Precision Agriculture for Development

ATAI Roundtable - December 7, 2017

Shawn Cole (Harvard Business School/PAD)
Michael Kremer (Harvard University/PAD)

- Work in South Asia

Work in Africa

PAD's Scope

Background: Avaaj Otalo (AO)

- Randomized control trial (RCT) conducted in Surendranagar, Gujarat
  - Farmers receive weekly push calls with advice, including weather forecasts
  - Farmers can ask questions on hotline
  - Farmers can respond to each other and share info with peers

- Catalytic funding from ATAI to develop proof of concept

Source: Cole and Fernando (2016)

Behavior Change Treatment Effects

- High uptake
  - Almost all farmers called into the line at least once
  - Farmers with reminders used the system slightly more
- Systematic "improvement" in agricultural practices
  - Spent more on irrigation
  - Little difference between farmers with and without physical extension

Dependent Variable	Difference-in-Difference Estimates		
	Control Mean (Baseline)	Treat vs. Control (Endline)	Treat & Reminder vs. Control (Endline)
Panel A: Expenditure on Inputs			
Total Input Expenditure (log rupees)	9.758 (0.741)	0.099 (0.210)	0.277 (0.223)
Expenditure on Irrigation (log rupees)	4.821 (4.469)	0.605 (0.369)	0.817** (0.404)
Panel B: Index of All Input-Related Decisions (standard deviation units)			
Cotton	0.000 (0.289)	0.061** (0.029)	0.074** (0.034)
Wheat	0.000 (0.433)	0.038 (0.037)	0.056 (0.041)
Cumin	0.000 (0.347)	0.064 (0.043)	0.048 (0.054)

Source: Cole and Fernando (2016)

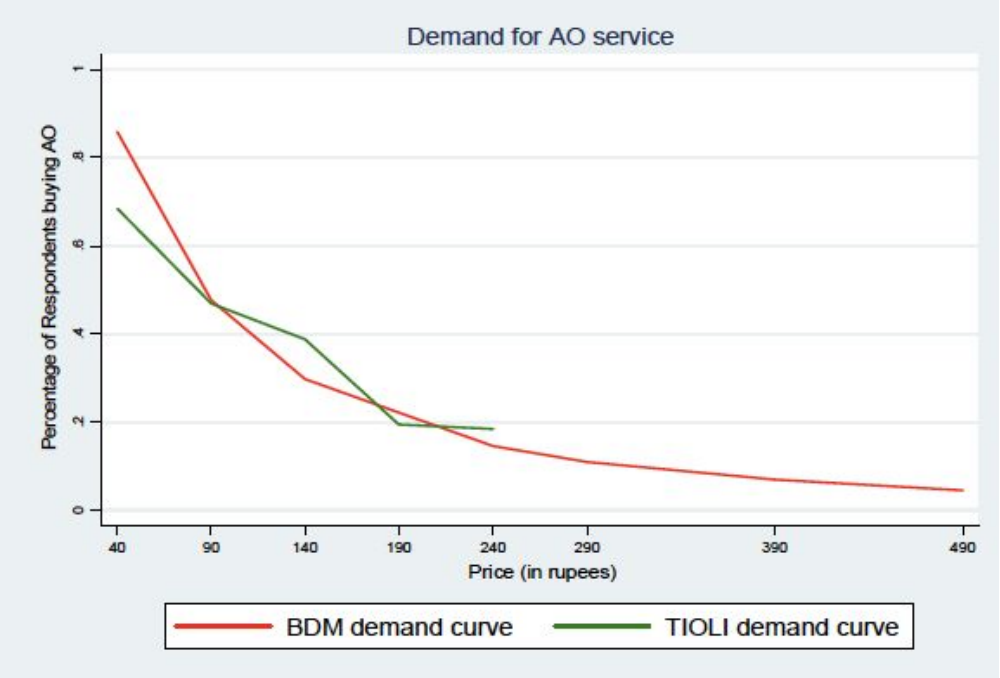
Other Tentative Effects

- Farmers with AO access increased crop yields:
  - By 8.6% for cotton (with reminders)
  - By 28.0% for cumin
- Consistent with $100/farmer/season increase in profitability (not statistically significant)
- However, we need to continue to lower the cost of measuring effects on yields and profits
- Peer Effects: Treated farmers had positive effects on both other treated farmers and non-treated farmers

Source: Cole and Fernando (2016)

Willingness to pay is low, despite apparent increase in profits

- Average WTP is roughly $2 for 6-month subscription
- Service costs $20 to provide
- Point estimate of average profitability:
  - $200 more cotton revenue
  - $65 more cumin revenue
  - $50 higher input costs
  - $215 higher profits per farmer



Source: Cole and Fernando (2016)

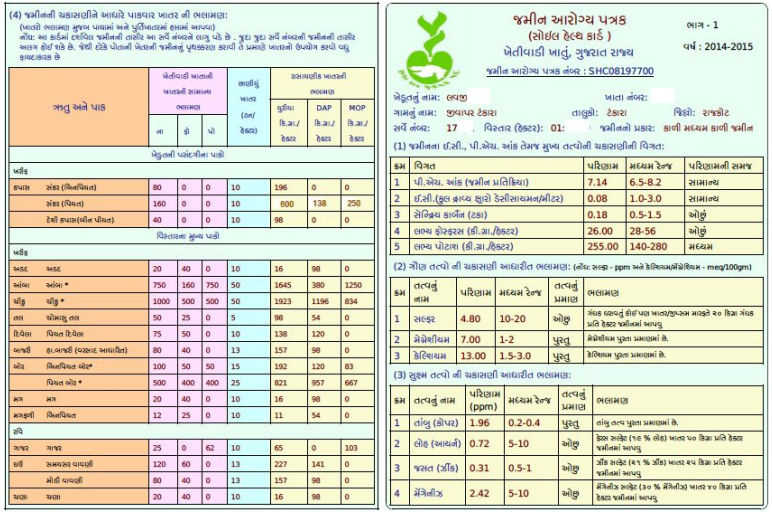
Conclusion: Avaaj Otalo (AO)

- Farmers listen to advice
- Changes in information sources and input adoption decisions
- Some evidence for productivity changes
- ICT model appears to be a viable substitute for traditional extension
- Currently being further tested with aims to scale by PAD
  - Aspire to bring Silicon Valley to Agricultural Extension, with customized, actionable advice delivered in the right manner at the right time
  - Build an evidence base of what works in which contexts

Source: Cole and Fernando (2016)

Background: Soil Health Cards (SHC)

- Government(s) in India have committed to test all smallholder farmers plots and distribute personalized Soil Health Cards
- SHCs are intended to help farmers with optimal site-specific fertilizer use
- However, they are hard to understand



(4) જમીનની ચકાસણીને આધારે પાકવાર ખાતર ની ભલામણ:

ક્રમ	પાક	ખેતીવાડી ખાતાની ખાતરની સામાન્ય ભલામણ			ભલામણ ખાતર (ટન/હેક્ટર)	રાસાયણીક ખાતરની ભલામણ		
		ના.	કી.	પો.		યુરિયા કિ.ગ્રા./હેક્ટર	DAP કિ.ગ્રા./હેક્ટર	MOP કિ.ગ્રા./હેક્ટર
	ખેતરની પાર્શ્વભૂમિ પાકો							
ખરીફ								
૧	કપાસ સંકર (બિનપિયત)	80	0	0	10	196	0	0
	સંકર (પિયત)	160	0	0	10	600	138	250
	દેશી કપાસ(બીન પીયત)	40	0	0	10	98	0	0
	વિસ્તારના મુખ્ય પાકો							
ખરીફ								
૨	અડદ અડદ	20	40	0	10	16	98	0
૩	અંબા અંબા *	750	160	750	50	1645	380	1250
૪	ઘઉંડુ ઘઉંડુ *	1000	500	500	50	1923	1196	834
૫	તલ બોમાસુ તલ	50	25	0	5	98	54	0
૬	દિવેલા પિયત દિવેલા	75	50	0	10	138	120	0
૭	બાજરી હા.બાજરી (વરસાદ આધારિત)	80	40	0	13	157	98	0
૮	બોર બિનપિયત બોર*	100	50	50	15	192	120	83
	પિયત બોર *	500	400	400	25	821	957	667
૯	મગ મગ	20	40	0	10	16	98	0
૧૦	મગફળી બિનપિયત	12	25	0	10	11	54	0
	રવી							
૧૧	ગાજર ગાજર	25	0	62	10	65	0	103
૧૨	ઘઉં સમયસર વાવણી	120	60	0	13	227	141	0
	મોડી વાવણી	80	40	0	13	157	98	0
૧૩	ચણા ચણા	20	40	0	10	16	98	0

જમીન આરોગ્ય પત્રક
(સોઇલ હેલ્થ કાર્ડ)
ખેતીવાડી ખાતું, ગુજરાત રાજ્ય
ભાગ - 1
વર્ષ : 2014-2015
જમીન આરોગ્ય પત્રક નંબર : SHC08197700

ખેડૂતનું નામ: લવજી ખાતા નંબર:
ગામનું નામ: જીવાપર ટંકારા તાલુકો: ટંકારા જિલ્લો: રાજકોટ
સર્વે નંબર: 17 વિસ્તાર (હેક્ટર): 01: જમીનનો પ્રકાર: કાળી મધ્યમ કાળી જમીન

(1) જમીનના ઈ.સી., પી.એચ. આંક તેમજ મુખ્ય તત્વોની ચકાસણીની વિગત:

ક્રમ	વિગત	પરિણામ	મધ્યમ રેન્જ	પરિણામની સમજ
1	પી.એચ. આંક (જમીન પ્રતિક્રિયા)	7.14	6.5-8.2	સામાન્ય
2	ઈ.સી.(ક્ષાર દ્રાવ્ય ક્ષારો ડેસીસાયમન/મીટર)	0.08	1.0-3.0	સામાન્ય
3	સેન્દ્રિય કાર્બન (ટકા)	0.18	0.5-1.5	ઓછું
4	લભ્ય ફોસ્ફરસ (કી.ગ્રા./હેક્ટર)	26.00	28-56	ઓછું
5	લભ્ય પોટાશ (કી.ગ્રા./હેક્ટર)	255.00	140-280	મધ્યમ

(2) ગૌણ તત્વો ની ચકાસણી આધારીત ભલામણ: (નોંધ: મધ્યમ - ppm અને કેલ્શિયમ/મેગ્નેશિયમ - meq/100gm)

ક્રમ	તત્વનું નામ	પરિણામ	મધ્યમ રેન્જ	તત્વનું પ્રમાણ	ભલામણ
1	સલ્ફર	4.80	10-20	ઓછુ	એરંડા વાવવાનું હોઈ પણ ખાતર/જીપ્સમ મારફતે ૨૦ કિગ્રા એરંડા પ્રતિ હેક્ટર જમીનમાં આપવુ
2	મેગ્નેશીયમ	7.00	1-2	પુરતુ	મેગ્નેશીયમ પુરતા પ્રમાણમાં છે.
3	કેલ્શિયમ	13.00	1.5-3.0	પુરતુ	કેલ્શિયમ પુરતા પ્રમાણમાં છે.

