The technology adoption puzzle: What can the CGIAR learn from field experiments?[1]

Alain de Janvry[2]

University of California at Berkeley and FERDI

Legend: Treated recipients of SwarnaSub1 seed minikits in Odisha RCT

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[1] CGIAR Conference on Impacts of International Agricultural Research: Rigorous Evidence for Policy, July 6-8, 2017 - Nairobi, Kenya - World Agroforestry Centre

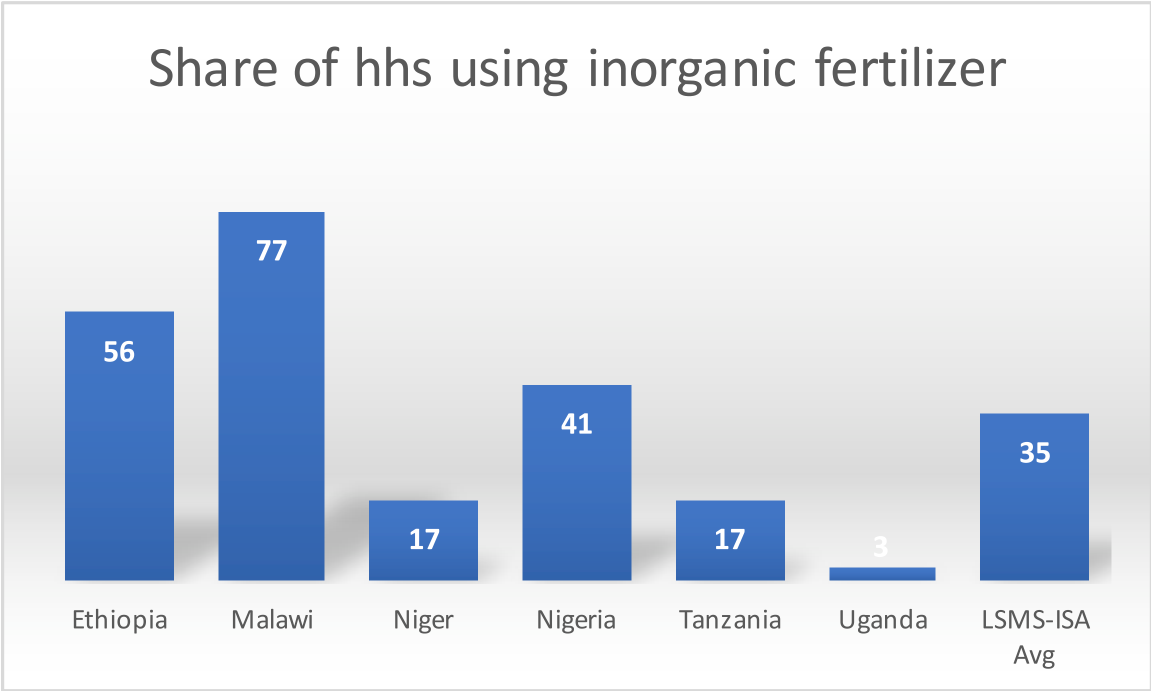
[2] Based on research done with M. Dar, K. Emerick, and E. Sadoulet, and by the CEGA-JPAL Agricultural Technology Adoption Initiative (BMGF-DFID), SPIA, and AMA-Basis

Outline of presentation

1. The **puzzle of low adoption** of agricultural technology in SSA and rainfed SA
2. **What do we want to achieve** with technology adoption?
3. The rapid development of **field experiments** in economics
4. **What have we learned about adoption** from field experiments?
5. **Seven considerations** in addressing the adoption puzzle

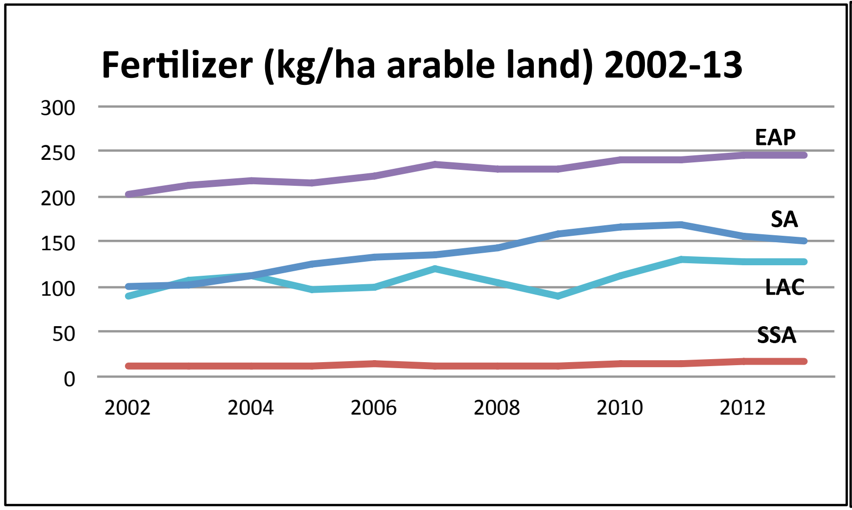
1. The low adoption of agricultural technology in SSA and rainfed SA remains a first-order challenge

