- Some farmers are better than others…
- Unobservable characteristics of farmers and their farm may affect both the adaptation strategy decision and net revenues => inconsistent parameter estimates
- Self selection

Switching Regression Model (Di Falco et al. 2011; Di Falco and Veronesi; 2013)

- Two stages procedure

1. We estimate the probability of choosing a particular strategy (selection model where a representative farm household chooses to implement a specific strategy)
2. The information stemming from the first step is used on farm revenue or risk exposure

=> Build a counterfactual analysis

Case study: Ethiopia Nile River Basin

Figure 3: Survey districts along with their agro-ecological settings in the Nile Basin of

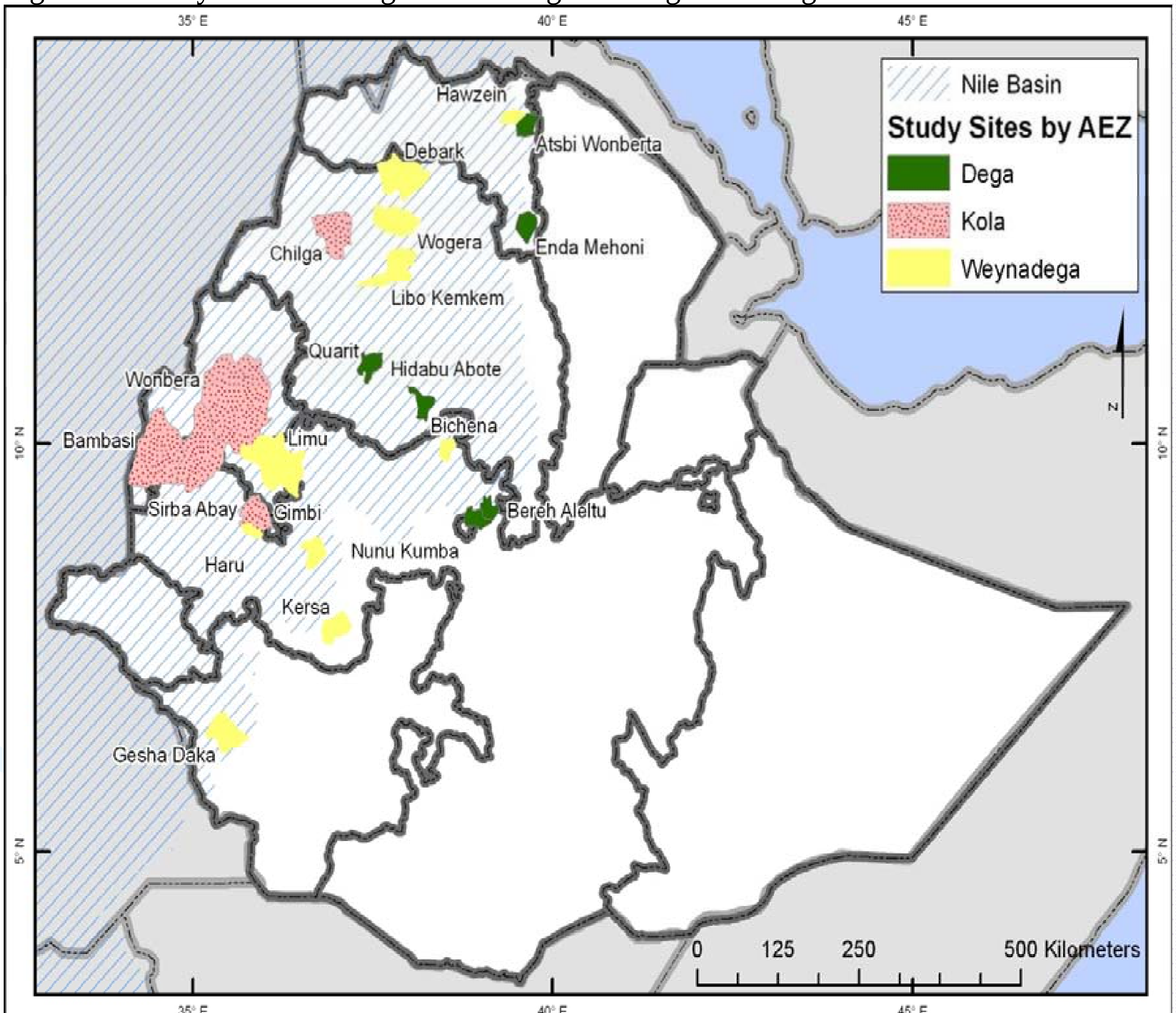


Table 1. Climate change adaptation strategies

	Frequency	%
Soil conservation	1,397	72.27
Changing crop varieties	1,186	61.36
Water strategies		
Building water harvesting scheme	309	15.99
Water conservation	82	4.24
Irrigating more	279	14.43
Other strategies		
Early-late planting	176	9.11
Migrating to urban area	23	1.19
Finding off-farm job	132	6.83
Leasing the land	3	0.16
Changing from crop to livestock	71	3.67
Reduce number of livestock	121	6.26
Adoption of new technology	26	1.35