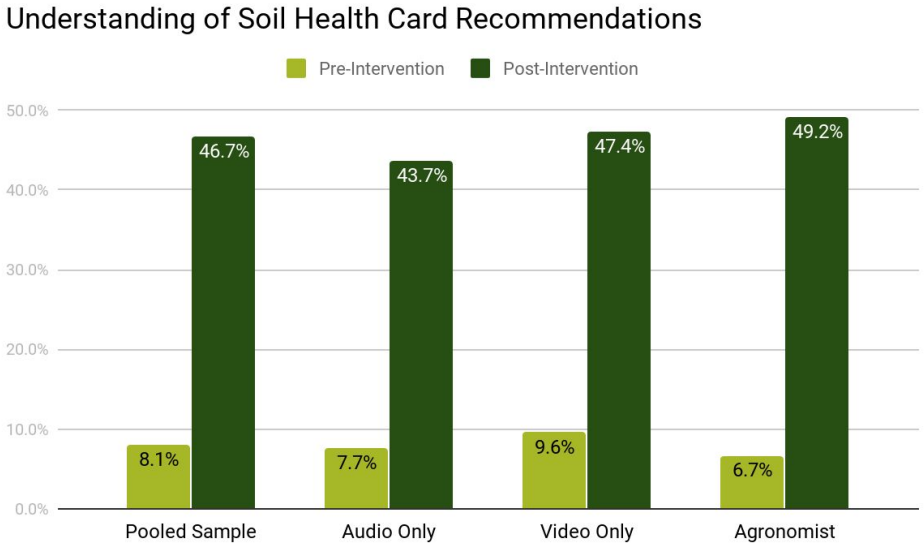
(3) સુક્ષ્મ તત્વો ની ચકાસણી આધારીત ભલામણ:

ક્રમ	તત્વનું નામ	પરિણામ (ppm)	મધ્યમ રેન્જ	તત્વનું પ્રમાણ	ભલામણ
1	તાંબુ (કોપર)	1.96	0.2-0.4	પુરતુ	તાંબુ તત્વ પુરતા પ્રમાણમાં છે.
2	લોહ (આયર્ન)	0.72	5-10	ઓછુ	ફેરસ સલ્ફેટ (૧૦ % લોહ) ખાતર ૫૦ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ
3	જસત (ઝીંક)	0.31	0.5-1	ઓછુ	ઝીંક સલ્ફેટ (૨૧ % ઝીંક) ખાતર ૨૫ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ
4	મેંગેનીઝ	2.42	5-10	ઓછુ	મેંગેનીઝ સલ્ફેટ (૩૦ % મેંગેનીઝ) ખાતર ૨૦ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ

Source: Cole and Sharma (2017)

Redesigned SHC & advice dramatically improves SHC comprehension

- Baseline comprehension only 8%
- Several forms of extension improved comprehension:
  - Audio only: +36%
  - Video only: +38%
  - Agronomist: +43%
- Only 6% of farmers have access to traditional agricultural extension



Source: Cole and Sharma (India Policy Forum, 2017)

Since 2016, ATAI has funded PAD to conduct a soil fertility study in Gujarat

Objectives: Learn how site-specific nutrient management can improve farmer outcomes

- Government of India committed to distributing tens of millions of farmer-level Soil Health Cards
- Examine whether (accurate) SHC information changes nutrient management and yields
    - SHC only
    - With eight customized telephone messages to walk farmers through nutrient management
    - WIth eight messages and an improved (simplified) Soil Health Card
- Potential rapid path to scale if found effective

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Krishi Tarang's Soil Health Card

Three levels assigned for each of the 6 nutrients – Low (Red), Medium (Yellow), High (Green)

Customized recommendation of fertilizers

Recommendation for irrigated cotton

Recommendation for unirrigated cotton

કિસાની તરંગ
ખેતી માહિતી સેવા

UID: 1_2
નામ: વાધરોડિયા મુન્નાભાઈ હકાભાઈ

આપની જમીન ચકાસણીના રિપોર્ટ મુજબ આપની જમીનમાં પોષક તત્વોનું પ્રમાણ દર્શાવતો ચાર્ટ

મુખ્ય પોષક તત્વો			ગૌણ અને સૂક્ષ્મ પોષક તત્વો		
નાઈટ્રોજન	ફોસ્ફરસ	પોટાશ	સલ્ફર	ઝીંક	આયર્ન (લોહ)
ઓછું	મધ્યમ	ઓછું	વધારે	મધ્યમ	મધ્યમ

કલર પ્રમાણે પોષક તત્વનું પ્રમાણ:- લાલ એટલે ઓછું | પીળો એટલે મધ્યમ | લીલો એટલે વધારે

** કપાસ પાક વાવતા પહેલા એક વીઘા દીઠ ૧.૫ ટન સારું કોહવાયેલું છાણિયું/દેશી ખાતર ચાસમાં અવશ્ય આપવું

જમીન ચકાસણી રિપોર્ટ મુજબ પોષક તત્વોની સ્થિતીને આધારે આપવાના થતાં ખાતરની ભલામણ (૧ વીઘા દીઠ જરૂરિયાત)

	વાવણી સમયે (પાયાનું ખાતર)	પાક વાવ્યા પછી 30 દિવસે	પાક વાવ્યા પછી 60 દિવસે	પાક વાવ્યા પછી ૯0 દિવસે
પિયત કપાસ (લાંબા ગાળાની જાતો માટે)	યુરિયા – ૨૪ કિલો ડીએપી – ૯ કિલો પોટાશ ખાતર – ૫૦ કિલો ઝીંક સલ્ફેટ – ૧ કિલો ફેરસ સલ્ફેટ – ૨ કિલો	યુરિયા – ૨૪ કિલો અથવા અમોનિયમ સલ્ફેટ – ૫૨ કિલો + ડીએપી – ૯ કિલો અથવા એસ.એસ.પી. – ૨૫ કિલો	યુરિયા – ૨૪ કિલો અથવા અમોનિયમ સલ્ફેટ – ૫૨ કિલો	યુરિયા – ૨૪ કિલો
બિન પિયત કપાસ (ટૂંકા ગાળાની જાતો માટે)	યુરિયા – ૧૦ કિલો ડીએપી – ૩ કિલો પોટાશ ખાતર – ૧૩ કિલો જીપ્સમ – ૨૦ કિલો	યુરિયા – ૧૦ કિલો અથવા અમોનિયમ સલ્ફેટ – ૨૩ કિલો + ડીએપી – ૩ કિલો અથવા એસ.એસ.પી. – ૧૦ કિલો	યુરિયા – ૧૦ કિલો અથવા અમોનિયમ સલ્ફેટ – ૨૩ કિલો	--

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Current progress

- Farmers randomized into three groups
  - Laboratory soil health card
  - Laboratory soil health card + calls from Krishi Tarang
  - Laboratory soil health card + calls from Krishi Tarang + Krishi Tarang's soil health card

- Baseline survey conducted in March-May 2017

- SHCs distributed in June and push calls with fertilizer recommendations sent in June-September

- Currently conducting midline survey focusing on 3 types of information:
  - Total land owned and cultivated, and total cotton cultivation
  - Use of fertilizers for cotton
  - Questions on SHCs related to compliance and understanding

- Next step will be to analyze the data on fertilizer adoption

- Final step will be to collect self-reported yield data in February, at end of cotton harvest
- Repeat again in 2018/19 based on learnings this year

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PAD's work in Gujarat is expanding to Odisha

Customer Acquisition
- Customer list received from Government of Odisha
- Geography: Puri and Balangir Districts

Customer Profiling
- Started 2nd week of June
- Team of 9 surveyors and 1 supervisor
- Profiling of 8000+ farmers complete (93% paddy farmers)

Customer Training
- Started 1st week of July (1500+ farmers trained)

Krishi Tarang Service
- 7500+ rice farmers enrolled
- Customization based on questions from farmer surveys

Advising Odisha's Scaling Efforts
- **MoU with GoO & BMGF**
- **Funding from BMGF**
- **GoO commits to use ICT for extension, bear costs after three years**
- **Anticipated scale 1-2m farmers**

➢ PAD got the service up and running from scratch in a span of 6 weeks

BMGF-Supported

From the early evidence, India work is expanding

- Launched in April 2016, Krishi Tarang in Gujarat now reaches 50,000+ farmers actively receiving push calls
- New service for rice farmers with **IRRI** and **Government of Orissa** (with 2 million farmer potential)
- Data analysis for **IFFCO-Kisan** (with 1.7 million farmer reach)
- Pilot with ag input aggregator (**Agrostar**) to generate sales/leads
- Advise **Coffee Board of India** to pilot services to coffee farmers in Karnataka
- Other partners:

J-PAL Awaaz.De

Push call	• ~2 minute call every Wednesday • Designed by experts based on local crop and geography
Q&A	• Farmers can call in and ask questions, answered by expert • Farmers can listen to questions asked by other farmers
Experience sharing	• Farmers can share experiences and perspectives with other farmers
Personal inbox	• History of farmers' interaction on service
Forward to friend	• Farmers can forward messages they receive to their peers
Ratings	• We rely on ratings from 1-5 to gauge quality of content and what is desired

Features of Krishi Tarang service in Gujarat.

Our initial SHC work is expanding to Pakistan

- Partnership with **Government of Punjab** to support mobile ag extension (5 million farmer potential)
- Human-centered design, emphasize quality of soil health card data
- PAD will assist government in augmenting paper soil health cards with an IVR system that explains results and facilitates asking questions
- Other partner:

CERP
Center for Economic Research in Pakistan

Work in South Asia

➢ Work in Africa

PAD's Scope

Background: Kenya

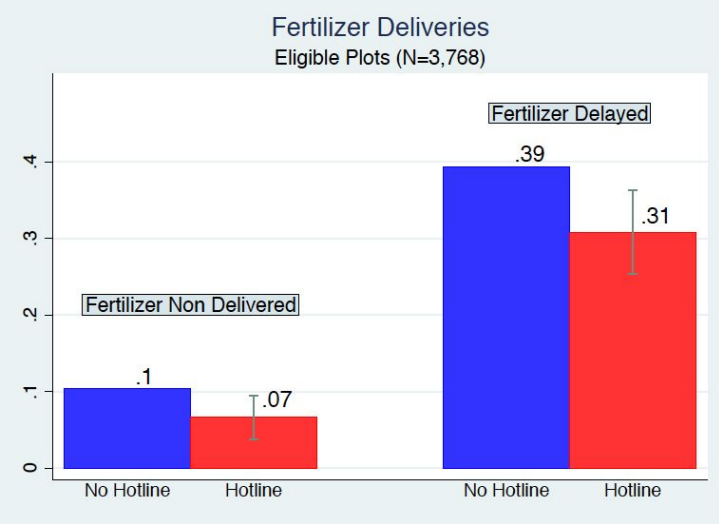
- Partnered with sugarcane contract farming company
  - One of the largest agro-businesses in East Africa
  - Provides inputs to farmers on credit

- Randomized control trial (RCT) conducted in Western Kenya
  - Intervention 1: Farmer hotline to communicate with company, e.g. about late fertilizer delivery
  - Intervention 2: Text messages to farmers timed to match agricultural cycle

Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

Improved Deliveries

- 36.5% (3.8 percentage points) reduction in failure to deliver fertilizer
- 21.6% (8.5 percentage points) reduction in fertilizer delivery after optimal time window



Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

Yield Impact

- Access to the text message service raised sugarcane yields by 8% (3.3 tons per hectare)
- Since take-up of the SMS service was 65%, implied treatment-on-treated effect was 11.5% higher yields
- These effects were concentrated among farmers with no prior agronomy training and those with little interaction with company field staff

Table 4: SMS: Yield Regressions

	Yields		
	(1)	(2)	(3)
SMS	3.326*	3.339**	3.331**
	[1.719]	[1.536]	[1.532]
Plot Controls	N	Y	Y
Extra Controls	N	N	Y
Mean Y Control	41.625	41.625	41.625
Observations	1849	1849	1849

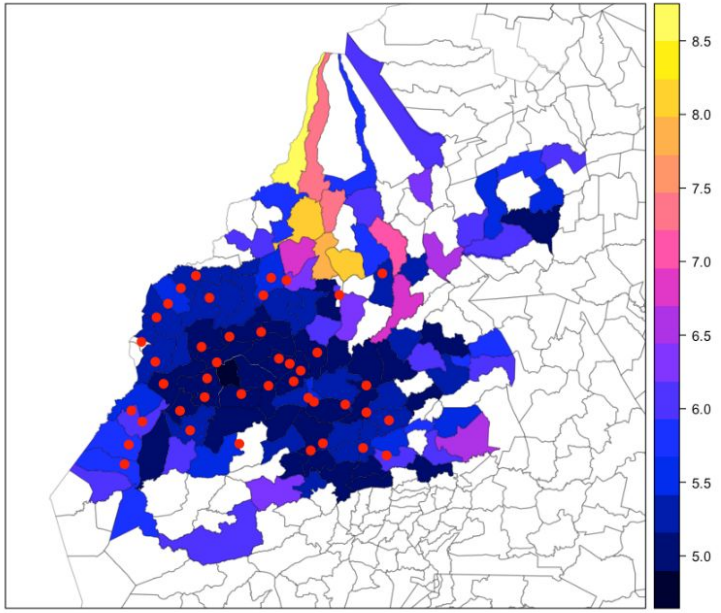
- Caveat: second trial yielded smaller estimated effect; cannot reject zero or highly cost effective

Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

With ATAI funding, we tested impact of SMS on lime adoption

- Where soil acidity is high, lime can raise yields
- Kenyan government SMS messages to farmers saying “If your soil pH is less than 5.5, apply lime” had no impact on lime purchases
- Tested SMS messages to customers of agro-dealers, tailored tc local soil chemistry

- Farmers who received our messages encouraging lime use **25% more likely to purchase lime** (2.8 percentage points) and **purchased 27% more lime**
- Farmers who received our messages not encouraging lime use **33% less likely to purchase lime** (2.9 percentage points) and **purchased 44% less lime**



Soil pH levels by ward in Western Kenya and markets (red dots).

