Smallholders' adoption of innovations – an agenda for learning

For an agricultural innovation to become widely adopted by smallholders, there must be a good match between the properties of the innovation and the goals, objectives, and constraints faced by the population of farmers. Our authors look at recent research using large-scale experiments and new approaches to measuring adoption at scale which together can help agricultural researchers understand more about this important process.

By Karen Macours and James Stevenson

In every sector of our economies, the rate at which productive innovations spread is a key determinant of growth and development. This is particularly true of the agricultural sector. There is a long history of research on the adoption and diffusion process in agriculture, going back to the 1950s and the seminal work of economist Zvi Griliches. Griliches studied how hybrid maize seeds diffused through the farming population of the United States in the prior decades, examining how varied this process was across different states. In this context, the term "adoption" refers to the decision by a farmer to use a particular agricultural innovation.

Understanding the process of adoption

Agricultural researchers – the plant breeders, agronomists, soil scientists, hydrologists, livestock researchers, or aquaculture scientists – work to develop new innovations that can be adopted by smallholder farmers. The

The African Chicken Genetic Gains Project aims to increase the access of poor smallholder farmers in sub-Saharan Africa to high-producing but agro-ecologically appropriate chickens.
Photo: Apollo Habtamu/ ILRI

MARKET FAILURES THAT CONSTRAIN ADOPTION OF AGRICULTURAL INNOVATIONS

- **Externalities** – Some technologies create spillovers that affect others. If farmer decisions ignore these spillovers, then technologies that create benefits for others may not be adopted, while technologies that impose costs on others may be adopted too widely.
- **Input and output market inefficiencies** – Problems with infrastructure and with supply chains, compounded by weak contracting environments, make it more costly for farmers to access input and output markets and access the benefits from technology adoption.
- **Land market inefficiencies** – In settings where land tenure is weak and property rights insecure, farmers may not have an incentive to invest in beneficial technologies.
- **Labour market inefficiencies** – New technologies need different types and timing of labour input. Restrictions on labour mobility and high costs in the labour market will interfere with adoption opportunities.
- **Credit market inefficiencies** – Many farmers have difficulty accessing credit and face high interest rates, which prevents investment in profitable technologies. Financial decisions may be difficult for farmers without high levels of financial literacy.
- **Risk market inefficiencies** – Technologies that carry a small risk of a loss may not be worth large expected gains if risks cannot be offset. Psychological issues around risky decisions further lower levels of adoption.
- **Informational inefficiencies** – If an individual does not know that a technology exists, does not know about its benefits or does not know how to use it effectively, then that technology will not be adopted.

Source: ATAI White Paper by Professor Kelsey Jack.

"impact pathway" articulates a theory for how the researchers hope to make a difference in the world. Adoption of these innovations by smallholders is often a crucial stepping-stone in this pathway, particularly in Africa.

This raises the question of how well we can evaluate the potential of new innovations from the perspective of the farmers. One school of thought on this topic is that action research, working with farmers to help understand objectives and constraints, is critical. We agree. It is through this process that hypotheses are formed. We also think it is important to put these hypotheses to an empirical test to study what kinds of interventions are necessary and sufficient in bringing about positive changes for farmers in large numbers. Economics offers three important insights here.

The first insight comes from research on how farmers evaluate technologies as compared to the perspectives of agricultural researchers. For example, it is common for agricultural researchers to dedicate their career to finding ways to increase the yields of specific crops or systems. And while farmers also care about yields, the major concern for many of them is the expected profitability from any change in their operations, while other aspects that can contribute to their utility (such as nutritional benefits) may also factor in. An innovation that increases yields but also raises the costs borne by the farmer may not be adopted – the farmer first must learn whether the change is worth it. But let's assume the innovation is indeed potentially profitable for many farmers to adopt. What next?

The second insight is that farmers face numerous constraints to adoption. An innovation that is potentially profitable under controlled research conditions may not be feasibly adopted under real world conditions, owing to one or more constraints. The Agricultural Technology Adoption Initiative (ATAI) laid out seven areas where "market failure" may result in innovations not being adopted that would be profitable under ideal conditions (see Box). Lifting those constraints could hence lead to increased adoption. The beauty of this scheme is its simplicity. We can theorise about what causes low adoption, but then we can rigorously test those theories in large-scale experiments with farmers. By introducing innovations alongside a complementary programme that alleviates one or more constraints, we can learn about farmers' behavioural responses. ATAI is one of several specialised initiatives, including Precision Agriculture for Development (PAD), the Feed the Future Innovation Lab for Market Risk and Resilience (MRR) and the CGIAR (Consultative Group on International Agricultural Research) Standing Panel on Impact Assessment (SPIA), which support this kind of structured learning about constraints to adoption of agricultural innovations. Using experimental methods, a series of papers by researchers at the International Rice Research Institute (IRRI), the University of California at Berkeley and Tufts University in Massachusetts, both in the USA, gradually tested for different mechanisms that could help increase adoption and diffusion of stress-tolerant rice varieties, including peer learning, demonstrations and farmer-field days, and partnerships with private suppliers. They also demonstrated that when key constraints are lifted, additional gains can be obtained if farmers crowd in effort and other inputs.

