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Expanding Impacts: Merging Seed & Financial Innovations for Resilient Agricultural Growth

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Workshop on the Drought Tolerant Maize-Index Insurance Pilot Project
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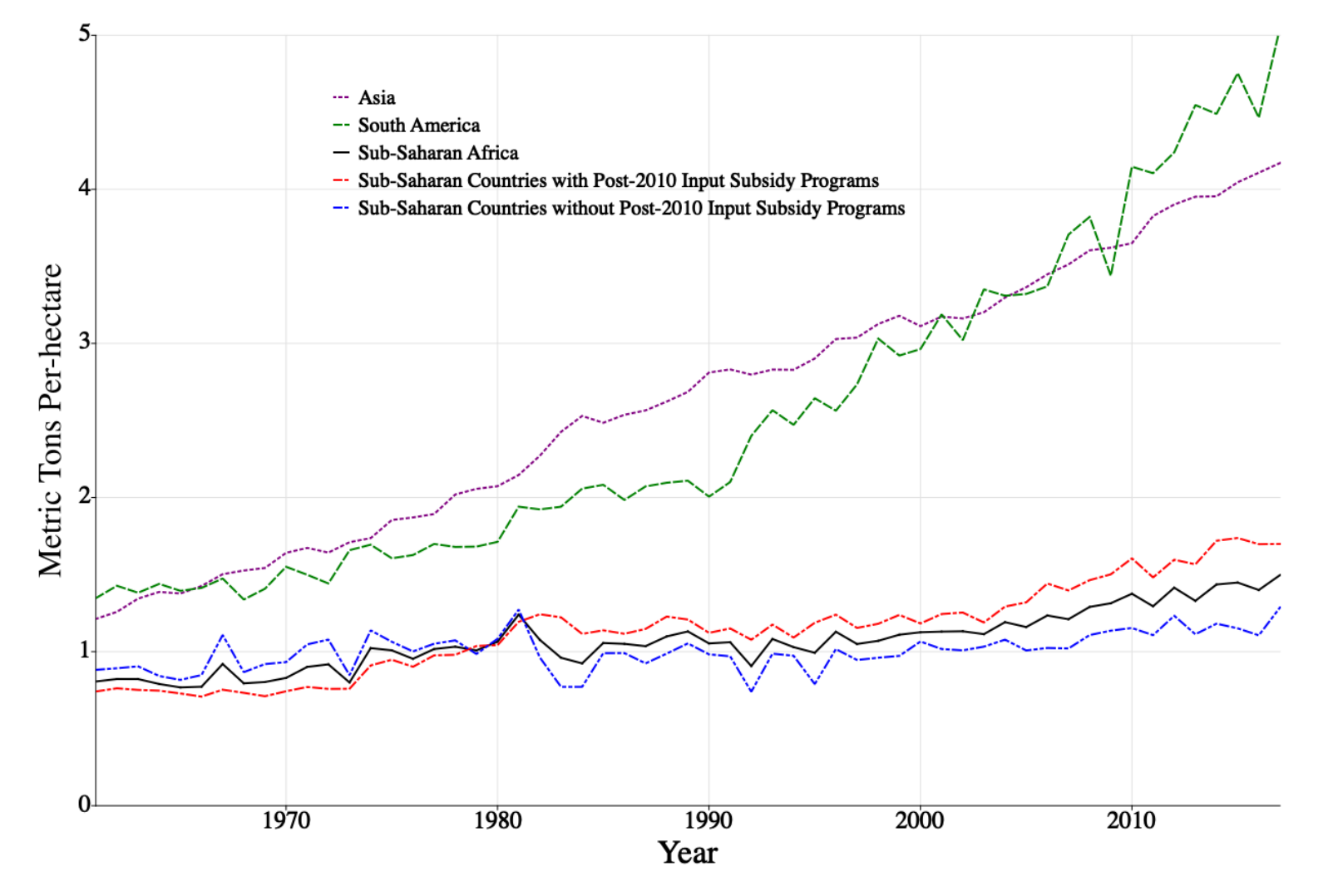
The Green Revolution that Wasn't, 1960-2005, (and Maybe is Just Starting)



Source: FAOSTAT data on cereal yields

What's Risk Got to Do with It?

- So why did the green (seed-fertilizer) revolution largely bypass the continent?
  - Seed-fertilizer technologies not profitable because of nature of soils and agro-ecological conditions across large parts of the continent
  - Technologies are profitable, but farmers 'misbehave,' *e.g.* are time inconsistent
  - Technologies are profitable, but farmers constrained by:
    - Lack of information & experience
    - Lack of finance
    - Discouraged by risk
- This latter explanation, risk, has always loomed large as an explanation for this sub-Saharan African exceptionalism
  - Less than 5% of the cultivated area is irrigated
  - Substantial areas exposed to high risk of total crop failure

What's Risk Got to Do with It?

- The veracity of this risk-based explanation is supported by multiple insurance studies that demonstrate that de-risking agricultural systems results in increased investment:
  - Ghanian maize farmers increased investment in improved inputs by 20% when covered by an index insurance (Karlan, Osei, Osei-Akato & Udry)
  - Malian cotton farmers increased investment by over 30% when covered by index insurance (Elabed & Carter)
- Note that if we define *resilience* as the ability to manage adversity and change without compromising current and future well-being, then we see that de-risking can create "*resilience plus*," meaning that households increase investment & improve their level of well-being over what it would have been absent improved risk management

Drought Tolerant Maize for Africa

- As reviewed earlier, substantial resources from Gates, USAID & others were dedicated to the development of drought tolerant maize varieties (DT)
- Can DT maize replicate the success of flood tolerant rice varieties seen in India where:
  - Flood tolerant seeds protected yields against a flood event, promoting resilience
  - Farmers with flood tolerant seed increased investment, creating resilience-plus (see Emerick *et al.*)