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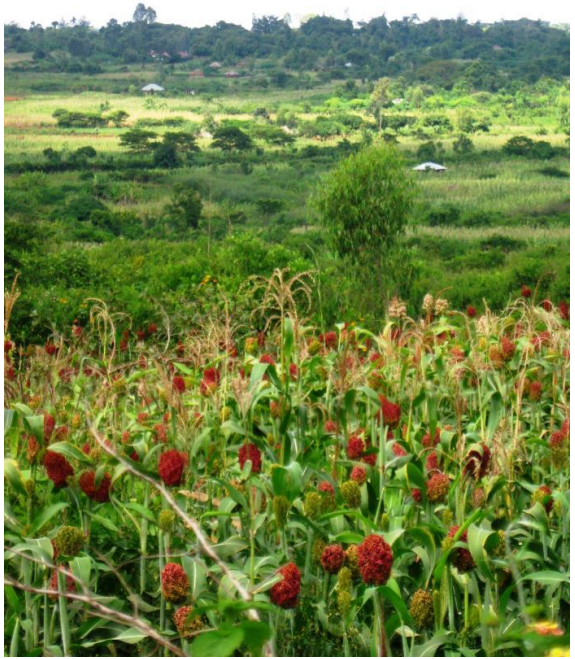
PAD partnership with One Acre Fund (OAF)



- RCT found SMS messages led to **28% increase in lime adoption** (3.0 percentage points)
- Highly cost effective
- Based on RCT:
  - OAF scaled to ~220k farmers in Kenya
  - PAD and OAF integrating A/B tests to optimize impact
  - Further message variants and social learning approaches being tested with ~40k farmers

BMGF-Supported

PAD/OAF partnership expanded to Rwanda

Population:

- 200,000 farmers enrolled in Aug-Sep 2017

Intervention:

- Sending SMS messages encouraging farmers to enroll in the OAF program and purchase lime.

Findings

- **11% increase in the likelihood of signing up for lime purchase** (0.7 percentage points)
- Machine learning to examine heterogenous response to messages and optimal message tailoring

BMGF-Supported

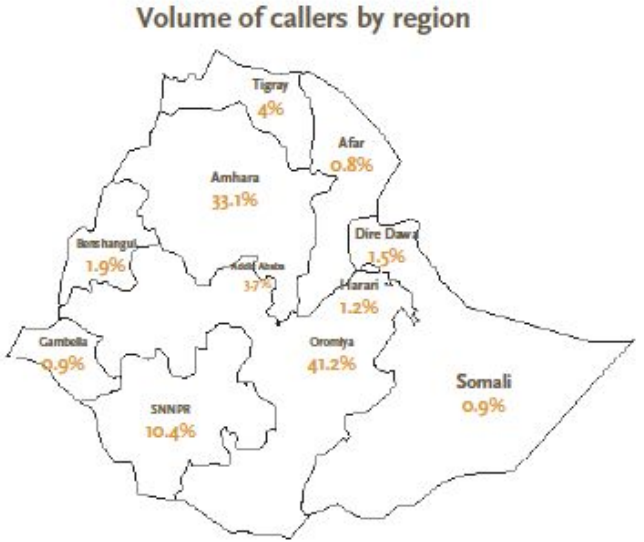
Partnership with Government of Kenya

Fall Armyworm emergency

- Working closely with the Ministry of Agriculture, the Association of County Agriculture Ministers, and Safaricom
- On behalf of the Ministry, preparing to launch a 2-way communication system to:
  - Alert farmers about FAW and provide recommendations on how to address
  - Allow farmers to report FAW
- Will ask all relevant Safaricom customers if they want SMS messages with other agricultural information

Ethiopia

- Partnership with Agricultural Transformation Agency (ATA) to assess and improve nationwide IVR/SMS system
- The system has been accessed by 3.1 million farmers (~600k new callers per year)
- However, usage is very low
- PAD's work focuses on qualitative and quantitative analysis to diagnose ways to improve service and usage
- Several clear opportunities to optimize using A/B tests:
  - Simplify user registration process
  - Train users on IVR system
  - Modify terminology to make content more easily digestible
  - Reorganize menus to make system easier to navigate



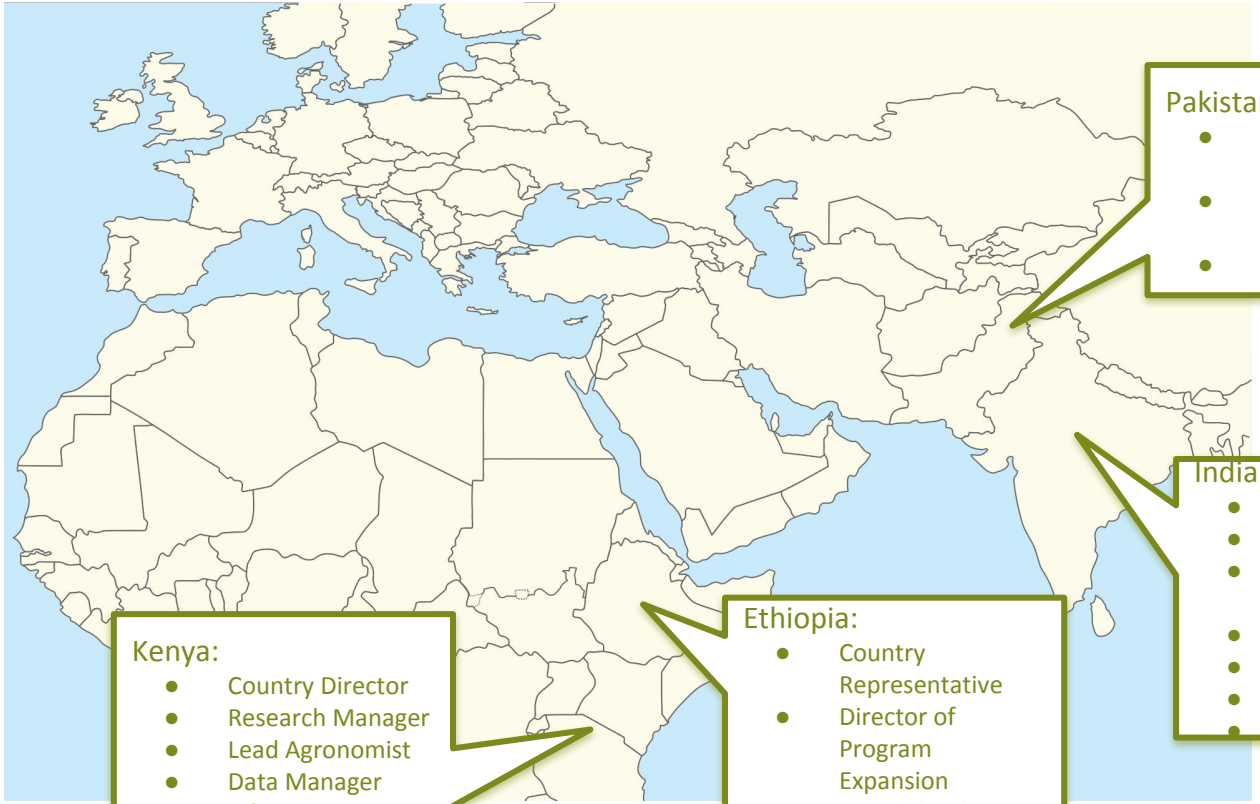
BMGF-Supported

Work in South Asia

Work in Africa

- PAD’s Scope

PAD's Geographic Scope



Pakistan:
- Senior Program Manager
- Project Coordinator
- Research Assistant

India:
- Country Director
- Lead Agronomist
- Director of Product
- Research Manager
- Data Manager
- 2 RAs
- 28 field staff

Ethiopia:
- Country Representative
- Director of Program Expansion
- Data Scientist

Kenya:
- Country Director
- Research Manager
- Lead Agronomist
- Data Manager
- 2 field managers

PAD staff reflect wide diversity of skills

Board Leadership:

- **Shawn Cole (Board Chair, South Asia Program Lead)** – Professor at Harvard Business School (HBS)
- **Michael Kremer (Africa Program Lead)** – Professor at Harvard University
- **Dan Bjorkegren (Technology)** – Professor at Brown University, formerly with Microsoft
- **Heiner Baumann (Managing Director)** – HBS alum, ex-McKinsey, experience in building, funding and growing social enterprises

HQ Team Members:

- **Heiner Baumann (Managing Director)**
- **Ofir Reich (Chief Data Scientist)** – Decade long experience of analyzing data for several projects
- **Megan Sheahan (Operations Director)** – MS in Agricultural Economics
- **Tomoko Harigaya (Senior Researcher)** – PhD in Public Policy from Harvard University
- **Carolina Corral (Director of Program Expansion)**
- **Robert On (Data Scientist)** – PhD from UC Berkeley
- **Jonathan Lehe (Research Manager)** – MPA/ID from Harvard Kennedy School

Country Directors:

- **Emmanuel Bakirdjian (Kenya Country Director)** – MSc in Economic Development from CERDI in France
- **Madhur Jain (India Country Director)** – MBA from Indian Institute of Management

PAD funders and partners

ONE ACRE FUND

IDB Inter-American Development Bank

Ethiopian ATA
Agricultural Transformation Agency
የኢትዮጵያ ግብርና ትራንስፎርሜሽን ኤጀንሲ

The Horace W. Goldsmith Foundation

jasmine SOCIAL INVESTMENTS

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UP

MULAGO

dioraphte

BILL & MELINDA GATES foundation

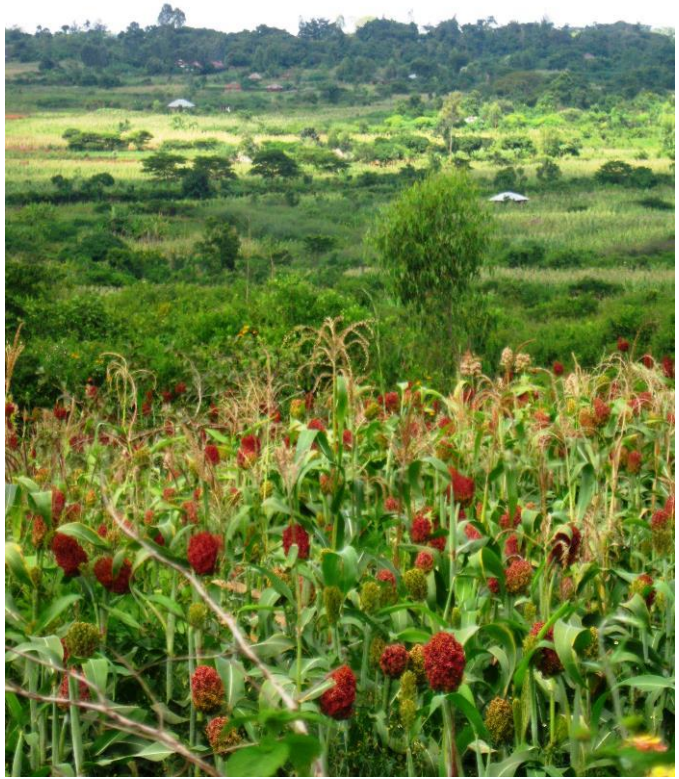
and two anonymous donors.