The third insight is that not only differences between agronomical trial results and outcomes in real-life-conditions, but also differences between the way agronomists and economists conceptualise yield gains further help understand low real-world adoption of technologies thought to be promising. Researchers from the International Institute of Tropical Agriculture (IITA), the Universidad de Los Andes in Bogotá, Colombia, and France's Paris School of Economics show how parcel and farmer selection, together with behavioural responses in agronomic trials, can explain why yield gain estimates from trials may differ from the yield gains of smallholders using the same inputs under real-life conditions. Adjusting for selection, behavioural responses, other corrections and estimates of yield gains can lead to both higher and lower returns. These results suggest that testing new agricultural technologies in real-world conditions and without researcher interference early in the agricultural research and development process might help with identifying which innovations are more likely to be taken up at scale.

ADOPTION OF CGIAR-RELATED INNOVATIONS IN ETHIOPIA – SUMMARY OF RECENT EVIDENCE

A recent study by the CGIAR Standing Panel on Impact Assessment (SPIA), the World Bank Living Standards Measurement Study and the Ethiopian Central Statistical Agency (CSA) documents the reach of CGIAR-related agricultural innovations in Ethiopia. The data collection effort cut across the core domains of the CGIAR research portfolio: animal agriculture, crop germplasm improvement, natural resource management and policy research. An initial "stocktaking" exercise documented 52 agricultural innovations and 26 claims of policy influence from the past two decades of research cooperation in Ethiopia. CGIAR scientists and their national partners have generated a plethora of new ideas, many of them leading to agricultural innovations and policy changes.

Quantitative evidence on the adoption of 18 of these innovations was obtained by integrating data collection protocols, including DNA fingerprinting for maize, sorghum and barley, into the Ethiopian Socioeconomic Survey (ESS). It is estimated that in 2018/19, between 4.1 and 11.0 million Ethiopian households were reached by agricultural innovations linked to CGIAR research. The lower bound estimate (4.1 million households) includes only those innovations with clear observable features in survey data and for which their adoption can be strongly linked back to CGIAR research efforts. The upper-bound figure (11.0 million) should be interpreted as the 'potential reach' of CGIAR in the country: it captures the number of households that in theory could benefit from CGIAR research.

Piecemeal assessments of diffusion provide an incomplete picture, as different innovations reach different types of farming households and regions. Analysis of the socio-economic characteristics of the adopting households shows that innovations often do reach the types of household that CGIAR researchers target, with substantial adoption among smallholders, poor households, and young and female farmers. However, there is substantial heterogeneity when comparing across different innovations (farm size, market access, socioeconomic status, gender, age, and region). Diffusion levels for some innovations are lower than expected, and the theories of change for these innovations may need to be revisited.

Tracking adoption at scale

Accurately quantifying the diffusion of agricultural innovations at scale requires addressing complex measurement and sampling challenges. Consider farmers' adoption of an improved variety of cassava. Typically, the evidence on adoption of cassava varieties has relied on either asking experts' opinions or using survey data collected from farmers. Both are imperfect if we want accurate estimates. In recent years, the use of DNA fingerprinting for identifying specific crop varieties has been piloted and is now being implemented in farm surveys in several countries. As a result, we can now compare the data reported by farmers to the DNA fingerprinting data: there often is a big mismatch (see Table).

Remote sensing is another example of a breakthrough in measurement that is being leveraged to track adoption of innovations. As sensor accuracy improves and data costs from remote sensing fall, it is now possible to detect adoption of some natural resource management innovations using remote sensing.

SPIA is working to mainstream these insights into large-scale, well-institutionalised agricultural surveys. Our strategy is to focus on countries that are high-priority for CGIAR, in order to generate reliable, independent data at a national scale which documents the reach of CGIAR and Nars (National Agricultural Research System) partners in the country. In particular, we have been working with the World Bank and the statistical agencies of both Ethiopia and Uganda to integrate new data collection protocols into their nationally-representative household surveys. In Ethiopia, we recently documented widespread adoption of soil and water conservation practices, improved maize varieties and cross-bred chicken. At the same time, many other innovations showed much more limited adoption (see Box for a summary). This highlights the need for more experimentation and testing of scaling strategies to maximise the returns to agricultural research and innovation.

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Adoption of improved varieties of cassava: Comparing estimates from farmers' statements to DNA fingerprinting of leaf material from their plots

Country	Survey year	**% agreement between DNA fingerprinting data and farmer-reported data** (on whether farmer is cultivating improved variety)	% improved varieties estimated by DNA fingerprinting	% improved varieties estimated by farmers	Percentage point bias of farmer-reported estimates
Ghana	2013	55	4	6	+2
Colombia	2014–15	27	9	17	+8
Nigeria	2015–16	67	77	60	-17