Drought Tolerant Maize for Africa

- One reason DT may not replicate the success of the flood tolerant rice is because the DT trait only protects against a sub-set of droughts, namely those that occur during the midseason flowering period of maize growth
    - Similarly, flood-tolerant rice varieties can only survive floods that last less than 15 days
    - The flood event studied in India was only 14 days–one more day and its impact on resilience would have evaporated!
- The partial protection afforded by seed genetics suggest a role for combining stress tolerant seed varieties with a complementary insurance contract

Seed & Insurance Technologies

- Simulation analysis shows that a stylized DT-insurance combo package works (Lybbert & Carter)

Table 22.2 Consumption and Certainty Equivalent Performance of DT, II, and Bundled DT–II

	Additional Cost Above Traditional Technology (USD/acre)	Mean Gross Income, USD (Net of Insurance Costs)	Certainty Equivalent, USD/acre	% Change Certainty Equivalent
Traditional maize	–	716	675	
DT maize	–	750	715	6.1
II-high coverage (15% yield shortfall strike)	66	710	692	2.6
II-low coverage (35% yield shortfall strike)	20	718	688	1.9
Bundled DT–II with low coverage II "optimized" for DT yield distribution	13	748	723	7.2

- But can such a complementary package really work in practice?
  - Can we devise a reliable insurance contract to complement DT seeds?
  - Do DT seeds work in farmers' fields, outside of the carefully controlled experiment conditions where they were bred?

Outline

- Devising a Fail-Safe Index Insurance Technology
  - Why quality matters
  - Designing for Quality
- Characterizing the DT Seed Technology
  - managed versus real Drought
  - Findings from farmer field Trials: Average impacts
  - Findings from farmer field Trials: Heterogenous impacts
- Learning about the Impacts & Effectiveness of the Twin Technologies
  - A portfolio approach to our Randomized Controlled Trial (RCT)
  - Raises the question about how farmers learn
- Steve will present findings from the RCT

Why Index Insurance Quality Matters

- Because it relies on an index to determine damages, index insurance avoids the need to visit every farmer and verify losses, making insurance protection feasible for small scale farmers
- This strength of index insurance is also its greatest weakness–the index may not trigger payments when the farmer has had a loss.
- In this case, the worst case scenario (crop failure) becomes worse (crop failure, paid premium, but no insurance payment)
- Index insurance can actually hurt people; Assuring quality is of paramount importance
- Cannot expect to spur the missing green revolution with failure prone contracts