Thank you for the
support of ATAI!
www.precisionag.org

Appendix

The issue

- **450 million poor, and often unproductive, smallholder farmers around the world**
- **Worldwide food demand continues to grow, but production is constrained**
- **Climate change, soil erosion, etc. are presenting new, unfamiliar challenges**
- **New technologies are improving agricultural productivity in developed countries… *but what about farmers in developing countries?***

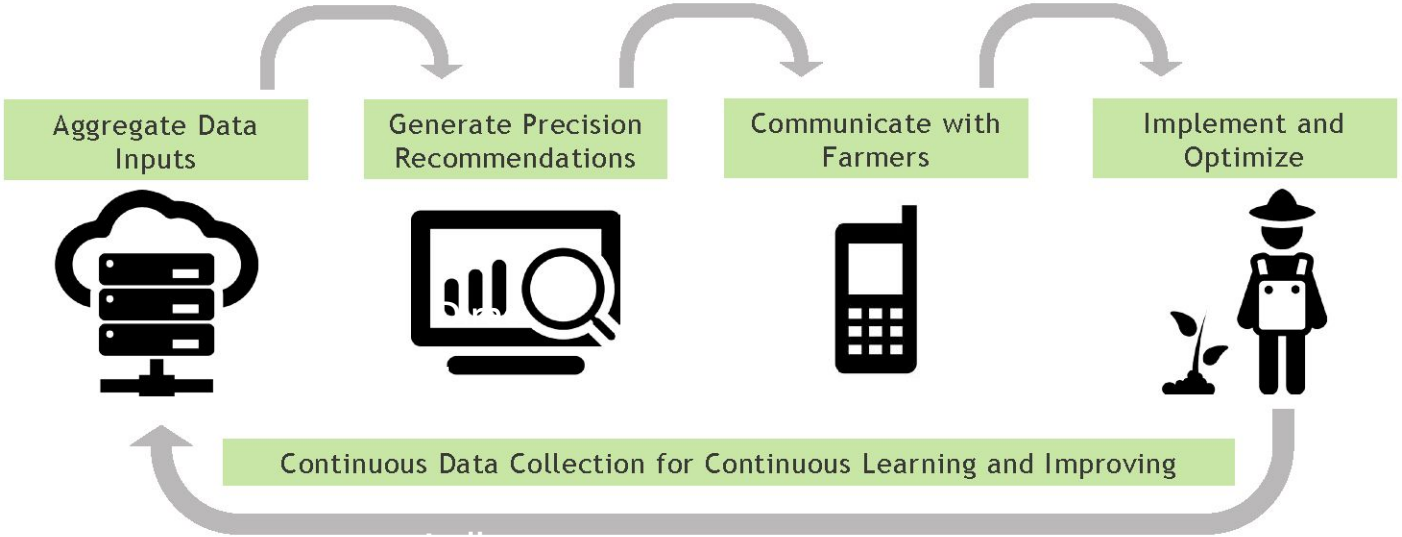


Our mission

Precision Agriculture for Development

Support smallholder farmers in developing countries by providing customized information and services via mobile phones that increase productivity, profitability, and environmental sustainability.

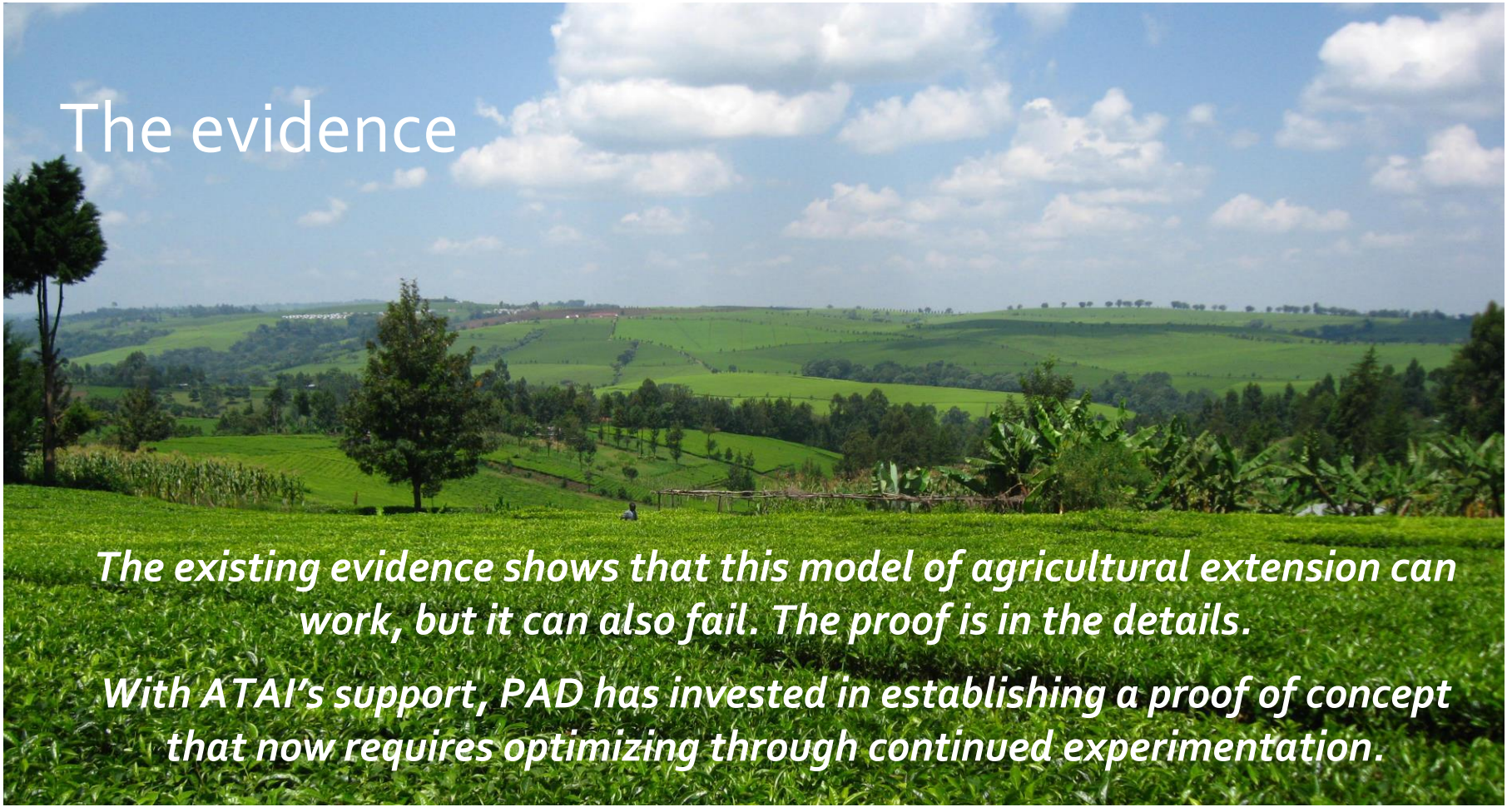
Our solution: Bringing data analytics and rigorous testing to agricultural extension



The evidence shows that this model can work, but the proof is in the details.

With ATAI's support, PAD has invested in establishing a proof of concept that now requires optimizing through continued experimentation.

The evidence



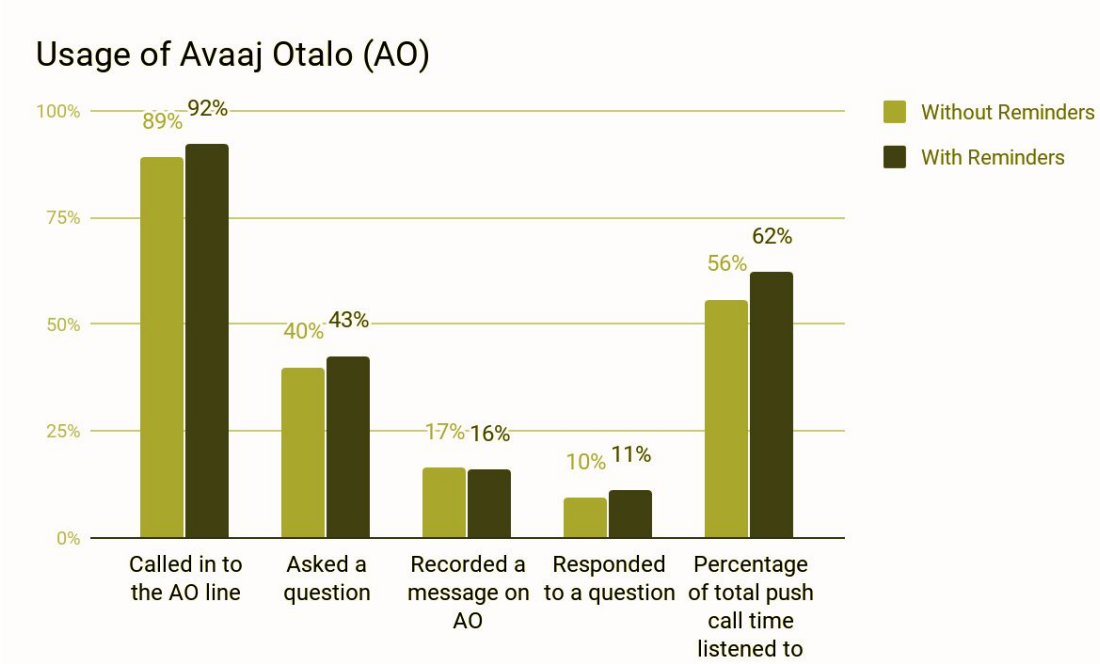
The existing evidence shows that this model of agricultural extension can work, but it can also fail. The proof is in the details.

With ATAI's support, PAD has invested in establishing a proof of concept that now requires optimizing through continued experimentation.

