# Climatic Factors and Productive Investments in African Agriculture: Micro Evidence from Ethiopia

Salvatore Di Falco, University of Geneva

Peter Berck, University of California, Berkeley

Mintewab Bezabih, LSE

Gunnar Köhlin, University of Gothenburg

# Agriculture and Development

- Important contribution of agriculture's to poverty reduction with the poorest and most vulnerable populations (Christiansen et al.; 2011)

- Little evidence exists: "African countries can bypass a broad-based agricultural revolution to successfully launch their economic transformations"

Diao et al. (2010)

# Motivation

- Ethiopia Large rural and poor population dependent upon rain fed agriculture
- Persistent food insecurity and among the highest rates of soil nutrient depletion in Africa (Stoorvogel and Smaling 1990; Grepperud 1996; FAO 2001; Shiferaw and Holden, 1997)
- 4.2 tonnes of fertile soil per hectare per year
- Soils that lack nutrients do not adequately support plants growth

# Climate change will:

- Increase weather variability => worsening conditions
- Increase the need for investments for soil conservation structures
- Previous research shown as key adaptation strategy
- (Deressa et al. 2009; Mendelsohn 2011; Di Falco and Veronesi, 2013)

- Soil conservation strategy –> building bunds
- Farmers improve the retention of soil nutrients and optimize water availability on their plots (Kassie) => food security
- Ethiopia has been target of many international micro development project to encourage farmers to invest in them
- Adoption of these agricultural technologies remained persistently low over a long period of time – **why?**

(Jansen et al. 2006; Wollni et al. 2010)

# Explaining the puzzle

- A (non-exhaustive) list:

HH endowments of physical and human capital (Asfaw and Admassie 2004; Pender and Fafchamps 2005; Ersado et al. 2003), Lack of credit, complementary inputs, labour ( Griliches, 1957 Gerhart, 1975; Dercon and Christiansen, 2005; Suri 2011), Asymmetric information and very high search costs (Feder and Slade, 1984; Shampine, 1998; Smale et al., 1994), perceptions and expectations (Kivlin and Fliegel, 1967; Ashby and Sperling, 1992), agricultural extension (Abrar et al. 2004; Mulat et al. 1998), limited off-farm opportunities (Pender and Gebremedhin 2004; Pender et al. 2003), limited profitability (Croppenstedt et al. 2003; Dadi et al. 2004; World Bank 2006), return uncertainty (Ardila and Innes, 1993), risk (McConnell, 1983, Barbier, 1990 and Grepperud, 1997, Dercon and Christiansen, 2011), poverty (Shively, 2001), population pressure (Grepperud 1996), tenure insecurity (Deininger et al. 2003; Benin and Pender 2001; Holden and Yohannes 2002; Gebremedhin and Swinton 2003; Alemu 1999)

# This paper

- It presents reduced form results and contribute to the existing literature in two ways

1/ Estimate the causal effect of rainfall and its variability on the implementation of stone and soil bunds

- The *total* effect of rainfall and its variability on investment in soil

2/ An important *partial* implication of climatic factors: their effect on farmers' impatience

# A behavioral explanation

- Mainstream economic view: RTP fixed and stable at least in the short medium run (Harrison et al., 2002)
- Is that so in the developing world?
- Exposure to shocks  can affect outlook on life: psychological literature
- “Malleable preferences”
- Conflicts and time preferences (Voors et al. 2012)
- Add on the literature on the Impact of climatic factors

# Data

- Ethiopian Environmental Household Survey, (2005 and 2007)
- About 800  hh in 14 villages in 2 regions.
- Shocks module: (27% & 38% experienced shock before 3rd and 4th rounds)
- Time preference experiments
- Weather variable from monthly weather station data.
- Spatial interpolation to each household