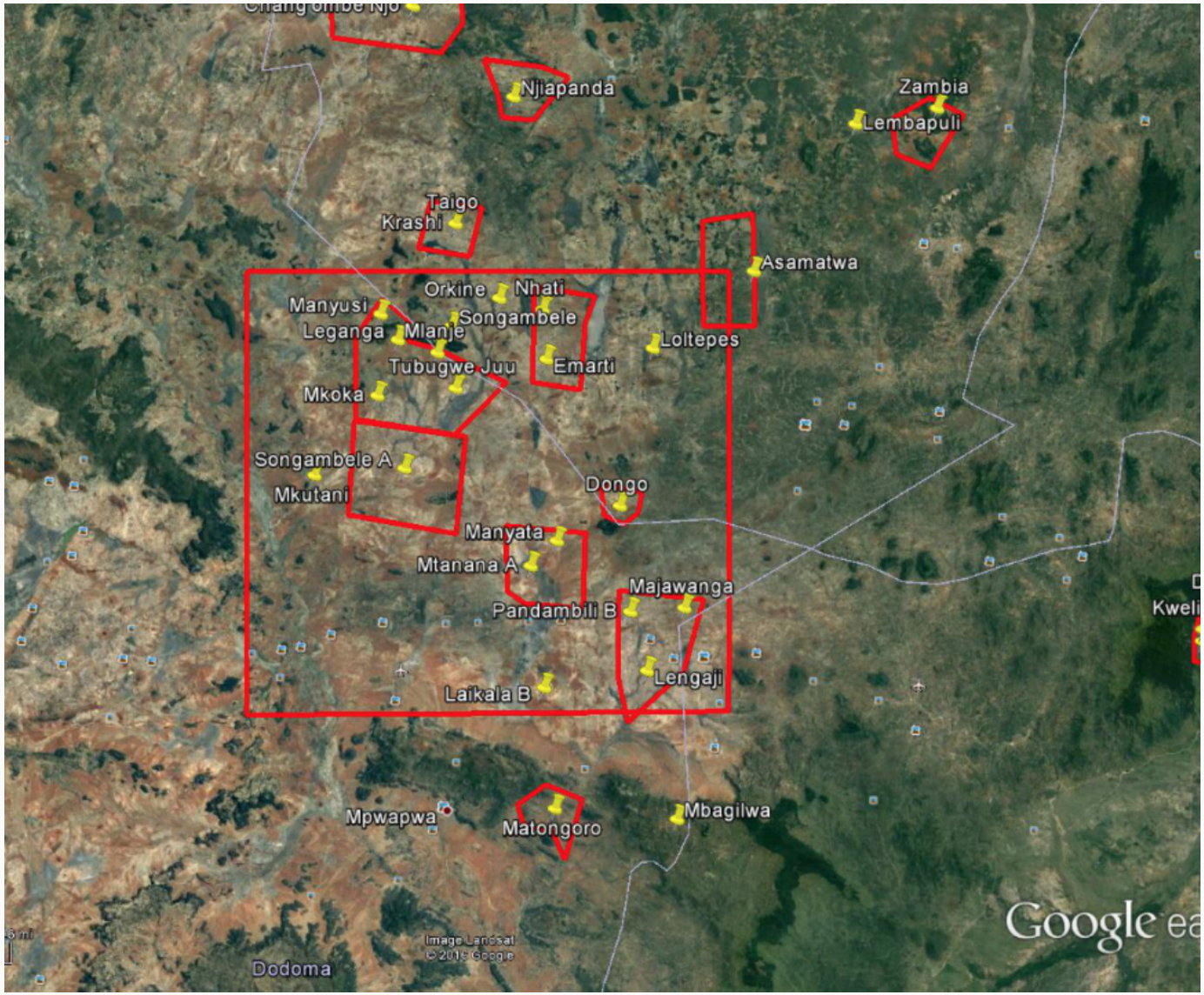
The Index Insurance Quality Problem

- A quality index insurance contract is one that:
  - Adequately protect farmers against income fluctuations; and,
  - Can achieve the objectives we seek in offering insurance to developing country farmers (the before & after impacts)
- Like hybrid maize seeds, quality of index insurance :
  - Is a hidden trait (that is, the farmer cannot look at the contract paper & tell if it will protect her)
  - High quality is more costly to develop and supply high quality than low quality
- Unlike certified hybrid seeds:
  - No defined & enforced quality standards (akin to germination & yield tests for seeds)
  - Takes many years for farmers to discern quality (even harder than for maize seeds)

Designing a Complementary Financial Technology

- Goal was to design an index insurance contract that offered protection against risks not well-covered by DT seed technology:
  - Early season rainfall deficit; and,
  - Large, end of season yield deficit likely caused by forces beyond mid-season drought
- Collected retrospective maize yield data that allowed us to design a quality contract based on two satellite indices:
  - Estimated rainfall data to detect early season drought
  - NDVI (a bio-mass or "greenness" index) to measure yield deficit
- Measure each of these at the level of "contract zones, which comprise roughly 3 villages
- Included a back-up, fail-safe audit option

Insurance Zones, Dodoma



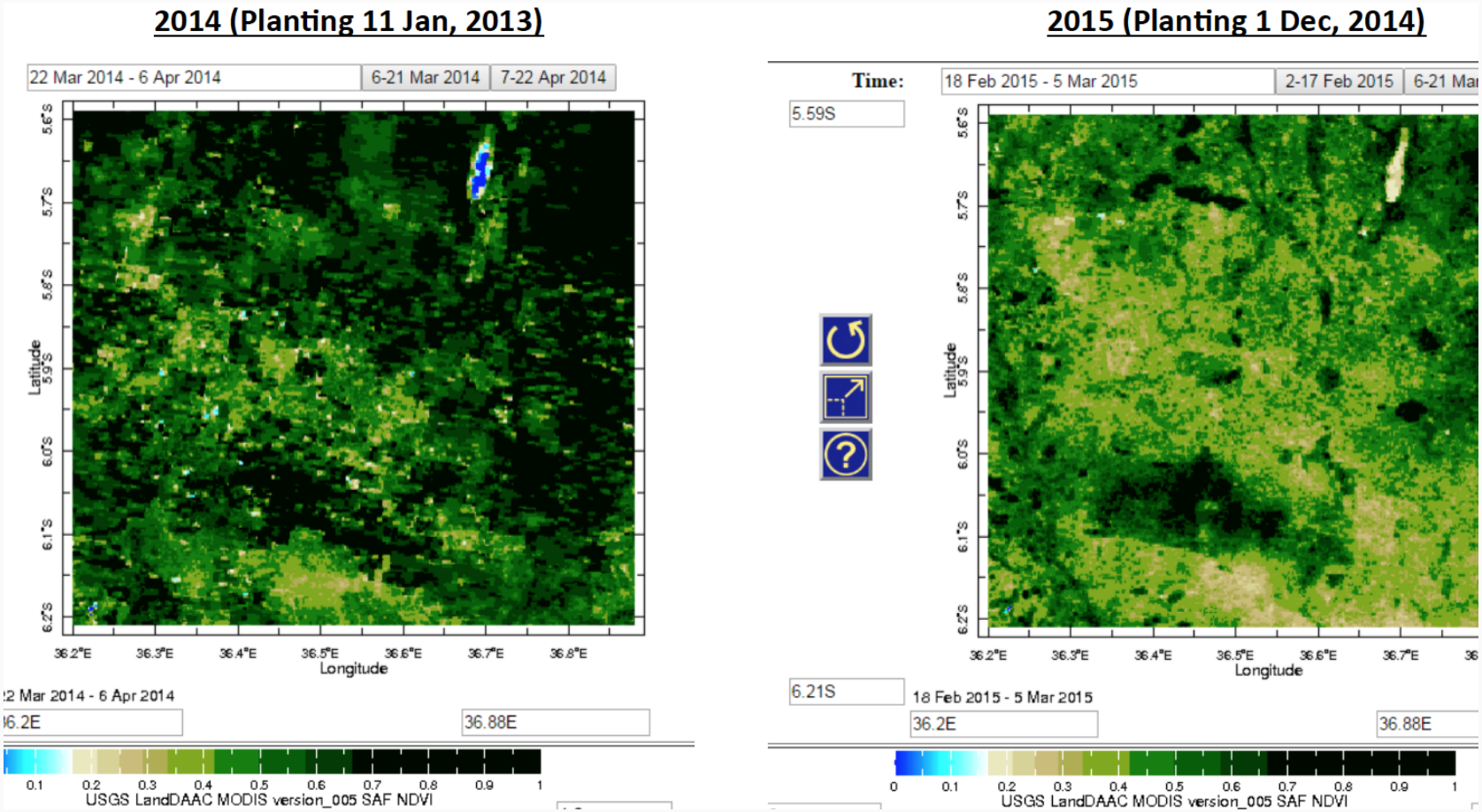
Index Design

- Data for ground-truthing, testing & (eventually) certifying insurance index is crucial
- Early season rainfall deficit trigger:
  - 5x5 kilometer (25 square kilometer) resolution
  - Data at 10-day (dekad) frequency
  - Use data to estimate planting date and then detect early season drought
  - Contract triggers payment if estimated rainfall below 90 mm over the first 40 days of the growing season