High AO Uptake

High Uptake

- Almost all farmers called into the AO line at least once
- Farmers with reminders used the system slightly more



Source: Cole and Fernando (2016)

Other Treatment Effects

- Farmers with AO access increased crop yields:
  - By 8.6% for cotton (with reminders)
  - By 28.0% for cumin
- Consistent with $100/farmer/season increase in profitability (not statistically significant)

Dependent Variable	Difference-in-Difference Estimates		
	Control Mean (Baseline)	Treat & Reminder vs. Control (Midline)	Treat & Reminder vs. Control (Endline)
Profit from Agriculture (log rupees)	11.463 (0.989)	0.051 (0.081)	0.093 (0.099)
Cotton Yield (kg/acre)	694.8 (468.8)	59.9* (36.0)	44.7 (35.5)
Wheat Yield (kg/acre)	981.1 (702.0)	-49.9 (84.6)	-28.3 (76.9)
Cumin Yield (kg/acre)	172.6 (191.0)	0.1 (26.8)	54.3** (25.9)

- However, we need to continue to lower the cost of measuring effects on yields and profits

Source: Cole and Fernando (2016)

Peer Effects

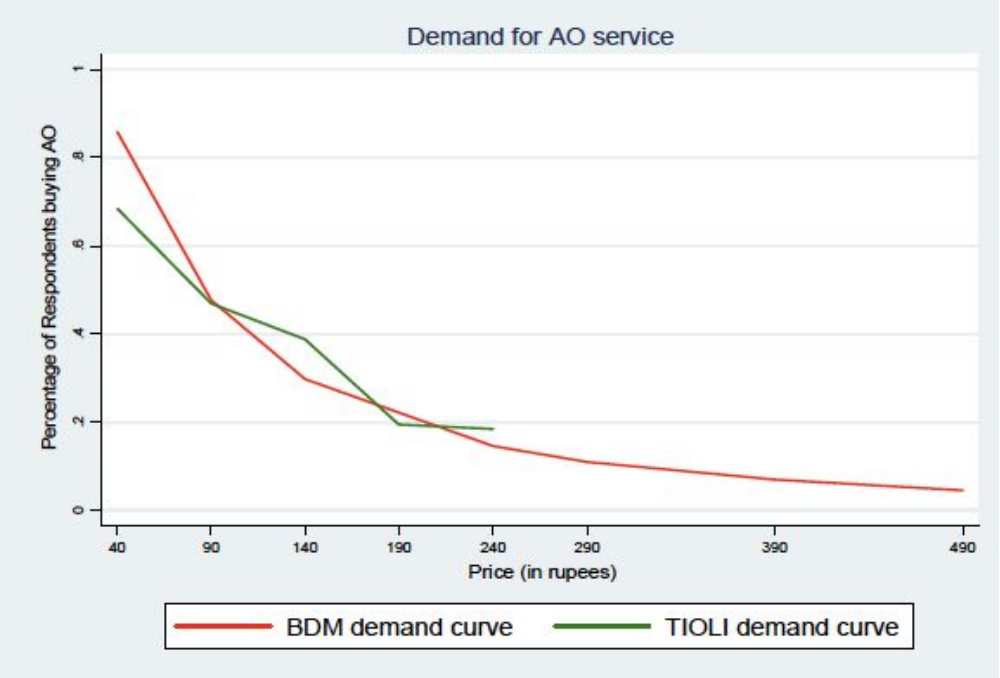
- Treated farmers had positive spillover effects on both:
  - Other treated farmers, who were more likely to adopt effective pest management strategies
  - Non-treated farmers, who grew more cumin (cash crop) and suffered less crop loss

Dependent Variable	Control Peer Group Mean	Fraction of Peers Treated
Index of Mobile Phone-Based Information Usage	-0.000 (0.878)	-0.005 (0.049)
Planted Cumin	0.237 (0.425)	0.059* (0.030)
Area of Cumin Planted (Acres)	0.525 (1.695)	0.255* (0.133)
Planted Wheat	0.253 (0.435)	-0.011 (0.031)
Area of Wheat Planted (Acres)	0.328 (1.153)	-0.050 (0.077)
Proportion of Cotton Lost to Pest Attacks (%)	0.142 (0.224)	-0.039*** (0.015)
Cotton Pest Management	0.000 (0.612)	0.087 (0.054)

Source: Cole and Fernando (2016)

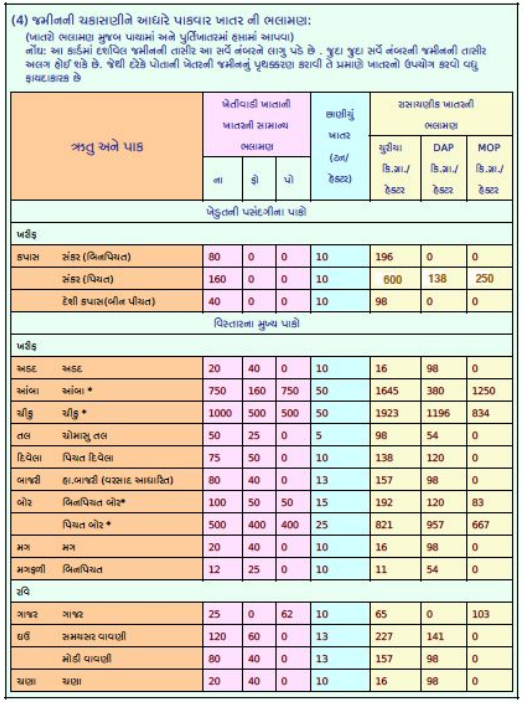
Willingness to pay is low, despite increased profits

- Average WTP is roughly $2 for 6-month subscription
- Service costs $20 to provide
- Point estimate of average profitability:
  - $200 more cotton revenue
  - $65 more cumin revenue
  - $50 higher input costs
  - $215 higher profits per farmer



Source: Cole and Fernando (2016)

SHCs in India are very hard to understand



(4) જમીનની ચકાસણીને આધારે પાકવાર ખાતર ની ભલામણ:

(ખાતરો ભલામણ મુજબ પાયામાં અને પુર્તિખાતરમાં હપ્તામાં આપવા)

નોંધ: આ કાર્ડમાં દર્શાવિલ જમીનની તાસીર આ સર્વે નંબરને લાગુ પડે છે . જુદા જુદા સર્વે નંબરની જમીનની તાસીર અલગ હોઈ શકે છે. જેથી દરેક ખેડૂતે પોતાની ખેતરની જમીનનું પૃથક્કરણ કરાવી તે પ્રમાણે ખાતરનો ઉપયોગ કરવો વધુ ફાયદાકારક છે

ઋતુ અને પાક		ખેતીવાડી ખાતાની ખાતરની સામાન્ય ભલામણ			છાણીયું ખાતર (ટન/હેક્ટર)	રાસાયણીક ખાતરની ભલામણ		
		ના	કો	પો		યુરીયા કિ.ગ્રા./હેક્ટર	DAP કિ.ગ્રા./હેક્ટર	MOP કિ.ગ્રા./હેક્ટર
ખેડૂતની પસંદગીના પાકો								
ખરીફ								
કપાસ	સંકર (બિનપિયત)	80	0	0	10	196	0	0
	સંકર (પિયત)	160	0	0	10	600	138	250
	દેશી કપાસ(બીન પીયત)	40	0	0	10	98	0	0
વિસ્તારના મુખ્ય પાકો								
ખરીફ								
અડદ	અડદ	20	40	0	10	16	98	0
આંબા	આંબા *	750	160	750	50	1645	380	1250
ચીકુ	ચીકુ *	1000	500	500	50	1923	1196	834
તલ	ચોમાસુ તલ	50	25	0	5	98	54	0
દિવેલા	પિયત દિવેલા	75	50	0	10	138	120	0
બાજરી	હા.બાજરી (વરસાદ આધારિત)	80	40	0	13	157	98	0
બોર	બિનપિયત બોર*	100	50	50	15	192	120	83
	પિયત બોર *	500	400	400	25	821	957	667
મગ	મગ	20	40	0	10	16	98	0
મગફળી	બિનપિયત	12	25	0	10	11	54	0
રવિ								
ગાજર	ગાજર	25	0	62	10	65	0	103
ઘઉં	સમયસર વાવણી	120	60	0	13	227	141	0
	મોડી વાવણી	80	40	0	13	157	98	0
ચણા	ચણા	20	40	0	10	16	98	0

જમીન આરોગ્ય પત્રક
(સોઇલ હેલ્થ કાર્ડ)
ખેતીવાડી ખાતું, ગુજરાત રાજ્ય

ભાગ - 1

વર્ષ : 2014-2015

જમીન આરોગ્ય પત્રક નંબર : SHC08197700

ખેડૂતનું નામ: લવજી ખાતા નંબર:

ગામનું નામ: જીવાપર ઠકારા તાલુકો: ઠકારા જિલ્લો: રાજકોટ

સર્વે નંબર: 17 . વિસ્તાર (હેક્ટર): 01: જમીનનો પ્રકાર: કાળી મધ્યમ કાળી જમીન

(1) જમીનના ઈ.સી., પી.એચ. આંક તેમજ મુખ્ય તત્વોની ચકાસણીની વિગત:

ક્રમ	વિગત	પરિણામ	મધ્યમ રેન્જ	પરિણામની સમજ
1	પી.એચ. આંક (જમીન પ્રતિક્રિયા)	7.14	6.5-8.2	સામાન્ય
2	ઈ.સી.(કુલ દ્રાવ્ય ક્ષારો ડેસીસાયમન/મીટર)	0.08	1.0-3.0	સામાન્ય
3	સેન્દ્રિય કાર્બન (ટકા)	0.18	0.5-1.5	ઓછું
4	લભ્ય ફોસ્ફરસ (કી.ગ્રા./હેક્ટર)	26.00	28-56	ઓછું
5	લભ્ય પોટાશ (કી.ગ્રા./હેક્ટર)	255.00	140-280	મધ્યમ

(2) ગૌણ તત્વો ની ચકાસણી આધારીત ભલામણ: (નોંધ: સલ્ફર - ppm અને કેલ્શિયમ/મેગ્નેશિયમ - meq/100gm)

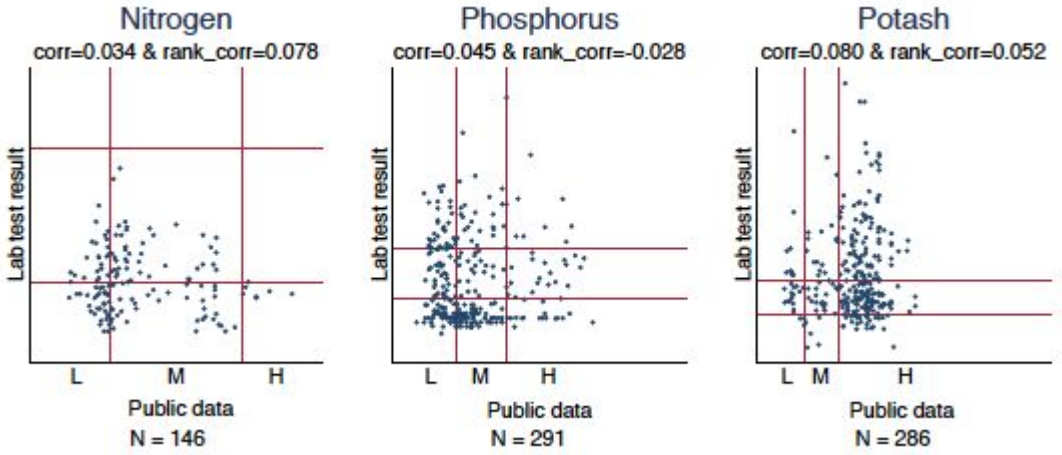
ક્રમ	તત્વનું નામ	પરિણામ	મધ્યમ રેન્જ	તત્વનું પ્રમાણ	ભલામણ
1	સલ્ફર	4.80	10-20	ઓછુ	જીંકઇ ધરાવતું કોઇ પણ ખાતર/જીપ્સમ મારફતે ૨૦ કિગ્રા જીંકઇ પ્રતિ હેક્ટર જમીનમાં આપવુ
2	મેગ્નેશીયમ	7.00	1-2	પુરતુ	મેગ્નેશીયમ પુરતા પ્રમાણમાં છે.
3	કેલ્શિયમ	13.00	1.5-3.0	પુરતુ	કેલ્શિયમ પુરતા પ્રમાણમાં છે.

