Climate Adaptation and Agriculture

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MIT Sloan

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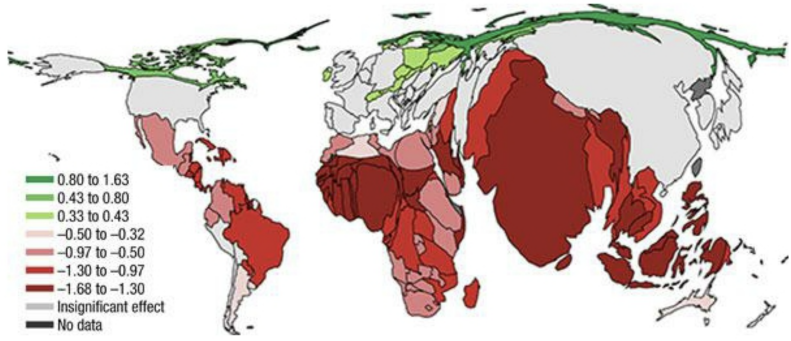
The Problem: Development and Climate Vulnerability



Sources: Natural Earth; ScapeToad; UN World Population Prospects; World Bank Group Cartography Unit; and IMF staff calculations.

Note: The map depicts the contemporaneous effect of a 1°C increase in temperature on per capita output.

⇒ Even with deep emissions cuts adaptation is critical

Between-country inequality decreased over last 50 years, BUT global warming may have slowed that decrease (Diffenbaugh and Burke, 2019)

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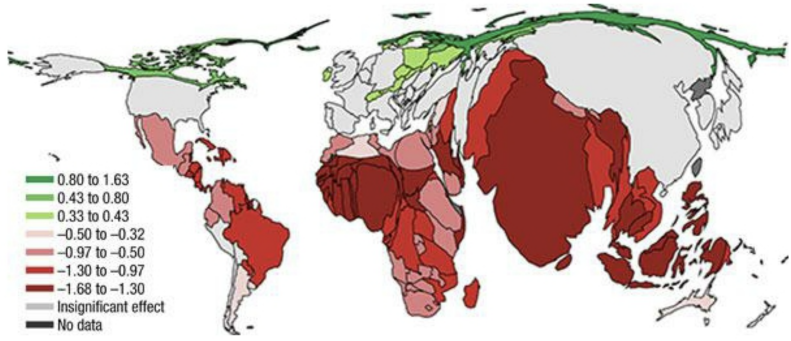

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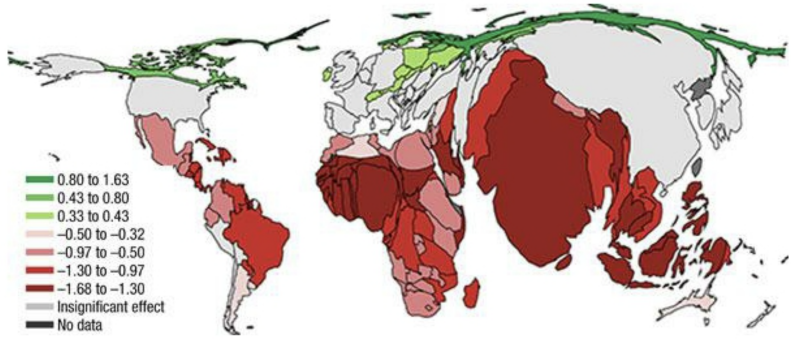

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Agriculture and Development

- Agricultural employs a substantial proportion of labor force in developing countries
- Key sector for GDP, food security
- Also a highly weather-sensitive sector $\rightarrow$ consequences for climate change impacts and their distribution within/across economies