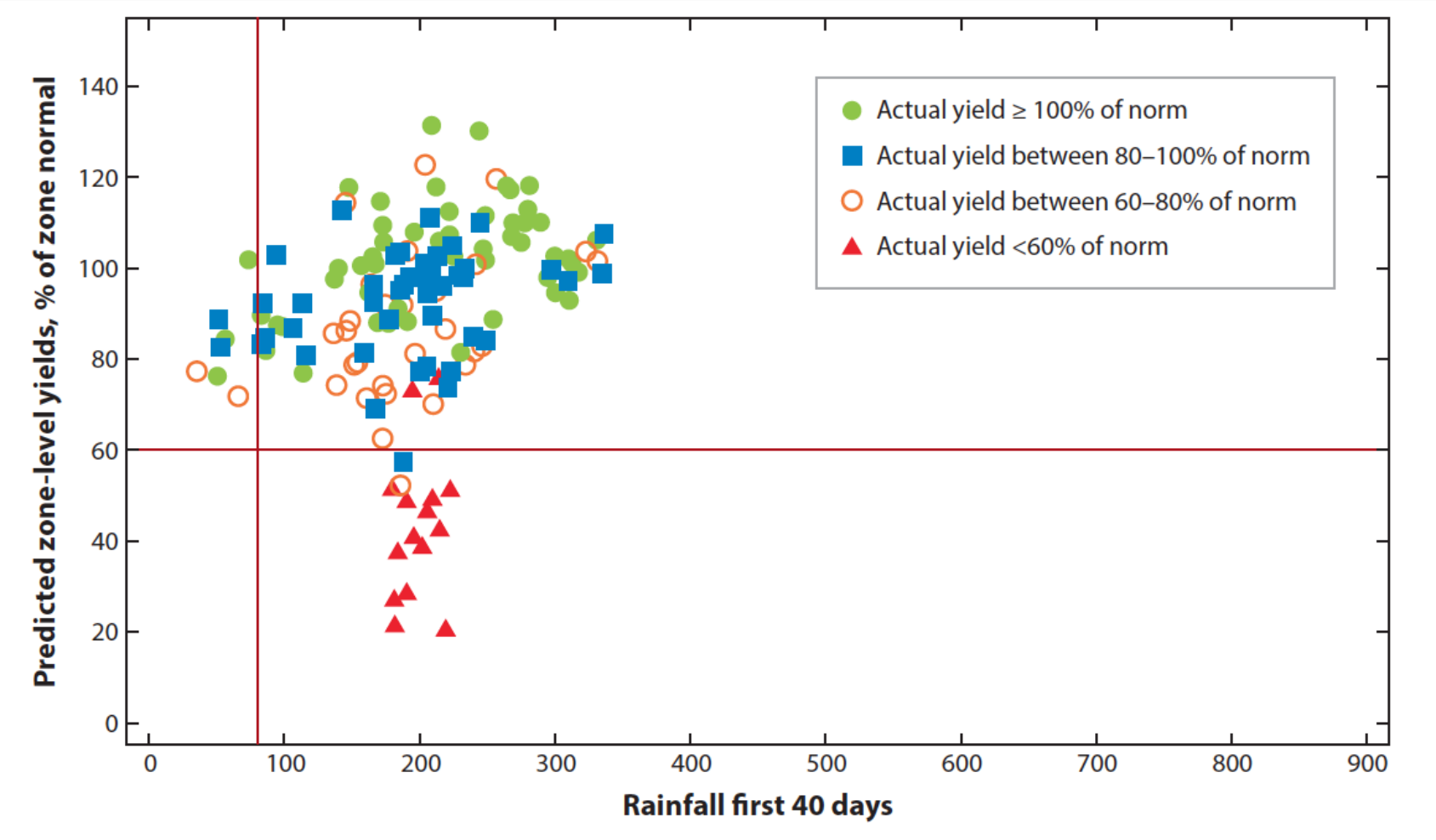
Index Design

- Yield shortfall trigger based on Normalized Difference Vegetation Index (NDVI)
  - Measures biomass growth over the maize growing season
  - Data available on 250 m x 250 m grid (6 hectares) since 2002
  - Crop masking used to discard pixels that are not maize
  - Contract Triggers if predicted yields are less than 65% of their long-term average
- Optimized statistical model explains 80% of zone variation in yields (still some design risk)
- Scope for improvement with downscaling & ultra-high resolution data from Planet Labs (3mx3m)