(3) સુક્ષ્મ તત્વો ની ચકાસણી આધારીત ભલામણ:

ક્રમ	તત્વનું નામ	પરિણામ (ppm)	મધ્યમ રેન્જ	તત્વનું પ્રમાણ	ભલામણ
1	તાંબુ (કોપર)	1.96	0.2-0.4	પુરતુ	તાંબુ તત્વ પુરતા પ્રમાણમાં છે.
2	લોહ (આયર્ન)	0.72	5-10	ઓછુ	ફેરસ સલ્ફેટ (૧૯ % લોહ) ખાતર ૫૦ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ
3	જસત (ઝીંક)	0.31	0.5-1	ઓછુ	ઝીંક સલ્ફેટ (૨૧ % ઝીંક) ખાતર ૨૫ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ
4	મેંગેનીઝ	2.42	5-10	ઓછુ	મેંગેનીઝ સલ્ફેટ (૩૦ % મેંગેનીઝ) ખાતર ૪૦ કિગ્રા પ્રતિ હેક્ટર જમીનમાં આપવુ

SHC quality is also low

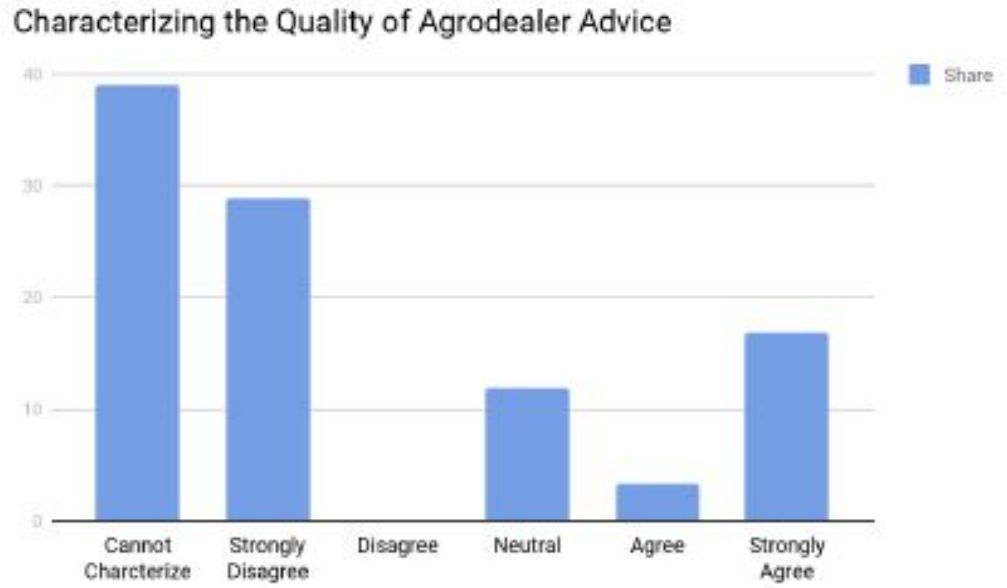
- Low correlations between measurements from Indian government SHCs and independent lab tests for the same plots
  - Nitrogen: 0.034
  - Phosphorus: 0.045
  - Potash: 0.080



Source: Cole and Sharma (2017)

Farmers can get information from other sources, but it is often low quality

- Agro-dealers may have profit-maximizing motive to encourage overuse of inputs
- Agro-dealers also may not have access to accurate information themselves



Source: Cole and Sharma (2017)

Background: Soil fertility study in Gujarat

Issues:

- Fertilizers can enhance soil nutrients and increase crop yields, but the benefits are **highly context specific**, and fertilizer recommendations do not capture the **variation in soil quality across plots**.
- Farmers have traditionally been unwilling to pay for soil tests given the **high costs**, their **limited experience** with how fertilizer use impacts yields, and general **lack of knowledge** about soil fertility.

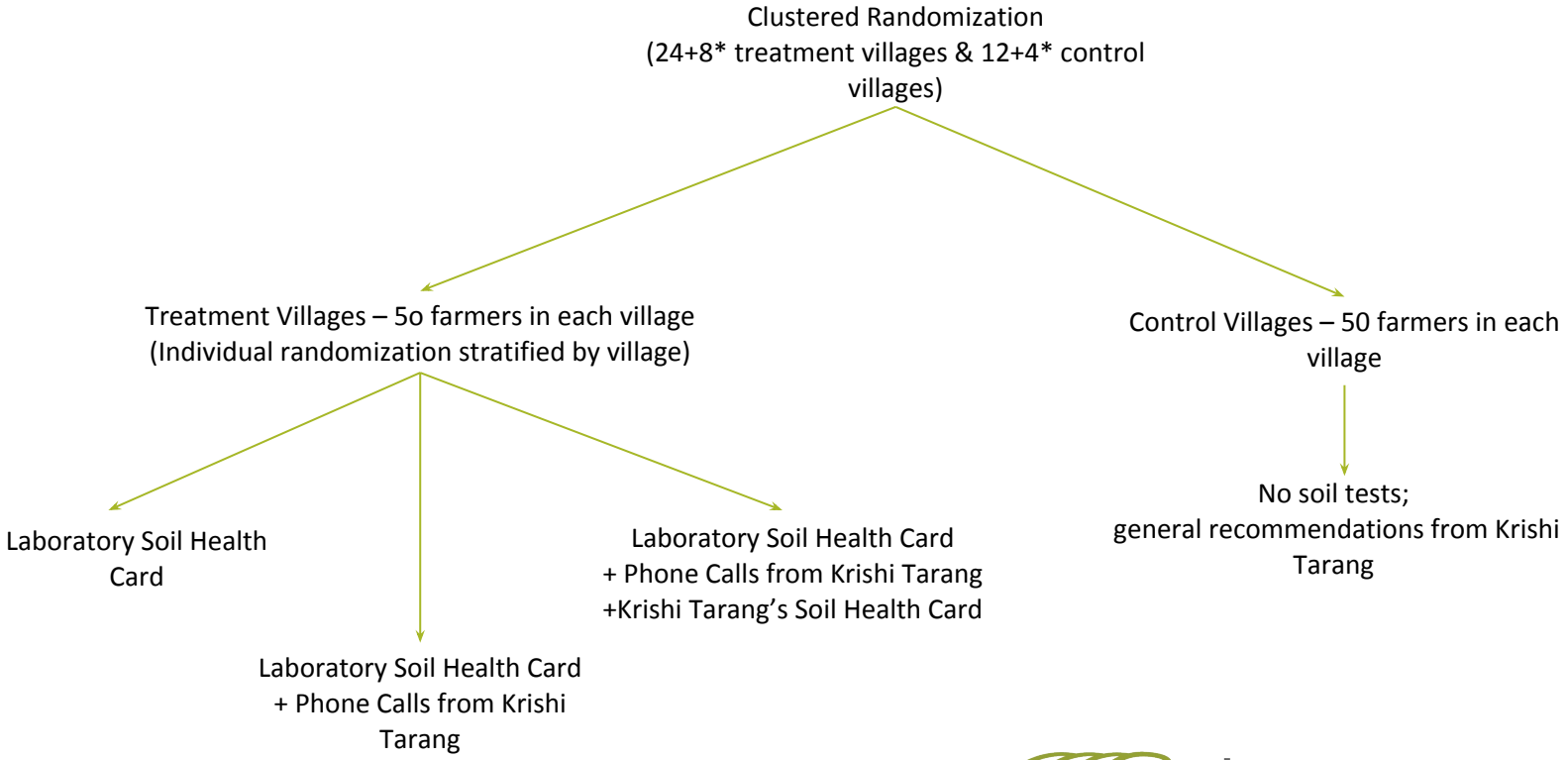
Solutions:

- There is new publicly available data on various soil fertility measures to **make information more customized**.
- The proliferation of mobile phones has made it **easier to disseminate information** on soil nutrient levels and fertilizer recommendations.

Research Plan: Soil fertility study

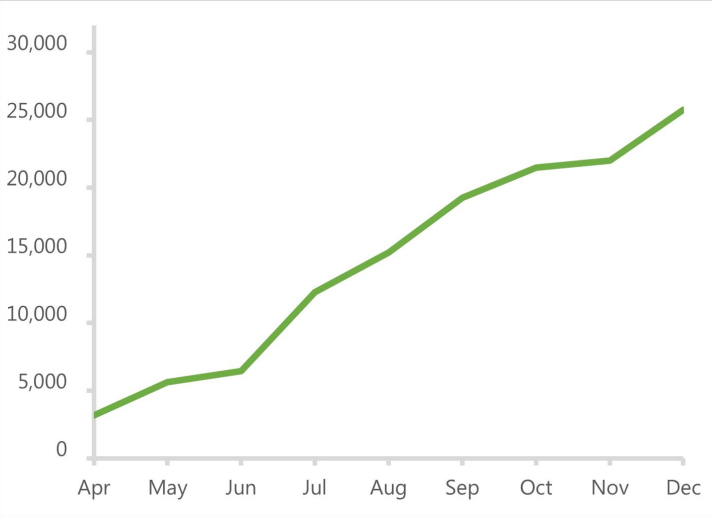
- Compare impact of customized vs. general fertilizer recommendations on input adoption and yield
- Compare impact of different information channels on input adoption and yield
- Compare the impact of recommendations based on composite (10-acre) vs. individual plot soil tests
- Analyze cross-plot variability of soil fertility measures
- Validate publicly available data on soil fertility measures
- Perform A/B tests on timing and content of messages to measure impact on input adoption practices
- Assess accuracy of field-based soil testing kits and scanners as lower cost alternatives

Experimental Design



atai AGRICULTURAL TECHNOLOGY ADOPTION INITIATIVE

Krishi Tarang launched in April 2016 and has grown rapidly



Results as of November, 2017 (20 months)

- **50,000+** active users
- **8,000,000+** push calls sent
- **26,000+** unique incoming calls
- **20,520** unique callers
- **82%** average pick-up rate
- **62%** average listening duration (during main season, conditional on pick-up)

The agro-business introduced two interventions to improve information flow

- Intervention 1: Farmer hotline
  - Urea fertilizer delivery is managed by field staff and contractors, and monitoring is costly
  - Delays are costly for the farmer and the company
  - Farmers can report valuable information on delays in fertilizer delivery

- Intervention 2: Text messages
  - Messages contain farmer's name, cane age, fertilizer delivery date, cycle type, etc.
  - "Good morning [farmer name]. It is 12 weeks since you planted, your plot may have weeds by now from the last time you weeded your plot; Please remember to weed this week."

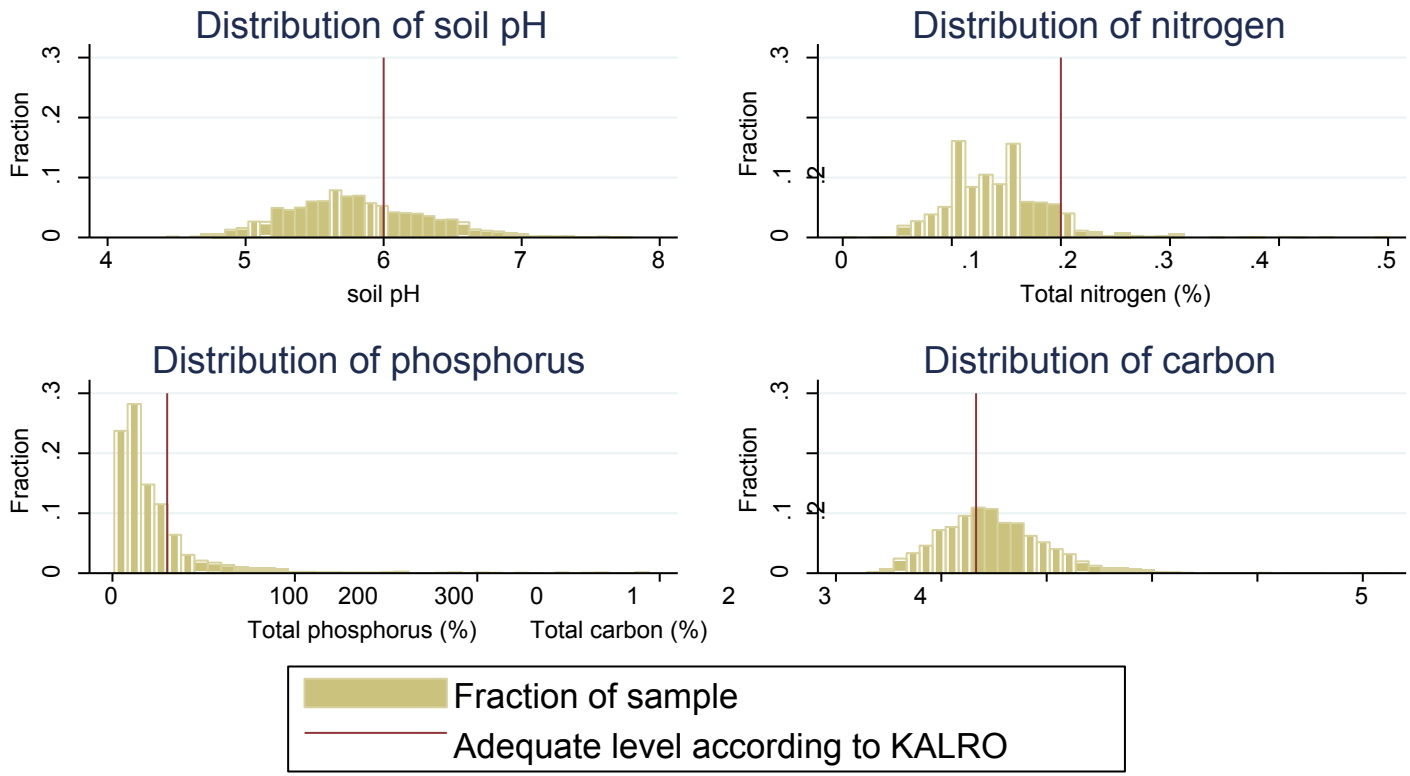
Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