**Table 2. Rainfall and its coefficient of variation per village and year**

| Village | Rain in 2005 | Coefficient of Variation (CV) in 2005 | Rain in 2007 | Coefficient of variation (CV) in 2007 | Change in Rainfall (in %) | Change in CV |
|---|---|---|---|---|---|---|
| Amanuel, East Gojam | 1181.93 | 0.065 | 1294.73 | 0.051 | 9.5 | -21.5 |
| D.Elias, East Gojam | 1181.93 | 0.065 | 1294.73 | 0.051 | 9.5 | -21.5 |
| Kebi, East Gojam | 1167.96 | 0.067 | 1281.32 | 0.056 | 9.7 | -16.4 |
| Wolkie, East Gojam | 1180.38 | 0.066 | 1293.88 | 0.052 | 9.6 | -21.2 |
| Telma, East Gojam | 1418.7 | 0.122 | 1506.2 | 0.144 | 6.2 | 18.0 |
| Sekla, East Gojam | 1351.18 | 0.12 | 1440.26 | 0.154 | 6.6 | 28.3 |
| Kete, South Wollo | 986.82 | 0.006 | 1239.05 | 0.01 | 25.6 | 66.7 |
| Godguadi, South Wollo | 1016.61 | 0.07 | 1244.51 | 0.1 | 22.4 | 42.9 |
| Amba, South Wollo | 1091.23 | 0.1 | 1244.88 | 0.11 | 14.1 | 10.0 |
| Yamed, South Wollo | 1015.23 | 0.07 | 1244.03 | 0.1 | 22.5 | 42.9 |
| Addis me, South Wollo | 1081.1 | 0.1 | 1237.86 | 0.12 | 14.5 | 20.0 |
| Chorisa, South Wollo | 1074.33 | 0.09 | 1243.26 | 0.11 | 15.7 | 22.2 |
| Indood, South Wollo | 990 | 0.066 | 1237.9 | 0.1 | 25.0 | 51.5 |

# Two reduced form models

$$Soil\ Conservation_{ht} = \alpha_0 + \alpha_1\, rain_{ht} + \alpha_2 rain\ variability_{ht} + \beta_1 X_{ht} + u_{ht} \qquad (1)$$

$$RTP_{ht} = \alpha_3 + \alpha_4 rain_{ht} + \alpha_5 rain\ variability_{ht} + \beta_2 X_{ht} + \nu_{ht} \qquad (2)$$

| Dependent variable: Time spent for soil conservation measures | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| **Climatic Factors** | Rainfall | 0.0204** | 0.0209** | 0.0211** | 0.0204** | 0.0207** | 0.0206** |
| | | (0.00893) | (0.00900) | (0.00922) | (0.00938) | (0.00948) | (0.00950) |
| | | | | | | | |
| | Coefficient of Variation | -105.01*** | -104.9*** | -100.9*** | -101.6*** | -101.0*** | -100.8*** |
| | | (26.46) | (26.53) | (27.24) | (27.56) | (27.67) | (27.70) |
| | | | | | | | |
| **Non climatic Shocks** | Theft shock | | -0.303 | -0.634 | -0.873 | -0.825 | -0.770 |
| | | | (1.912) | (1.992) | (2.043) | (2.050) | (2.060) |
| | | | | | | | |
| | Death in the family | | 0.841 | 1.023 | 1.348 | 1.358 | 1.355 |
| | | | (1.185) | (1.288) | (1.330) | (1.331) | (1.332) |
| | | | | | | | |
| | Financial Shocks | | -0.282 | 0.484 | 0.630 | 0.693 | 0.659 |
| | | | (1.262) | (1.367) | (1.399) | (1.402) | (1.408) |
| | | | | | | | |
| **Time varying controls** | HH size | | | 2.060** | 2.098** | 1.984* | 1.964* |
| | | | | (0.978) | (1.026) | (1.035) | (1.038) |
| | | | | | | | |
| | Age | | | 0.0121 | 0.0418 | 0.0339 | 0.0365 |
| | | | | (0.132) | (0.142) | (0.142) | (0.143) |
| | | | | | | | |
| | Land | | | | | 0.534 | 0.538 |
| | | | | | | (0.623) | (0.624) |
| | | | | | | | |
| | Livestock | | | | | 0.0896 | 0.0874 |
| | | | | | | (0.361) | (0.361) |
| | | | | | | | |
| | Rainfall t-1 | | | | | -0.0231 | -0.0222 |
| | | | | | | (0.0515) | (0.0517) |
| | | | | | | | |
| | Temperature | | | | | | -0.0373 |
| | | | | | | | (0.125) |
| **Time effects** | | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** | **Yes** |
| | | | | | | | |
| *N* | | 1526 | 1526 | 1431 | 1354 | 1354 | 1354 |
| Standard errors in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ | | | | | | | |

| Dependent variable: Rate of time preference | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | (1) | (2) | (3) | (4) | (5) | (6) |
| **Climatic Factors** | Rainfall | -0.000160 | -0.000219 | -0.000175 | -0.000218 | -0.000249 | -0.000264 |
| | | (0.000314) | (0.000316) | (0.000312) | (0.000314) | (0.000316) | (0.000317) |
| | | | | | | | |
| | Coefficient of Variation | 3.957*** | 4.022*** | 3.815*** | 3.764*** | 3.712*** | 3.729*** |
| | | (0.930) | (0.930) | (0.923) | (0.923) | (0.923) | (0.923) |
| | | | | | | | |
| **Non climatic Shocks** | Theft_shock | | -0.0245 | -0.0309 | -0.0475 | -0.0523 | -0.0466 |
| | | | (0.0671) | (0.0675) | (0.0684) | (0.0684) | (0.0687) |
| | | | | | | | |
| | Death in the family | | -0.0137 | 0.0141 | 0.0227 | 0.0218 | 0.0215 |
| | | | (0.0416) | (0.0436) | (0.0445) | (0.0444) | (0.0444) |
| | | | | | | | |
| | Financial shock | | 0.0769* | 0.0801* | 0.0813* | 0.0755 | 0.0721 |
| | | | (0.0442) | (0.0463) | (0.0469) | (0.0468) | (0.0469) |
| | | | | | | | |
| **Time varying controls** | HH size | | | -0.00437 | 0.00246 | 0.0131 | 0.0110 |
| | | | | (0.0331) | (0.0344) | (0.0345) | (0.0346) |
| | | | | | | | |
| | Age | | | 0.00608 | 0.00601 | 0.00674 | 0.00701 |
| | | | | (0.00449) | (0.00475) | (0.00474) | (0.00475) |
| | | | | | | | |
| | | | | | | | |
| | Land | | | | | -0.0486** | -0.0482** |
| | | | | | | (0.0208) | (0.0208) |
| | | | | | | | |
| | Livestock | | | | | -0.00926 | -0.00949 |
| | | | | | | (0.0120) | (0.0120) |
| | | | | | | | |
| | Rain t-1 | | | | | -0.000685 | -0.000592 |
| | | | | | | (0.00172) | (0.00172) |
| | | | | | | | |
| | Temperature | | | | | | -0.00379 |
| | | | | | | | (0.00416) |
| | *N* | 1526 | 1526 | 1431 | 1354 | 1354 | |
| Standard errors in parentheses* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$ | | | | | | | |

# Rainfall Anomalies

- The difference between the weather at the time of the survey and the 1976-2006 climatic data divided by the 1976-2006 standard deviation
- This allows for the possibility that drier areas having larger variability is taken into account, and the likelihood of scale effects is eliminated (Nicholson, 1986)
- This measure has been used by Barrios, Bertinelli, and Strobl (2010), who also emphasize that these anomalies can be considered as exogenous to the farm-household

| | (1) | (2) |
|---|---|---|
| | time_conservation | rtp |
| Rainfall Anomalies | -6.698*** | 0.463*** |
| | (1.873) | (0.0609) |
| | | |
| Theft shock | -0.905 | -0.0536 |
| | (2.045) | (0.0665) |
| | | |
| Death in the family | 1.170 | 0.0303 |
| | (1.329) | (0.0432) |
| | | |
| Financial shock | 1.017 | 0.0633 |
| | (1.390) | (0.0452) |
| | | |
| HH size | 1.850* | 0.0252 |
| | (1.038) | (0.0337) |
| | | |
| Age | 0.0231 | 0.00731 |
| | (0.142) | (0.00461) |
| | | |
| Land | 0.407 | -0.0397* |
| | (0.622) | (0.0202) |
| | | |
| Livestock | -0.0614 | -0.00511 |
| | (0.357) | (0.0116) |
| | | |
| Temperature Anomalies | 5.624 | -0.173 |
| | (3.869) | (0.126) |
| Time effects | | |
| $N$ | 1354 | 1354 |
| adj. $R^2$ | -0.663 | -0.890 |

# Summary of results

- Rainfall variability is negatively associated with Investment in soil conservation
- RTP are endogenous and not fixed => ”malleable”
- Rainfall variability increases RTP
- Future patterns of increased rainfall variability will have a detrimental impact on private initiative to undertake soil conservation measure
- One direct, by inducing farmers to choose less profitable strategies ( Binswanger and Rosenzweig)
- The other indirect, by making farmers more impatient and hence less willing to put in place investment (Duflo et al.)

# Conclusion

- Increased weather variability under climate change:

=> Need for more SC

=> Reduced investments in soil conservation

$\Rightarrow$ Increased land degradation and lower Ag productivity

$\Rightarrow$Less development

$\Rightarrow$ Poverty trap (not driven by assets)

# Comments are very welcome

**Thank you**

salvatore.difalco@unige.ch