Index Design: NDVI



Overall Contract Performance



Fail-Safe Audit

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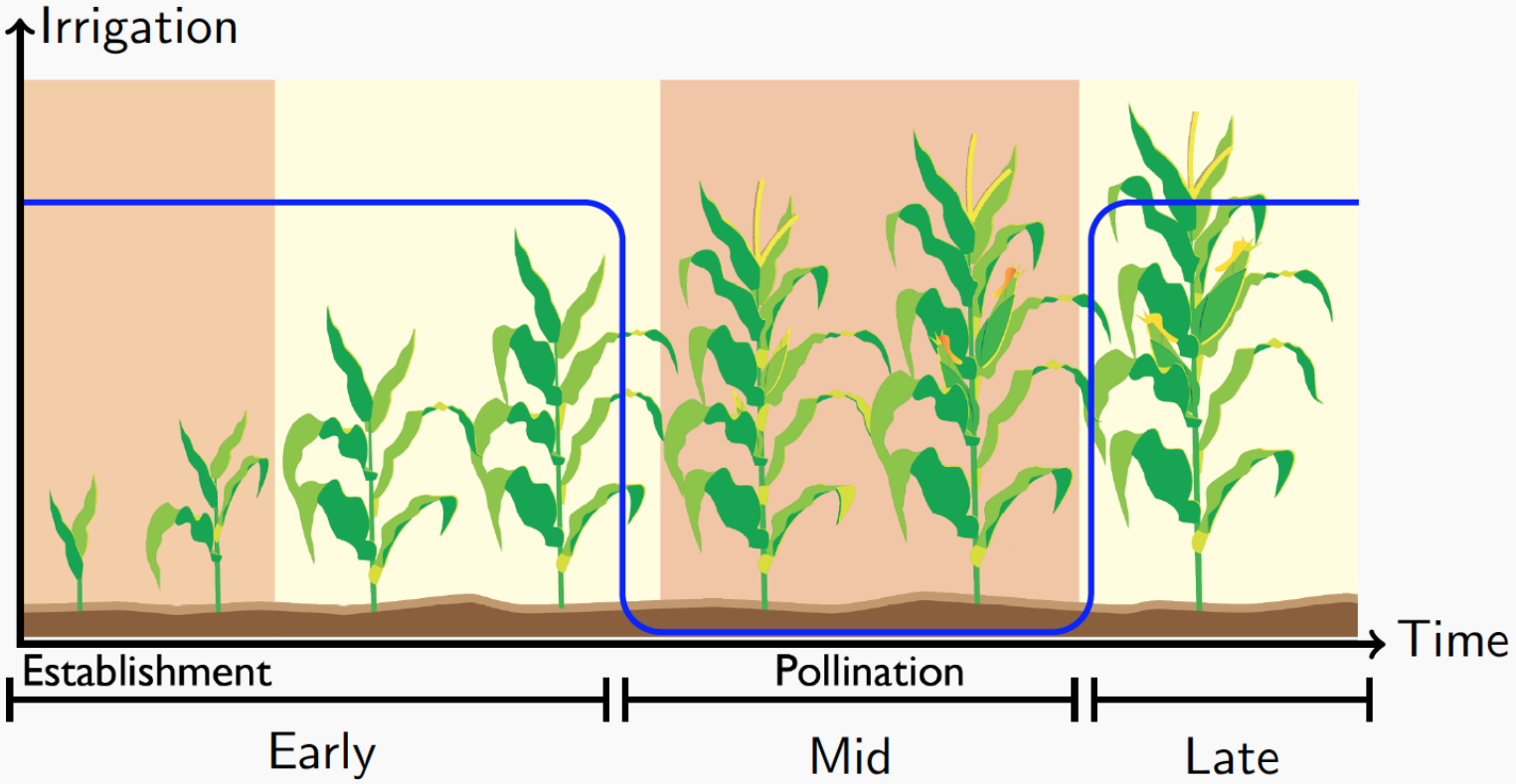
- An on-farm audit can occur if farmers experience yield losses that are not predicted by the satellite data:
  - Farmers are notified 100 days after planting if insurance payout will occur in advance of harvest;
  - Farmers may then call for an audit if they believe the insurance did not properly cover their losses
- Audit triggered if at least 50% of farmers complain
- Camera-based audit is conducted by a team trained by CIMMYT

Summary of Steps to Design for Quality

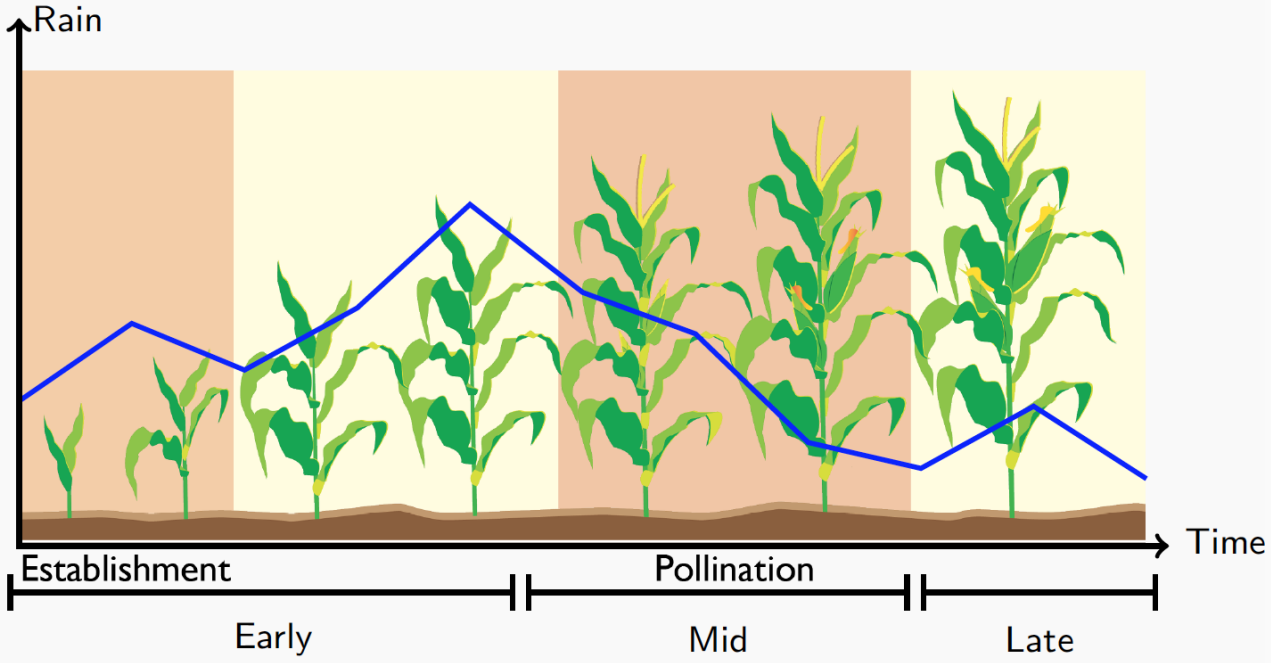
- Scale down insurance zones to smallest level possible given technology & moral hazard problems (including reliance on double trigger contracts as with cotton contracts)
- Use ground-truthing & technology to eliminate design failure
- Consider fail-safe audit to definitively eliminate design failure
- Beware that in some environments index insurance may never work because intrinsic idiosyncratic risk is too high

Managed Drought & the Impact of DT on the Experiment Station



- Experiment station results showed that DT seeds had up to a 137% yield advantage under managed drought
- Under non-drought conditions still maintained a modest but respectable 10% yield advantage

From Managed Experiment Station Drought to Real Drought in Farmers' Fields



- Real drought is not well-managed and other things can go wrong when mid-season drought occurs
- Real farm unlikely to have the same soil and management qualities as an experiment station
- Will the DT advantage survive these less favorable conditions?
- Or, does it take well nourished & well-curated plants to express the DT advantage?