However, this impact on yields was not replicated

- In a second SMS trial in the same context, there was no significant effect on sugarcane yields
- We are currently investigating potential reasons for the difference in results across the two trials

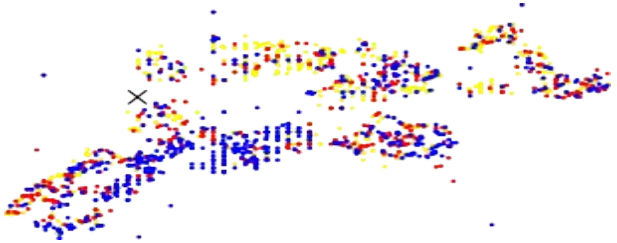
Source: Casaburi and Kremer, PEDL Research Note

Background: Maize soil quality is heterogenous...

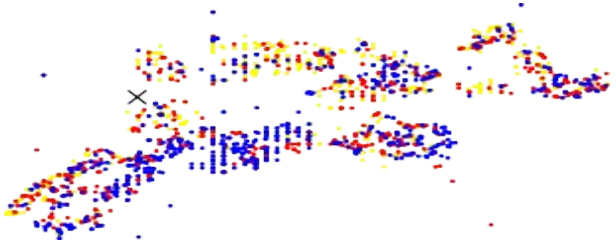


...And yet spatially correlated

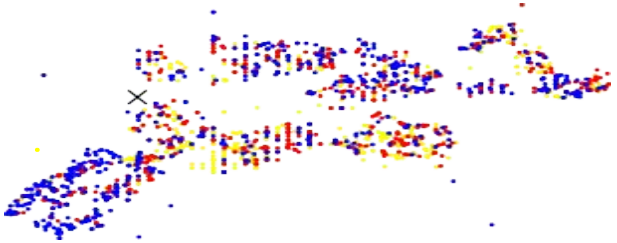
Spatial Distribution of Nitrogen



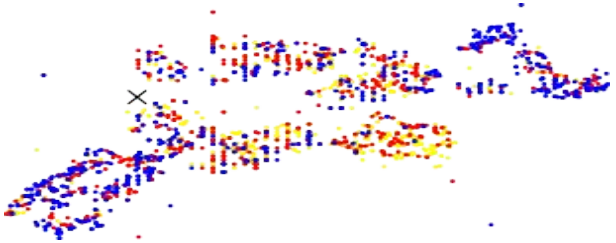
Spatial Distribution of Carbon



Spatial Distribution of Phosphorus

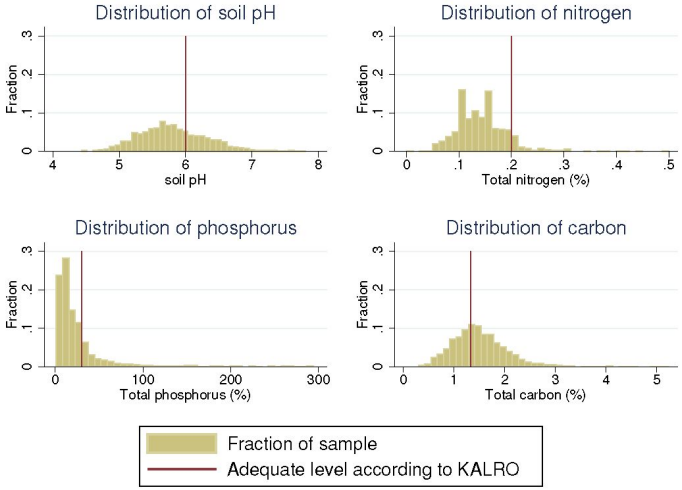


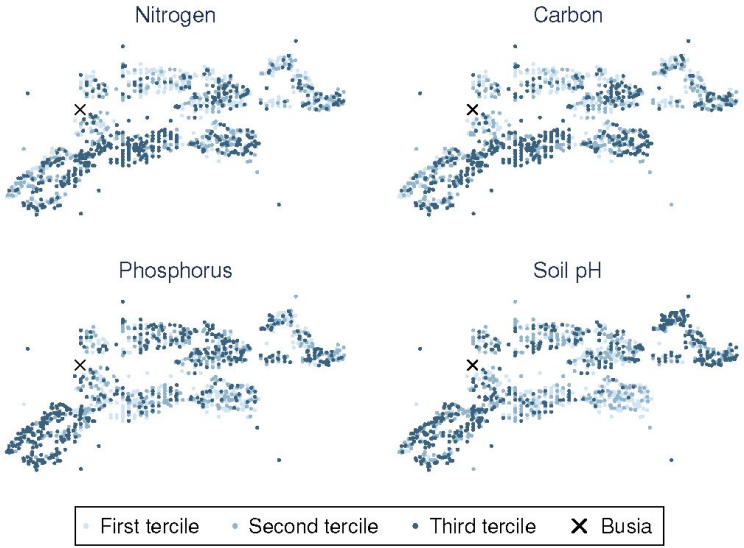
Spatial Distribution of pH



First tercile Second tercile Third tercile Busia

Background: Maize soil quality is heterogenous...





...And yet spatially correlated

Soil Acidity: Farmers value information on soil chemistry in their area

Findings:

- Traditional in-person training (Farmer Field Days) **increased knowledge of lime**
- Mobile e-extension information service **did NOT increase knowledge of lime**
- No effect on the correct fertilizer quantity used
- Kenyan government SMS messages to farmers saying “If your soil pH is less than 5.5, apply lime” had no impact on lime purchases, even with steep discount

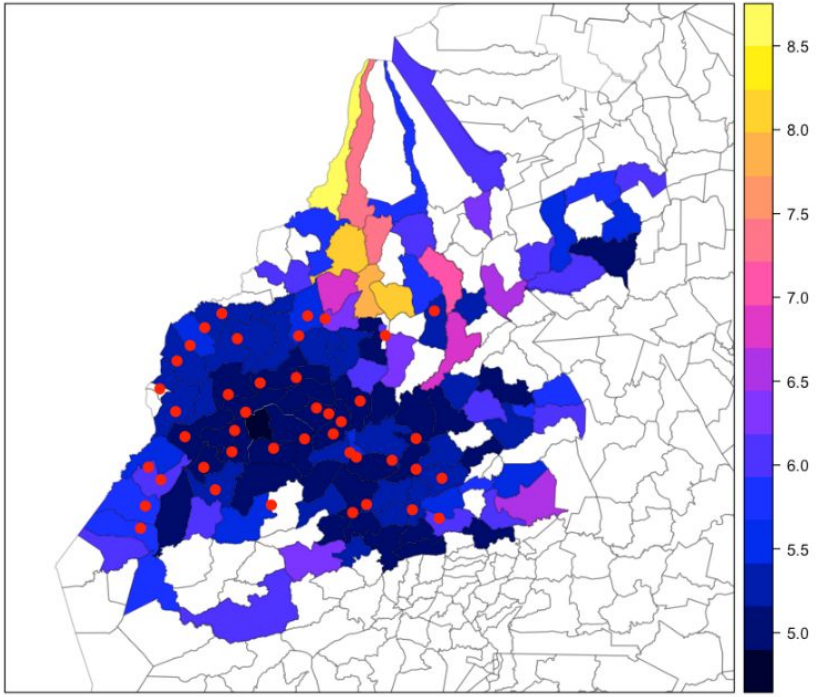
Key Takeaways:

- Without customization, there is no impact
- Poorly designed messages don’t work, so A/B testing is critical

Background: Lime adoption in Western Kenya

Focusing on soil fertility

- Soil acidity is a major issue in the region → agricultural lime can help to alleviate
- However, agricultural lime is not widely known in this area and despite being relatively cheap, usage is relatively low
- Using available soil data, we provide and communicate lime recommendations to farmers based on their location



Soil pH levels by ward in Western Kenya and markets (red dots).

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Soil test results are valuable to farmers

- Soil tests performed by Kenya Agricultural Research Institute (KARI)
  - Cost of $10 per test

- Elicited maize farmers willingness to pay for information on soil test results
  - Average WTP = $2.17-4.87
  - Farmers willing to pay more for more precise information

- Cost of providing information
  - With information shared in-person, costs at scale **<$0.50 per farmer**
  - However, can be much cheaper using cell phones and new soil testing technologies
  - Estimated cost at scale **<$0.15 per farmer**

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Large impact of SMS-based information on lime adoption

Findings

- Farmers who received our messages and were encouraged to use lime were **25% more likely to purchase lime** (2.8 percentage points) and **purchased 27% more lime**

- Farmers who received our messages and were encouraged not to use lime were **33% less likely to purchase lime** (2.9 percentage points) and **purchased 44% less lime**

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Partnership with One Acre Fund in Kenya

Sample:

- 40,000 farmers in 1 district of Western Kenya (Enrollment in Aug-Sep 2016)

Intervention:

- Sending SMS messages to OAF farmers to encourage lime purchase based on local soil test

Findings:

- **28% increase in lime adoption** (3.0 percentage points)
- More customized messages are more effective

Partnership with One Acre Fund in Kenya

Scaled up the SMS campaign to all OAF farmers in Kenya for 2018 season, and integrating A/B tests to optimize impact

- Testing message framing
  - Gain vs. loss framing
  - Social comparisons
  - Local vs. general information
- Testing social learning
  - Encouraging farmers to learn from peers that had good experience with lime

Partnership with Government of Kenya

Initial plan:

- Start with pilot of 25k- 100k farmers
- Assess the response rate, test and refine
- Work with CABI and Ministry to develop messages
- Conduct phone and in-person surveys to get feedback
- Scale to all areas in Kenya affected by FAW

Long run vision:

- Help the government set up a system that can be used to communicate messages on other agricultural topics
- Expand partnerships in other countries that have been affected by Fall Armyworms (e.g., Tanzania, Uganda, etc.)