Table 5. Impact on Net Revenues by Adaptation Strategy

Combination is Better

	(1) Actual net revenues (Etb/Ha)	(2) Counterfactual net revenues if farm households did not adapt (Etb/Ha)	(3) Impact (treatment effect - Etb/Ha)
· Changing crop varieties only	3,963.939	3,804.036	159.903
	(263.250)	(342.301)	(350.000)
· Water strategies only	4,752.995	3,325.668	1,427.327
	(748.523)	(774.360)	(939.035)
· Soil conservation only	4,349.334	3,689.859	659.475
	(306.116)	(305.365)	(361.593)
· Water strategies and changing crop varieties	4,173.987	1,842.288	2,331.700***
	(428.234)	(346.832)	(445.253)
· Soil conservation and changing crop varieties	4,598.201	2,404.897	2,193.304***
	(267.543)	(203.820)	(203.980)
· Water strategies and soil conservation	5,211.351	3,481.522	1,729.829***
	(449.527)	(582.655)	(601.024)
· Water strategies, soil conservation, and changing crop varieties	4,493.598	3,196.787	1,296.811***
	(281.635)	(337.170)	(349.426)
· Other strategies	3,682.941	2,689.196	993.745***
	(323.024)	(192.481)	(266.453)

Adaptation and Downside risk

Finger et al. (2011) irrigation and variability

- Di Falco and Veronesi (2014)
- Past adaptation to climate change

(i) reduces current downside risk exposure, and so the risk of crop failure

(ii) would have been more beneficial to the non-adapters if they adapted, in terms of reduction in downside risk exposure

(iii) is a successful risk management strategy that makes the adapters more resilient to climatic conditions

Drivers and barriers

- The dissemination of information on changing crops and implement conservation strategies are very important – increase awareness
- Credit markets (Deressa et al., GEC 2009)
- Extension services (also training)
- Farmer to farmer extension
- Soil conditions – when too degraded or highly fertile no scope for implementation

Do climatic shocks affect farmers preferences?

- Behavioural parameters explain investment decisions
- Risk aversion and undertaking potentially profitable investments if these entails some more risk (Rosenzweig and Binswanger, 1983)
- More impatient people more present oriented, less prone to capital accumulation and therefore invest less or adopt less productivity enhancing technologies (Cardenas and Carpenter, 2013; Tanaka, Camerer and Nguyen, 2010; Duflo, Kremer and Robinson, 2011)
- Climatic shocks, risk and discounting the future

Rainfall and risk aversion

- Risk experiments in the highlands of Ethiopia in 2007
- First two moment of the the distribution of rainfall

Table 2. Risk aversion and Climate change

Dependent variable: Risk averter

	(1)	(2)	(3)	(4)
Rainfall	−0.000815*** (0.000119)	−0.000652*** (0.000110)	−0.000550*** (0.000106)	−0.000564*** (0.000105)
Rainfall CV	0.940*** (0.355)	1.007*** (0.366)	1.114*** (0.313)	1.115*** (0.312)
Distance to the plots		−0.00312*** (0.000338)	−0.00326*** (0.000251)	−0.00310*** (0.000281)
Distance to town		−0.0000175 (0.000306)	−0.000171 (0.000324)	−0.000171 (0.000319)
Tenure insecurity		0.202*** (0.0237)	0.209*** (0.0188)	0.208*** (0.0183)
HH size			0.0357*** (0.00955)	0.0356*** (0.00968)
Livestock			0.00780** (0.00341)	0.00865** (0.00348)
Gender			0.161*** (0.0319)	0.165*** (0.0323)
Age			0.000706* (0.000405)	0.000633 (0.000422)
Illiterate			−0.0368 (0.0390)	−0.0341 (0.0386)
Temperature				0.00427*** (0.000900)
N	763	626	626	626

Panel data: elicitation of impatience at two different points in time

- Spatial and temporal variation
- We conducted a set of lab in the field experiments in 2005 and 2007 in the Highlands of Ethiopia
- Ethiopia large rural and poor population dependent upon rain fed agriculture
- Small holders farmers
- Persistent food insecurity and among the highest rates of soil nutrient depletion in Africa
- Soils that lack nutrients do not adequately support plants growth
- (FAO 2001; Shiferaw and Holden, 1997)

Models

$$discount_{ht} = \beta_0 + \beta_1\, rainfall\ shocks_{ht-1} + u_{ht} \quad (1)$$

$$discount_{ht} = \beta_0 + \beta_1\, rainfall\ shocks_{ht-1} + \beta_2 \boldsymbol{W}_{ht} + \beta_3 year_t + u_{ht} \quad (2)$$