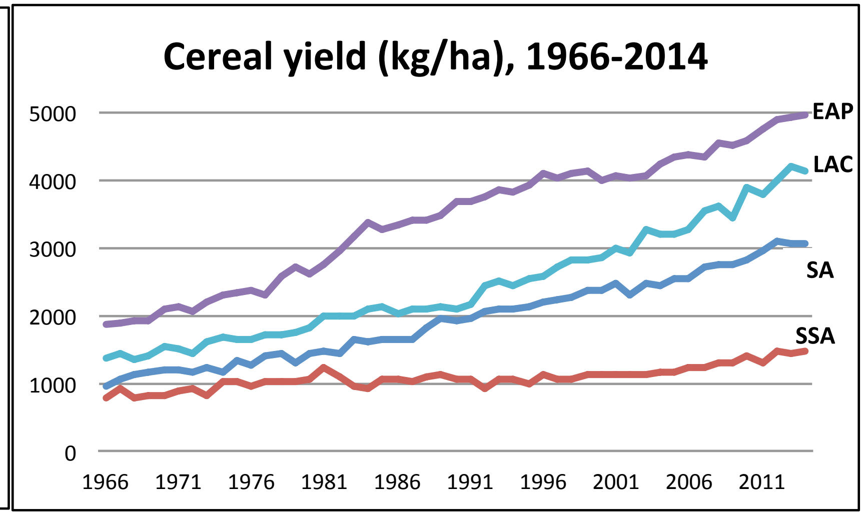
- Chemical fertilizer used as a metric of agricultural modernization, e.g., driven by technological change in seeds
- LSMS-ISA data show progress with fertilizer use



From high use with subsidies (Malawi) to minimal in Uganda (3%)

- But macro picture for fertilizer use in SSA remains basically unchanged over the long period





Low and stagnant use of fertilizers in SSA (mainly rainfed) and low and stagnant cereal yields

The technology adoption puzzle posed:

- **Why** is agricultural technology adoption still **low** in SSA (and rainfed SA) compared to other regions of the world?
- **What** can be done to **enhance** adoption if profitable?

The research question: Can **field experiments** (RCT, lab-in-the-field exp.) give a useful methodological approach to (1) identify the **determinants** of adoption, (2) identify the **impact** of adoption, and (3) help **design** effective interventions for adoption?

Common features of context where the adoption puzzle occurs:

- **Rainfed** (good potential) agriculture in SSA and SA
- High **complexity** and **risk** of farming systems
- High **heterogeneity** of farming/household circumstances
- **Smallholder** farmers embedded in household behavior
- Generally **poor** and **risk averse**
- Non-separability: **market failures** and missing **institutions**
- Large **populations** and very high share of world **poverty**
- **Agriculture** the main source of local sustainable growth

This makes solving the agricultural technology adoption puzzle both a first-order challenge and an extremely difficult task

2. What we want to achieve with technology adoption is more than a Green Revolution: Ag and Rural Transformations

- For most rural poor, solution to rural poverty has to be found **within rural areas**, not through migration and structural change (Christiaensen): rural poverty is **not a selection** issue created by successful urban-based Structural Transformations

- A **Green Revolution for Africa** (AGRA) is a **necessary** starting point, but will **not be sufficient** to take rural populations out of poverty

- What we want to achieve through technology adoption is the **role of agriculture for development**:

(1) A **Green Revolution** (GR) for favorable rainfed areas by increasing the yield of staple foods

(2) An **Agricultural Transformation** (AT) through the **diversification** of production systems to smooth out **labor calendars** in agriculture over the year and improve diets. Main cause of rural poverty is not low **labor productivity** per hour worked, but idleness in labor calendars (low annual productivity)

(3) A **Rural Transformation** (RT) with the emergence of **local, town-based, rural non-farm industries and services** driven by agriculture that offer complementary sources of income to the rural population

Using technology adoption to achieve GR+AT+RT to take rural populations out of poverty is useful for priority setting

3. The rapid development of field experiments since 2010 has revolutionized research on adoption and impact evaluation

- **2010 SPIA report** (SPIA-WDR 2008 Berkeley meeting) on methods for ex-post impact assessment of ag. technology
  - Critique of state of the arts in evaluation:
    - k-factor approach for epIA not causal
    - PSM approach not rigorous if control could adopt
  - Proposition of using RCTs and illustrative examples