Agricultural Impacts and Coping Behavior

Climate Change Impacts on Yields Net of Adaptation

Adaptation reduces impacts by $\sim$ 30% in Sub Saharan Africa

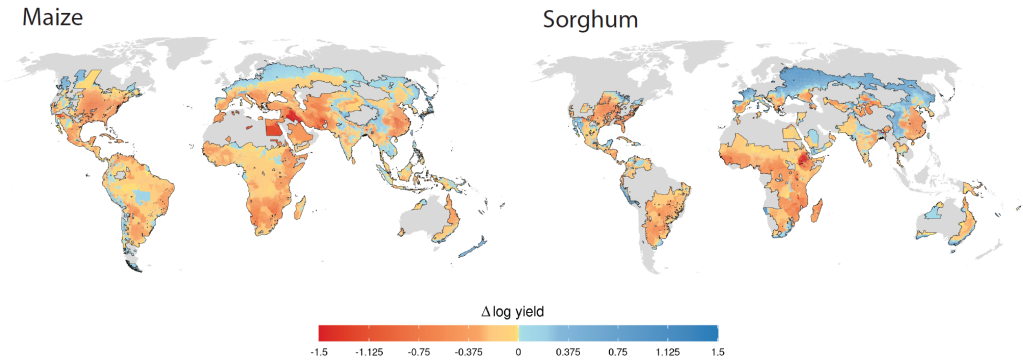

Fig. 2: Projected end-of-century change in log crop yields due to climate change, accounting for adaptation to climate and rising incomes. Colors indicate central estimate in a high emissions (RCP 8.5) scenario, net of adaptation costs and benefits, for **(A)** maize, **(B)** soybean, **(C)** rice, **(D)** wheat, **(E)** cassava, and **(F)** sorghum for 2089 - 2098. Projections computed for 24,378 subnational units, uncropped regions are shaded in grey. Wheat shows winter wheat and spring wheat projections combined, weighted by their area share in each region. Estimates in each location are ensemble means across climate and statistical uncertainty. Incomes from SSP3 (*44*).

Adaptive Behaviors by Agricultural Households

When faced with weather and climate induced income volatility, households cope and adapt in numerous ways

- Alter agricultural practices like irrigation (Taraz, 2017), crop diversification (Auffhammer and Carleton 2018), planting dates (Kala, 2019)
- Risk-sharing (e.g. Townsend, 1994, Morten 2017): less effective for aggregate risk
- Asset Choices (Rosenzweig and Binswanger, 1993)
- Migration (Conte, 2022)
- Sector-switching (Liu et al, 2023)

Impacts vary by regions, income and access to adaptive technologies (financial and technological) $\rightarrow$ important implications for policy targeting

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Adaptation in Agriculture: Some Technological and Financial Examples

Improved Agricultural Technologies: Dar et al., 2013

Approximately 30% of the cultivated rice area in India is prone to crop damage from prolonged flooding. Can flood-resistant varities mitigate losses?

- Randomized control trial (RCT) testing Swarna-Sub1 under field conditions in 128 villages of Orissa's flood-prone lowlands.
- Nearly identical to popular high-yielding variety grown in this area, with the only difference being improved flood tolerance
- Random subset of 5 farmers in each of 64 treatment villages were provided a small package of Swarna-Sub1 seed and instruction materials

Average Impacts

Reduces downside risk considerably (45% higher yields when fields are submerged for 10 days), *but* performance significantly lower than in agronomy trials

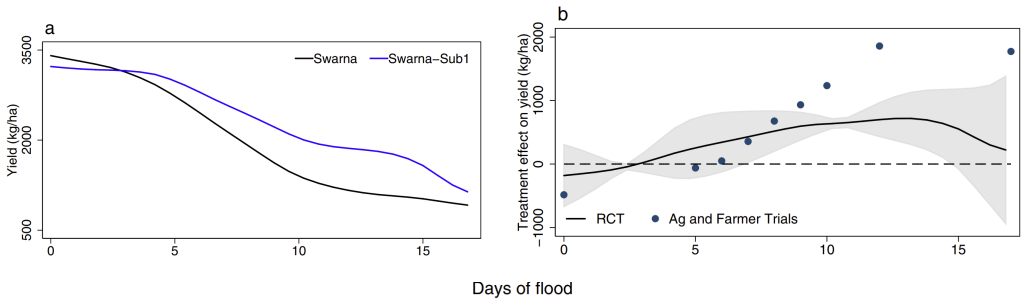

Figure 1 | **Impact of flood-tolerant rice (Swarna-Sub1) on yield during the 2011 wet season.** (a) Relationship between yield (kg/ha) and flood duration (days). (b) Estimated yield advantage of Swarna-Sub1 relative to Swarna, as a function of duration of flooding. Solid black line is treatment effect and shaded area represents 95% confidence interval. Dots are impact estimates from 133 data points collected from published agronomic field trials and unpublished data from NGO trials on farmer's fields. (c) Distribution of flood duration. (d) Cumulative distribution of flood duration.