On-Farm Trials

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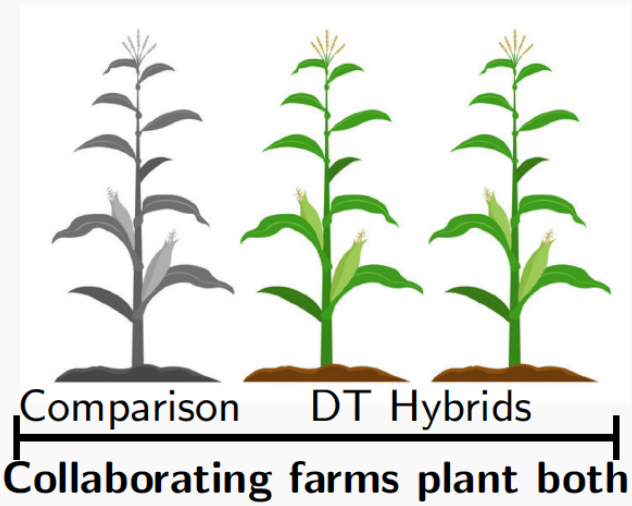
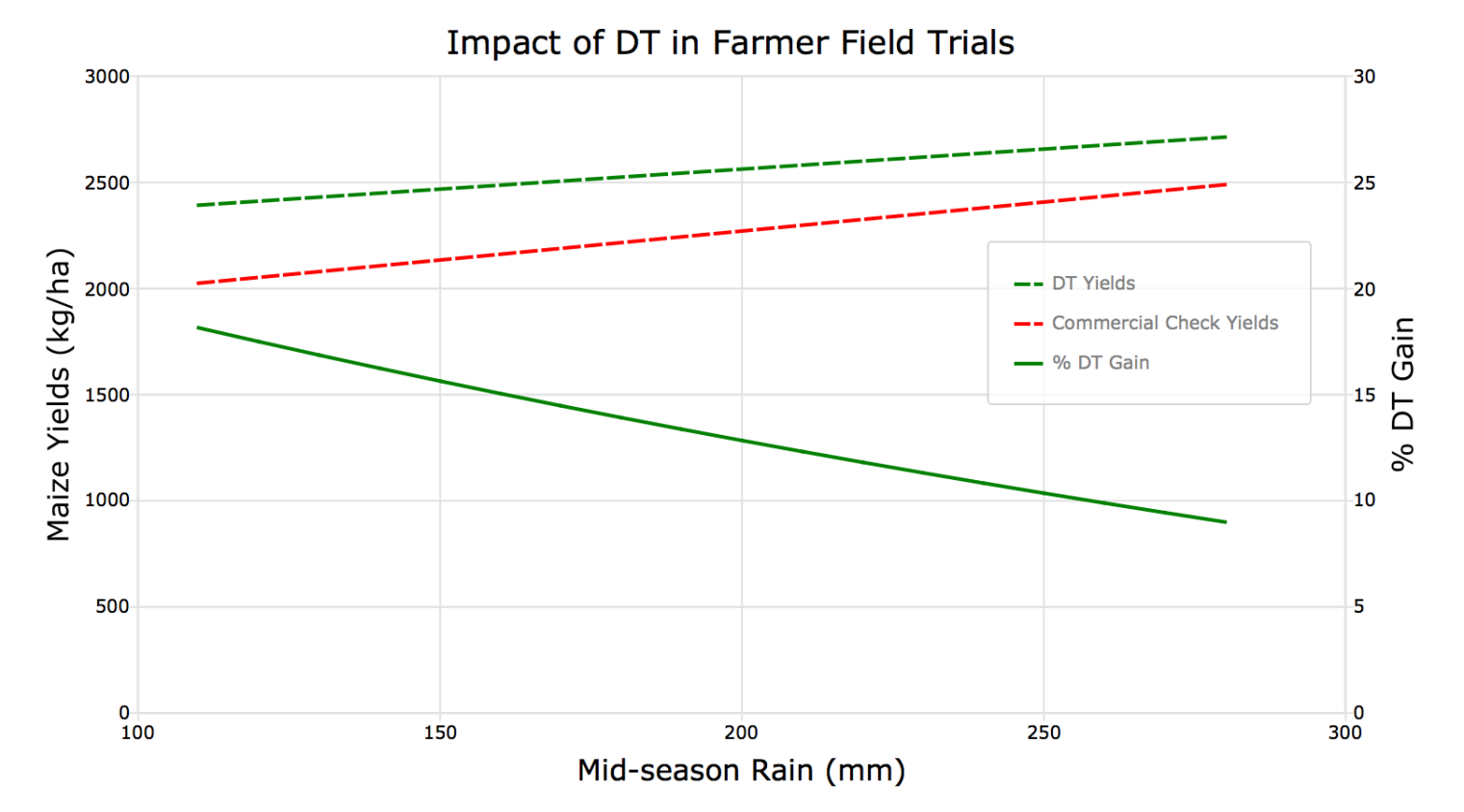