- **2016 Handbook of Field Experiments as state of the arts**
  - Explosion in Field Experiments on technology adoption & impact under ATAI(CEGA-JPAL)-SPIA(CGIAR)-AMABasis(USAID)-others

- **State of the arts in using Field Experiments for impact evaluation:** Use of experimental approach for
  - Rigorous **evaluation** of technology in **farmers' fields**
  - Identification of **determinants of adoption** and **behavioral responses to adoption** (re-optimization)
  - Design **corrective or complementary policies and programs** for adoption
- But more clarity must be given to what can be done with complementary **traditional approaches**:
  - **Diagnostics**: tracking adoption and diffusion; correlates
  - Development of **business models** before experimentation
  - **Pilots** to ascertain likelihood of success

- And **progress** needs to be made with RCT to
  - **Sustain** analysis to measure cumulative long-term effects (**dynamics**)
  - **Broaden** the scope of experiments to measure general equilibrium effects, e.g., on consumers, labor market, and second-generation adopters (**scale**)
  - Experiment with **complementarities in instruments** (**portfolio approach**)
  - Complement with **natural experiments** for large/long-term impacts, especially on poverty

- **However,measuring the impact of technology adoption on poverty is difficult.** CGIAR/SPIA has been interested in establishing a link between technology adoption and **poverty reduction**.

  This is laudable but **difficult** to achieve. Four reasons:

  (1) Yield gain affected by state of nature: need **several seasons** to assess impact on yield (Udry & Rosenzweig)

  (2) Difficult to **separate** the role of technology in impacting poverty from role of intervention that induced adoption

  (3) Adopting farmers increase yields but not necessarily **consumption**, with no immediate effect on poverty

  (4) Yield gain only contributes a **small** increase in household income given the diversity of sources of income

- Which does not mean that technology will not ultimately contribute to **poverty reduction** through **GR/AT/RT**

(4) Results from field experiments on the adoption puzzle and impact: What have we learned?

(4.1) A theory of change for technology adoption and impact

Availability: Technology profitable/adopted/adoptable under most favorable national conditions exists

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Potential profitability/adoptability under **heterogeneity** conditions if **constraints** on adoption are removed

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ATAI approach to adoption Identify constraints to adoption under heterogeneous conditions and design how to lift constraints

Supply-side constraints

Effective supply given heterogeneity
- Information & learning
- Local availability

Contextual constraints

Institutions: Credit, insurance
Markets for products and factors
- Transaction costs, depth

Policies
- Subsidies

Demand-side constraints

Asset endowments
- Land, skills

Behavioral traits
- Time consistency
- Capacity to notice

Adoption

↓

Impacts of adoption
Yields, profits; GR/AT/RT; poverty reduction

Two steps: establish expected profitability, and remove constraints on adoption

4.2. Lessons from RCT experiments on adoption, impact, and design

Step 1: The profitability issue. The expected profitability of technology is difficult to establish and limited by heterogeneity

- **Expected profitability** of new technologies is **difficult** to establish:
  - Results are **fickle**: Optimum fertilizer doses depend on unidentified mediating factors, states of nature (Duflo et al.)
  - **Costs are difficult to measure**: family labor, self-provided inputs, idiosyncratic price bands (Rosenzweig & Foster)
  - **Learning-by-experimenting difficult for farmers** as changes are stochastic, small, not immediate (depend on states of nature). Too many marginal releases (Atlin)?

- **Yield penalty** in normal years for yield resilience: BD56, short duration varieties such as NERICA; **specificity/limits of resilience value** (e.g., flood duration, type of drought) → Difficult calculus of expected gains (Emerick et al.)
- **Heterogeneity of conditions limits learning-from-others** (esp. as heterogeneous determinants not well informed) (Tjernström)
- **Heterogeneity of conditions severely restricts external validity** of profitable technology (Jayne et al., Barrett et al., Suri) due to soils and infrastructure

- **Lessons from the successful example of SwarnaSub1 for flood tolerance: it can be done** and gives hints about conditions for success
  - **Easy to adopt**: Same agronomic practices as Swarna
  - **Win-Win**: No yield penalty in normal years
  - **High profitability**: High expected benefit/cost ratio of 2.7
  - **Double yield gain**: Risk reduction leads to re-optimization in normal years
  - **Pro-poor** in benefiting most exposed to risk

- **But success difficult to replicate for drought tolerance**: more complex for Sahbhagi Dhan, BD56, IR64D