Use dummies to capture different intensity of anomalies

Negative and positive shocks	Dummy -2	See text for description. -3< Rainfall anomaly <=-2	15%
	Dummy -3	See text for description. -Rainfall anomaly <=-3	23%
	Dummy + 2	See text for description. 2=< Rainfall anomaly <3	8.8%
	Dummy +3	See text for description. 3=< Rainfall anomaly	36%

Results

Dependent Variable: Discounting		
	No controls	With controls
	(1)	(2)
Dummy - 2	0.100	0.0741
	(0.0619)	(0.0640)
Dummy – 3	0.956***	0.918***
	(0.0751)	(0.0794)
Dummy + 2	0.0287	0.0228
	(0.0918)	(0.0882)
Dummy + 3	-0.847***	-0.834***
	(0.101)	(0.0989)

Economic implications?

- Heavy discounting of the future may in principle push individuals towards myopic economic decisions (Fuchs, 1992, Card, 1995, Chavas 2013).
- As result farmers may be less likely to undertake profitable investment and therefore perpetuate their condition of poverty (Haushofer and Fehr, 2014)

Table 3. Investment and discounting

	Investment in Oxen		Investment in Soil	
	No Controls	With Controls	No Controls	With Controls
	(1)	(2)	(3)	(4)
Discounting	-0.138^{*}	-0.134^{*}	-0.140^{***}	-0.123^{***}
	(0.0707)	(0.0696)	(0.0365)	(0.0376)
		*		

Fazit

- Macro and microeconomic and social
- Extremes are going to affect productivity, risk exposure, price dynamics, and preferences
- A resilient sector should adapt to these challenges and anticipate the implications of increased temperatures and extremes
- Economic, climate, behavioral data and develop models that can better study these effects

Fazit

- Adaptation significantly increases farm net revenues and reduces risk of crop failure
- Changing crop varieties has a positive and significant impact on net revenues when coupled with water and soil investment
- Training, credit and information are key drivers

Fazit

- Negative rainfall anomalies during the growing season increase impatience, while positive anomalies reduce it.
- Evidence on the role of discounting on investments.
- The role of climatic factors on behavioral parameters and their implications for investment decision is a very important and promising research area
- Lots of work to do!