From the initial proof of concept, many new opportunities are emerging

India

- Advise **Coffee Board of India** to bring services to all coffee farmers, beginning with pilot in Karnataka in 2018

Kenya

- Assist **CIMMYT** to design and evaluate effectiveness of info on locally appropriate seed varieties through mobile phones

Ethiopia

- Second phase evaluation and opportunities for expansion of nationwide IVR/SMS system run by the **Agricultural Transformation Agency**

Pakistan

- Partnering with **Government of Punjab** to provide mobile phone-based explanations of paper soil health cards

Ecuador

- Work with a **contract farming company** to create and evaluate customized mobile phone ag system

We are constantly testing and retesting our operations to improve impact

Continued experimentation and optimization is key

- Sending "too many" SMS messages one season in Kenya had negative impact, tailoring the next season had positive impact

A/B tests offer evidence-based way to improve services

- Experimenting with/without jingle at start of voice message to measure impact on listening rates

Learnings from one geography can influence another

- Positive results from coupling paper soil health cards with mobile messages in India contributed to program changes in Pakistan

Searching for optimal message framing takes work

- Message content and framing experiments ongoing with partners in Kenya and Rwanda

Our farmer reach is growing

PAD farmer reach: current and potential

	Current *(labs + partnerships)*	Potential *(estimated)*	
India	60,000	100,000,000	All smallholders with phones
Kenya	12,600	14,000,000	All smallholders with phones
Rwanda	200,000	200,000	All farmers from partner NGO
Pakistan	-	5,000,000	All smallholders in Punjab
Uganda	-	60,000	All farmers from partner NGO
Ethiopia	-	2,500,000	All farmers reached by gov't service
Ecuador	-	2,000	All farmers from partner company

Example of Hyper-personalized information on PAD's service

Precision Agriculture for Development

XX

- XX

Highly-Personalized fertilizer recommendations – Soil Pilot (Funded by ATAI)

- Actual soil analysis for farmers in agricultural universities
- Systems to develop personalized recommendations via algorithms and its automatic dissemination have been put in place
- Also plan to add name of each individual farmer while sending the info

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We will soon have the functionality to send personalized price and weather recommendation to each of the farmers based on their profile

Krishi Tarang's push calls customize information across many dimensions

Present

Crop

Irrigation

Soil characteristics

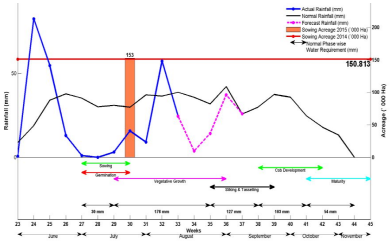
Sowing Week

Language

In the works

Highly localized weather

Crop modeling



Other technology opportunities

- Sensors and lasers
- Satellite / drone imagery
- Smartphone

Krishi Tarang also provides a Question & Answer service

How it works:

Farmer asks a question

1

Moderator receives question and directs to an expert

2

Expert gives his answer and sends for moderation

3

4

Moderator approves expert's answer and farmer gets response on his mobile phone!

The evidence

Encouraging evidence around a proof of concept technology

Affect behavior change?

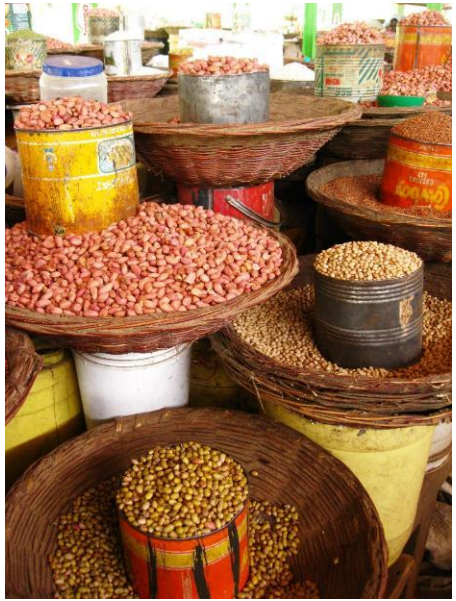
- **Maize farmers in Kenya 4-6% more likely to buy agricultural lime (relative to 11-17% baseline) when promoted through an SMS based service customized to results from local soil tests**

Our work to date: *Kenya*

- PAD pilots in western Kenya with 8,000 maize farmers and 200 agro-dealers on soil fertility and pest management
- Growing partnership with **One Acre Fund** promoting lime through mobile phones (potential reach of 300,000 farmers)
- Other partners:

Our work to date: *Rwanda*

- Designing and evaluating an SMS-lime service among all 200,000 clients with **One Acre Fund** (full scale)
- Only half of all farmers have access to a mobile phone → encouraging and measuring spillovers
- Partner: ONE ACRE FUND



Expansion and Partnerships Explored by PAD

Odisha	Test robustness of existing 2-way IVR advisory system with 10,000 rice farmers, in partnership with IRRI and Odisha government. PAD has set up a local office and the service will go live in first week of July
Input Supply	Randomized experiment with Agrostar (agri input aggregator) to test effectiveness by tracking usage statistics and differences in lead creation and sales across different treatment groups. Agrostar will pay for the airtime costs
Karnataka	Coffee Board of India is interested in implementing PAD's solution to all coffee farmers by end of 2018. We are exploring possibility of a pilot in 2017.
Punjab	In talks with a VC backed ag.-tech. startup to partner and implement PAD's service for a "National Bank for Agriculture and Rural Development" funded project

PAD Discussions with the Odisha Govt.

Precision Agriculture for Development

- The prin. Secretary (PS) came to know about PAD from JPAL
- During our first interaction he showed interest in implementing our service in Odisha as a pilot to start with and take it to a scale of 2 million farmers in 2-3 years
- Due to the procedural issues at the end of govt., there has been lot of back and forth
  - Main issue seems to be ability to pay for PAD local team costs without going through an EoI, but it could be for the whole operations too

We have received level 2 clearance from BMGF – collaboratively developing a proposal for Odisha

Appendix: Examples of PAD's Rigorous A/B testing

Precision Agriculture for Development

- A/B testing used to answer questions such as:
  - What type of training is most effective in engaging users?
  - What type of voice is preferred by users receiving information?
  - How accurate is collected data?
  - How effective are incentives in acquiring referrals?

- RCT with 3,600 farmers testing relative effectiveness of different training types
  - One-on-one
  - Remote
  - Group
  - Community mobilizer

- Ongoing RCT to test the incremental benefits of providing customized fertilizer recommendations based on soil analysis of individual plots

The evidence

… but it doesn't always work

Lack of customization = no impact

- A research organization in Kenya sent SMS messages to farmers saying "If your soil pH is less than 5.5, apply lime" which had no impact on lime purchases, even with steep discount

New technology, too soon

- Initial offering of a voice-based service in Kenya met with disinterest since farmers are not accustomed to leaving or receiving voice messages

Automating everything doesn't work

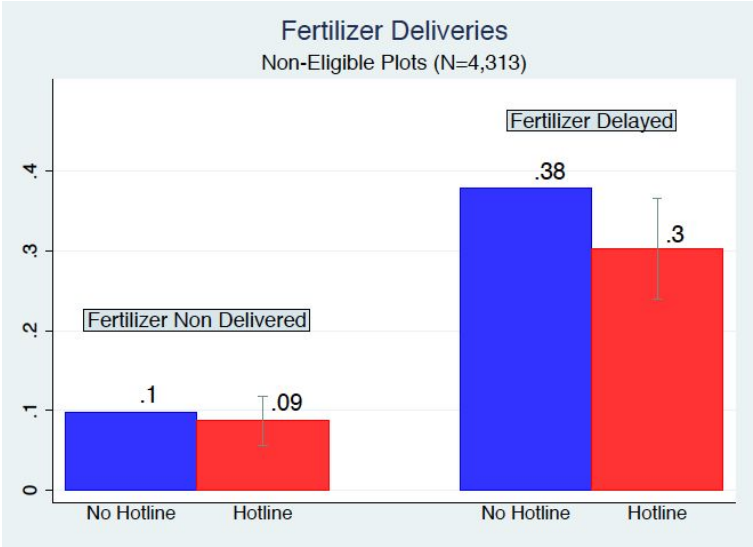
- Initial attempt to offer automated profiling in India received low farmer response and provided poor quality data

Positive spillovers for neighboring plots…

- Among non-eligible plots in treatment fields, late deliveries decreased by 19.8% (7.5 percentage points)

Table 9: Hotline Intervention: Non-Eligible Plots

	Urea Not Delivered		Urea Not Delivered in Time	
	(1)	(2)	(3)	(4)
Hotline	-0.010	-0.015	-0.075**	-0.075**
	[0.016]	[0.016]	[0.032]	[0.032]
Mean Y Control	0.097	0.097	0.378	0.378
Controls	N	Y	N	Y
Observations	4313	4313	4313	4313



Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

...and for more distant fields

- Exploits time series data
- One additional treatment plot reduced delivery delays by 0.1 percentage points across entire contract farming scheme
- This mitigates the concern that gains on treatment plots came at the expense of non-treatment plots, and suggests positive spillovers of better management of fertilizer deliveries

Table 10: Hotline Intervention: Impact on Non-Treatment Plots

	(1)	(2)	(3)	(4)
N. treatment plots	0.001	-0.011	-0.092**	-0.098**
	[0.040]	[0.035]	[0.035]	[0.035]
Mean Y Control	39.247	39.247	39.247	39.247
Calendar Month FE	N	Y	Y	Y
Time (year-month) Trend	N	N	Y	Y
Year FE	N	N	N	Y
Observations	36	36	36	36

Source: Casaburi, Kremer, Mullainathan, and Ramrattan (2014)

Netflix for Agriculture: A vision for personalized farmer recommendations

- Personalized (or at least localized) recommendations
  - Geographic and temporal info: soil type; weather; altitude; local input, output market conditions
  - Farmer-specific info: demographics, education, cognitive scores, risk aversion, previous farming experiences

- Two-way communication and information aggregation
  - Farmers have incentives to contribute accurate information to get better recommendations from the system.
  - This leads to better recommendations for other farmers.

Our value proposition

PAD creates and delivers value to farmers through multiple channels.

	PAD Lab	PAD Building	PAD Advisory	PAD Knowledge Hub
What we do	• We design, build, operate, and learn from our own services	• We design, build, operate and evaluate mostly new high-growth services with and for others	• We perform cutting-edge data analysis, evaluate and help make existing high-potential services better	• We disseminate knowledge and tools
Why we do it	• Serves as lab, where we can experiment, identify best practices, and build credibility	• Start new services with high growth and learning potential based on PAD lab experiences	• Main avenue for impacting large number of farmers in a very cost-efficient manner	• Contribute to field by making learning and code widely available
Examples	• Krishi Tarang, Gujarat, India • Pilots in western Kenya	• Government of Odisha, India • Government of Punjab, Pakistan	• One Acre Fund • IFFCO-Kisan • Government of Ethiopia	• Publications • Presentations • Tools
Scale and costs 12-18 month	• 50-100k farmers, $10-50 per farmer	• 20-300k farmers, $1-2 per farmer	• 300k-2m farmers, $0.1-0.9 per farmer	• TBD farmers, $close to 0

PAD has adopted a scientific approach to product development using A/B Testing

Examples of questions address by A/B tests

- Soil-based recommendations at different levels of customization, e.g. individual vs. neighborhood; phone vs. soil health card; with budget constraint vs. without)
- Price information (different means of delivery—SMS or voice; frequency of delivery)
- Training type (in-field, remote, peer, group, by post, automated)
- Peer referral (different incentives offered to high users to increase referrals)
- Peer-to-peer training with different incentive schemes for training fellow farmers
- Automated survey and data collection (incentive/nudges to encourage users to call in and offer information)
- Voice type (agronomist, female, male, farmer voices)
- Jingle in messages (include service jingle at the start, the end, or not at all)
- Weather accuracy for different providers (tracking multiple sources to assess accuracy of prediction over time)

Initial Results

- On average, participants were:
  - 36 years old
  - 70% literate
  - Nearly all male
  - 94% grow cotton
  - For 60-70%, the most important plot is irrigated

- 20-30% understand that the purpose of soil testing is to assess the level of nutrients in soil and/or to recommend fertilizers based on soil quality.

- Only 7% are familiar with the government's SHC scheme, and 10% report having ever had their soil tested.

- Only 2-10% are able to correctly answer questions on specific fertilizer quantities recommended in SHCs after they are shown it without any aids. Yet over 90% either fully or somewhat trust the recommendations.

Next Phase: Customized voice messages

During the kharif season, PAD sends 12 different messages to farmers based on their soil health reports at periodic intervals based on their personalized week of sowing