Equity Implications

Lower socio-economic groups more vulnerable to flooding, so this technology can potentially facilitate equitable adaptation

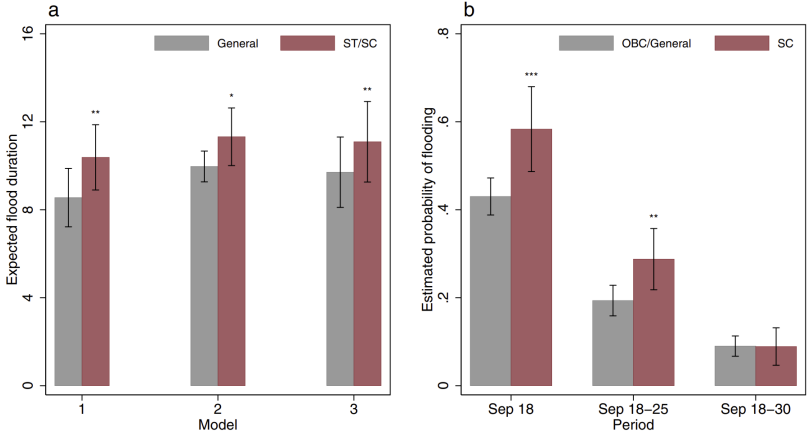

Figure 2 | Relationship between caste and flooding. (a) Predictions from OLS regression of days plot flooded on caste of cultivator. Bar heights represent predicted days of flooding. Whiskers are 95% confidence intervals (±1.96*SE). Model 1 includes caste indicators only. Model 2 additionally includes village fixed effects (village-specific intercepts). Model 3 includes village fixed effects and household covariates. Standard errors in all models allow for spatial correlation within villages. (b) Estimated probabilities of flooding using satellite data for villages in three districts of Orissa. Bar height is estimated

Agricultural Technologies and Practicies

Technologies such as improved seed varieties and irrigation can reduce downside risk in agriculture, raising incomes

- However, lab vs. field performance of technologies might vary
- Adaptations might trade off mean and variance in returns (Hultgren et al. (2022))
- Equity implications important to consider

High costs of new technologies (Glennerster and Suri 2018), costly experimentation and learning (Foster and Rosenzweig 1995) could inhibit the adoption of adaptive technologies. If information disseminated via social networks, adoption could be concentrated amongst households with better access to information.

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Innovative Financial Solutions

Weather-based insurance holds promise for adaptation, especially when combined with liquidity (Karlan et al, 2014), but take-up of these remains low

- Financial products that guarantee liquidity in the event of disaster can help adaptation in two ways (Lane, 2023)
  - increased ex-ante investment (insurance): treated farmers increase the amount of land dedicated to agricultural cultivation by 18%, have 19% increase in crop production on average
  - ex-post smoothing (consumption): increased consumption by 10% in flood-affected treated regions
- Overall profitable for the lender

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The Role of Policy

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Policies focused solely on climate change adaptation are not common, but we can draw lessons from interventions that mitigate agricultural income shocks

- Developing countries have lower access to social safety nets (Hanna and Oliva 2016), which can impact resilience and adaptive investments
- Cash transfers for productive investments and vocational skills training improve resilience to droughts– cash enhanced investments in businesses and skills training intensified wage-work and urban migration (Macours et al, 2022)
- Social protection e.g. workfare programmes (Garg et al, 2020) attenuate the negative effect of rising temperatures on learning by impacting agricultural income

Important political economy concerns may mediate vulnerability from climate shocks (Cole et al. 2012). Reducing vulnerability also reduces clientism (Bobonis et al. 2022)

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Takeaways

- Climate and weather shocks have significant impacts on agricultural outcomes such as productivity and income
- Rich literature documenting a range of coping strategies and adaptive behaviors employed by households, often only able to achieve partial mitigation of these impacts
- Innovative technological and financial solutions emerging, but need rigorous testing to prove impacts before scale-up
- Policies can provide safety nets and minimise frictions that catalyse adaptation, though political economy concerns may hinder adaptation and adaptation itself may reshape political relationships

Understanding how policy efforts can be best allocated to high-impact interventions, households, and regions forms a crucial set of questions for future work

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