Thank you very much

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	(1) Changing crop varieties only	(2) Water strategies only	(3) Soil conservation only	(4) Water strategies and changing crop varieties	(5) Soil conservation and changing crop varieties	(6) Water strategies and soil conservation	(7) Water strategies, soil conservation, and changing crop varieties	(8) Other strategies
Belg rainfall	-0.008	-0.030**	-0.010	-0.002	-0.021*	-0.027	-0.011	0.012
	(0.013)	(0.012)	(0.012)	(0.018)	(0.013)	(0.026)	(0.013)	(0.013)
squared Belg rainfall/1000	-0.007	0.031	-0.013	-0.018	0.020	-0.002	-0.007	-0.025
	(0.022)	(0.021)	(0.026)	(0.029)	(0.021)	(0.053)	(0.022)	(0.018)
Meher rainfall	-0.014	-0.024***	-0.003	-0.015*	-0.016**	-0.043***	-0.031***	-0.009
	(0.009)	(0.008)	(0.006)	(0.008)	(0.008)	(0.011)	(0.009)	(0.007)
squared Meher rainfall/1000	0.007	0.011***	0.0004	0.008*	0.008*	0.023***	0.016***	0.004
	(0.005)	(0.004)	(0.003)	(0.005)	(0.004)	(0.007)	(0.005)	(0.003)
average temperature	-0.021	4.029*	1.941**	4.143**	1.813*	-0.122	5.174**	0.125
	(0.757)	(2.346)	(0.793)	(1.911)	(1.099)	(2.443)	(2.364)	(0.677)
squared average temperature	-0.006	-0.100*	-0.048**	-0.102**	-0.049*	-0.006	-0.139**	-0.007
	(0.018)	(0.057)	(0.019)	(0.044)	(0.026)	(0.056)	(0.057)	(0.017)
highly fertile	-0.549*	-0.180	-0.454**	-0.546	-0.073	-0.520	-0.890**	-1.134***
	(0.297)	(0.725)	(0.226)	(0.500)	(0.213)	(0.491)	(0.365)	(0.373)
infertile	0.114	-0.066	-0.001	0.498	0.106	-0.580	-0.348	-0.761
	(0.328)	(0.728)	(0.330)	(0.399)	(0.285)	(0.515)	(0.408)	(0.470)
no erosion	0.046	0.614	-0.190	0.540	-0.015	-0.302	-0.405	0.099
	(0.270)	(0.593)	(0.276)	(0.452)	(0.235)	(0.448)	(0.324)	(0.362)
severe erosion	-0.358	0.087	-0.458	0.157	-0.307	-0.822*	-1.193**	-0.279
	(0.443)	(0.647)	(0.292)	(0.321)	(0.281)	(0.436)	(0.491)	(0.497)
crop type	-0.115**	0.116**	-0.011	0.031	-0.045	0.009	0.019	0.138
	(0.045)	(0.058)	(0.050)	(0.055)	(0.047)	(0.073)	(0.057)	(0.093)
tree planting	24.538***	24.802***	24.839***	24.998***	25.297***	25.629***	25.463***	25.401***
	(0.511)	(0.512)	(0.513)	(0.666)	(0.622)	(0.775)	(0.477)	(0.804)
animals	1.160*	-0.813	0.398	-0.298	0.177	0.382	0.250	1.346**
	(0.655)	(0.779)	(0.554)	(0.645)	(0.504)	(0.484)	(0.550)	(0.630)
literacy	-0.056	1.005**	0.694**	1.272**	0.205	1.397***	0.134	0.236
	(0.405)	(0.444)	(0.307)	(0.559)	(0.223)	(0.525)	(0.494)	(0.419)
male	0.425	-0.369	0.584	-0.544	0.940	0.598	0.427	0.042
	(0.903)	(1.410)	(0.969)	(1.342)	(0.700)	(1.189)	(0.908)	(0.798)
married	-0.557	0.322	0.008	0.588	-1.099	0.602	-0.414	-0.774
	(1.033)	(1.126)	(0.865)	(1.826)	(0.965)	(1.093)	(0.969)	(1.023)
	(0.069)	(0.082)	(0.101)	(0.128)	(0.071)	(0.109)	(0.100)	(0.073)
relatives	0.007	0.007	0.012*	-0.006	0.015**	0.005	0.016**	-0.014
	(0.008)	(0.013)	(0.007)	(0.011)	(0.007)	(0.007)	(0.007)	(0.025)
highlands (*Dega*)	-1.839**	0.067	-0.533	21.394	-0.422	0.807	1.316**	-0.395
	(0.744)	(0.937)	(0.495)	(21.035)	(0.683)	(1.055)	(0.631)	(0.610)
midlands (*WeynaDega*)	0.650	0.975	-0.011	21.319	0.357	1.608*	2.275***	1.260**
	(0.650)	(0.989)	(0.473)	(21.282)	(0.498)	(0.860)	(0.644)	(0.594)
Instrumental variables								
flood	-0.055	-1.019	0.694*	0.596	-0.222	-0.597	0.172	0.310
	(0.494)	(1.174)	(0.412)	(0.392)	(0.603)	(1.004)	(0.429)	(0.637)
drought	-0.068	0.511	0.087	-0.149	0.572	0.539	-0.062	-0.453
	(0.439)	(0.529)	(0.400)	(0.461)	(0.468)	(0.419)	(0.595)	(0.495)
hailstorm	0.203	1.092*	0.808	1.142**	0.508	0.274	0.095	0.276
	(0.555)	(0.664)	(0.573)	(0.549)	(0.388)	(0.563)	(0.543)	(0.615)
government extension	1.267***	0.315	0.411	0.485	1.058***	0.289	0.538	0.328
	(0.414)	(0.508)	(0.389)	(0.385)	(0.192)	(0.515)	(0.444)	(0.470)
farmer-to-farmer extension	0.417	-0.068	0.262	1.768***	0.198	1.164**	1.062**	-1.018*
	(0.429)	(0.479)	(0.294)	(0.451)	(0.345)	(0.566)	(0.429)	(0.544)
radio information	-0.026	0.331	-0.437	0.936	0.780*	1.503**	1.008**	0.466
	(0.454)	(0.651)	(0.484)	(0.600)	(0.427)	(0.625)	(0.448)	(0.443)
climate information	0.145	0.396	0.632*	1.030*	0.655	-0.066	1.685**	1.219**
	(0.419)	(0.855)	(0.343)	(0.625)	(0.507)	(0.484)	(0.693)	(0.535)
constant	8.147	-30.698	-16.965*	-61.952***	-8.505	19.555	-37.371	-0.356
	(11.270)	(24.324)	(9.881)	(12.082)	(13.078)	(29.689)	(24.398)	(7.637)
Wald test on instrumental variables (χ^2)	23.26 ***	13.11 *	24.69 ***	53.54 ***	64.13 ***	28.28 ***	55.12 ***	55.26 ***

Note: The baseline is farm households that did not adapt to climate change. Pseudo-R^2: 0.351. Sample size: 2,802 plots. Robust standard errors clustered at the *woreda* level in parentheses. * Significant at the 10% level; ** Significant at the 5% level; *** Significant at the 1% level.