- **Conclusion on the profitability issue**
  - There is a general **deficit of proven profitable and easily adoptable technologies** for smallholder farmers under favorable but **heterogeneous/risky** rainfed conditions
  - **Under-investment in discovery research** remains pervasive in the CGIAR (only 25% of budget), in spite of the CRP reforms
  - There is equally continued **under-investment** in agriculture and R&D in most SSA countries in spite of the **CAADP guidelines**

Step 2: The constraints issue/part1. A lot of progress has been made in exploring the ATAI constraints on the demand side and on the contextual framework

Many institutional innovations in support of adoption:

- **Demand-side constraints**
  - **Nudges to behavior** to overcome time inconsistency in fertilizer purchase (Duflo et al.)
  - **Help farmers notice** what matters in available information (Hanna et al.)
- **Contextual constraints**
  - **Market development**: helped by information (Aker), contracts (Ashraf; Casaburi), trading platforms (McIntosh), competitiveness of traders (Falcao), market transparency (Bernard et al.)

- **Access to credit**: customization of microfinance schemes (Field and Pande), limited liability (McIntosh), post-harvest loans (Burke); credit has been shown to be secondary to risk reduction for adoption (Karlan et al.; Emerick et al.)
- **Access to insurance**: Take-up of index insurance can be increased by better contract design, better data and measurement, better marketing, and better delivery (Carter et al.). Index insurance should be combined with precautionary savings, emergency credit, and social protection (Clarke and Dercon)

Step 2: The constraints issue/part2. But effective supply-side constraints remain

- Major constraints typically remain on the **effective supply of technology**: more effective **information** and diffusion methods (need re-invent **extension** services to correspond to learning), optimize entry points for **social learning** (Magruber et al.), use **motivated agents** in value chains as sources of information and technology (Emerick et al.)
- And greater efforts are needed at securing the **local availability of technology** given **heterogeneity** of technological needs (agro-dealers, seed supply systems, interlinked contracts with commercial partners)

(6) Conclusion: Seven observations for discussion in addressing the adoption puzzle

Observation 1: Technology adoption in rainfed agriculture remains a first-order challenge

In spite of dispersed progress (LSMS-ISA), low technology adoption in SSA and rainfed SA (aggregate data) remains **pervasive** and **important**

Reality is that supplying massively adoptable and profitable technologies to smallholder farmers under rainfed (**risky** and **heterogeneous**) conditions in SSA and Eastern SA is **exceptionally difficult**, **yet essential** for growth of agriculture-led countries/ regions and to meet the SDGs1&2

Observation 2: Field experiments in the social sciences help better understand and support adoption

Field experiments allow greater precision in identification of

- Causal **determinants** of adoption
- **Impact** of adoption
- **Design** of institutional innovations to help remove constraints

but progress still needed with methods to

- Analyze the **dynamics** and **scale** of adoption
- Design the **complementarities** of interventions
- Combine with **natural experiments**

Observation 3: Rural poverty reduction needs more than a GR: also an Agricultural and a Rural Transformation

Technology adoption to achieve a **GR** is necessary but not sufficient to make a dent in rural **poverty**. Essential for this is to smooth labor calendars in agriculture through an **AT**, and to complement agricultural with ag-driven non-agricultural incomes in local-town **RTs.**

Striving to achieve GR+AT+RT gives a useful **conceptual framework** in using technology adoption for development

Observation 4: The presumed widespread existence of adoptable technology for smallholder farmers needs revisiting

In spite of some spectacular successes, **the presumption of extensive existence of profitable** technologies when adoption constraints have been9 lifted by institutional innovations, **needs to be revisited** in view of the great degree of **heterogeneity** of circumstances: need ascertain that technologies offered for adoption are indeed **profitable** in expected value and with **low risk** in **local contexts**

It also suggests moving out of the difficult conditions of rainfed agriculture and **investing more into water control**

Observation 5: There has been much progress with institutional innovations in removing adoption constraints on the demand and contextual sides

While research is incomplete due to heterogeneity of conditions and changing states of nature, much **progress** (by ATAI/ SPIA/ AMA-Basis and other research) has been made with **removal of constraints** on

- The **demand** side: assets/property rights, behavior
- The **contextual** side: credit, insurance, market access, subsidies

Observation 6: Improvement still needed on access to information for SHF and learning for adoption

To achieve adoption of available technologies, better access to **information** and **learning** options is still lagging, especially through demand-driven **social learning**, **extension services,** and **motivated agents** in value chains

Extension services remain the poor child of development assistance

Motivated **agents in value chains** as sources of information in interlinked transactions are also incipient (Neuchatel Initiative)

Observation 7: Also need increase local availability of technology for adoption under heterogeneous conditions

Secure the **local availability** of technology under adoptable conditions for smallholder farmers principally through commercial channels in **value chains, especially accounting for heterogeneity of circumstances** that can be characterized and managed (e.g., Mahajan et al.)

End