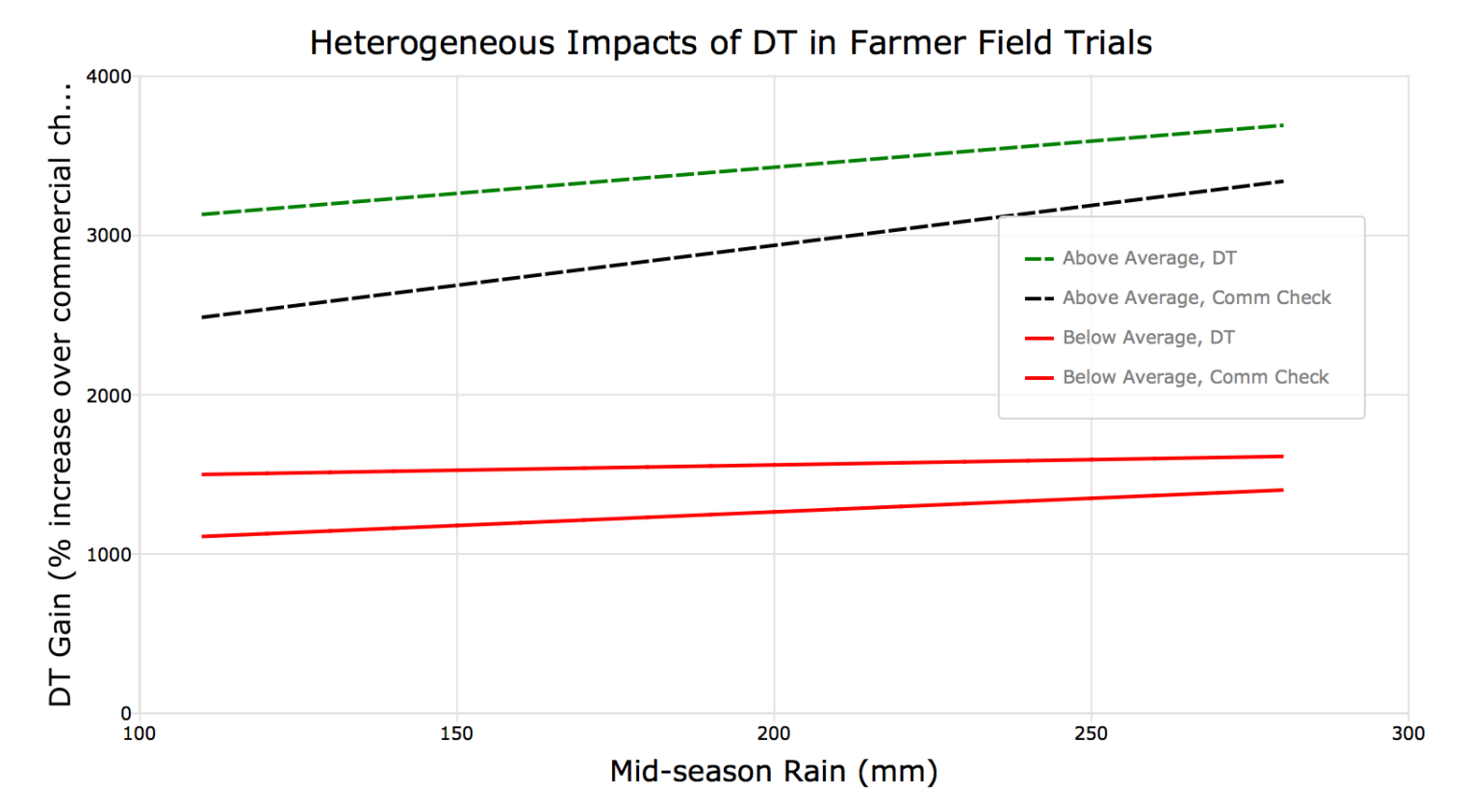
- CIMMYT On-Farm Trials
  - 69 collaborating farmers across Eastern and Southern Africa
  - Unbalanced panel from 2011 to 2015
- Remote Sensing Data from CHIRPS Rainfall and CHIRTS Temperature
  - 10 day rainfall and temperature high mapped to On-Farm Trial plots and maize planting season
  - Used to identify planting dates & mid-season & other droughts

On-Farm Trial Results: Average Impacts



Early & late season rains statistically held at their normal levels

On-Farm Trial Results: Heterogeneous Impacts



Early & late season rains statistically held at their normal levels

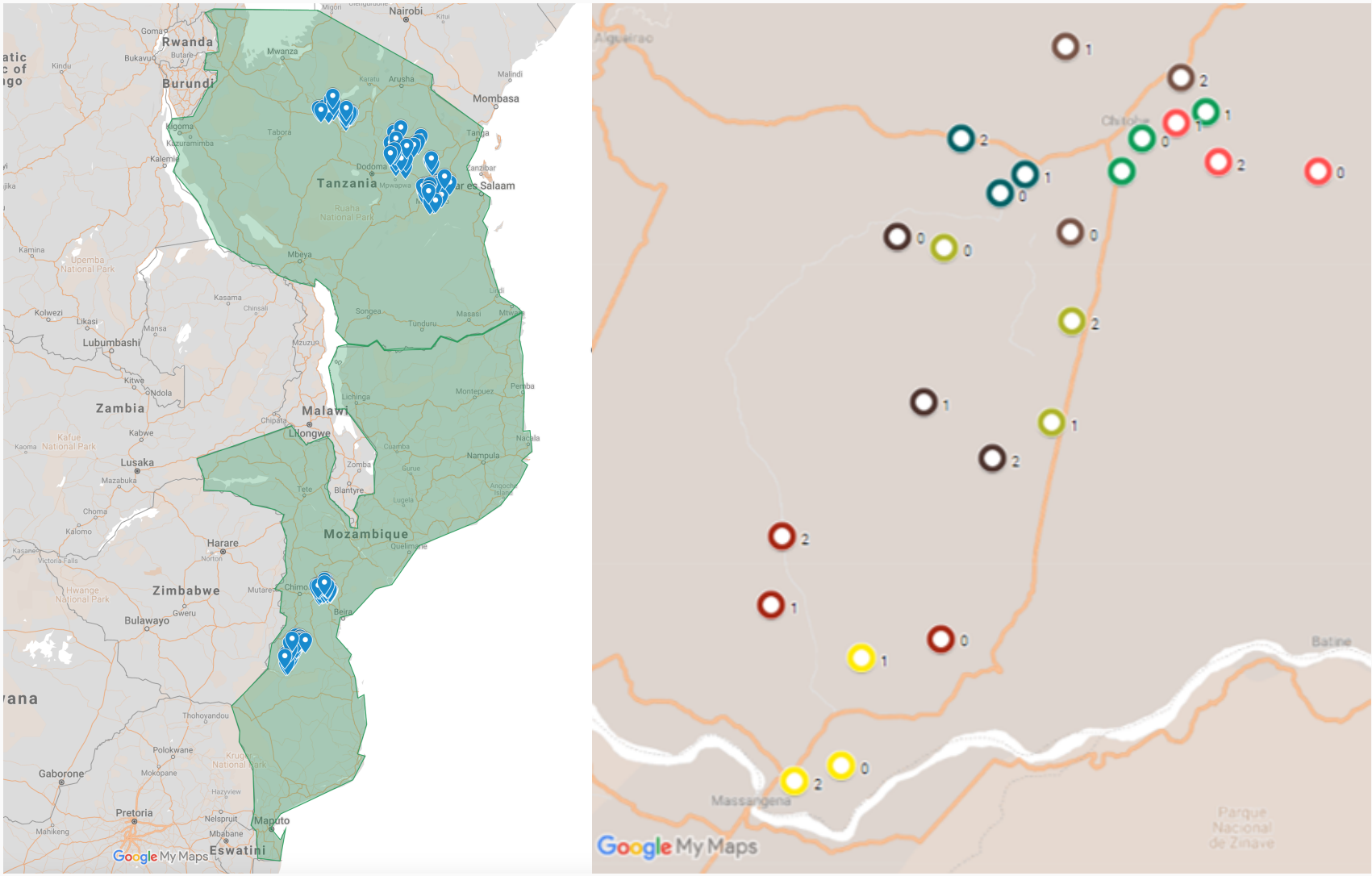
The Primary Research Questions

- Will ordinary farmers in disadvantaged areas purchase DT seeds alone or when packaged with insurance?
- Under these conditions, does the DT technology generate substantial benefits for farmers?
- What happens to DT farmers when confronted by more severe stresses that DT not intended to combat?
- What additional benefits do we see when insurance is incorporated into the package?
- Are the impacts of the technology strong enough to improve farmer income & even food security?

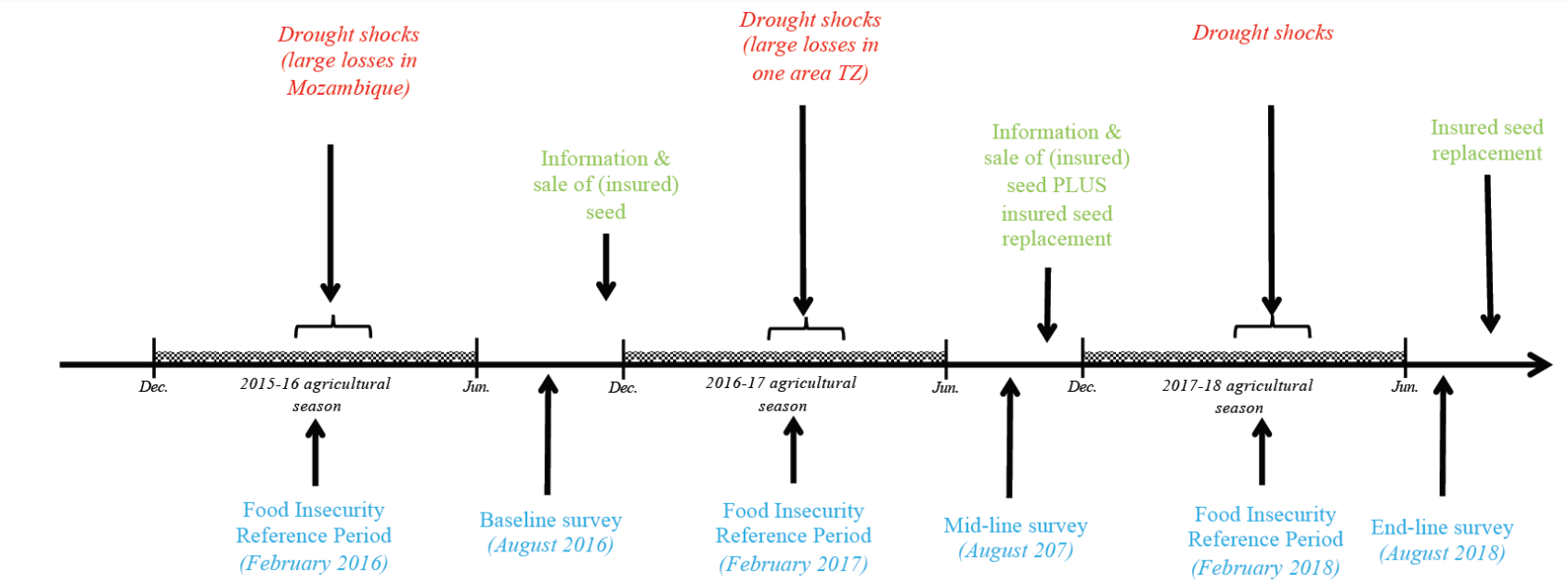
The Diversified DT-II Randomized Controlled Trial in Mozambique & Tanzania

- Learning about a technology that only can only display its benefits during infrequent bad years is challenging
- In our research, we took a diversified RCT design
  - 2 countries, 3 years
  - Further within country diversification
  - "Matched triplet" randomization
- However farmers do not have this ability to look statistically across years & space
- Steve will return briefly to the topic of farmer learning in his talk

An Diversified RCT Approach to Studying Technologies with Stochastic Benefits



An RCT Portfolio Approach to Studying Technologies with Stochastic Benefits



Thank you and Forward to the RCT Results!