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How can the tools of development economics be used for adaptation to climate change and environmental degradation?

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As reports about extreme weather events around the world hit the news with increasing frequency, policy discussions often revolve around what climate change "will" imply for future weather patterns and the related challenges for life as we know it. For people in low- and middle-income countries (LMIC), the consequences of climate change and environmental degradation are not a question for the future, however, having been a hard present reality for some time now. Irregular rainfall patterns are disturbing traditional agricultural growing seasons, extreme temperatures are affecting productivity in all sectors, cyclones, hurricanes and wild fires are destroying infrastructure and livelihoods with increasing frequency and intensity, and sea level raises have led to the loss of some of the most productive lands through salinity intrusion. Environmental decline further endangers livelihoods as pollution and ever-new emerging pests and diseases affect plants, animals, and people. Relatedly, soil fertility declines reduce crop productivity, and loss of biodiversity substantially reduces the natural asset base rural households, and humankind more generally, has long depended on for addressing adversities.

For vulnerable households in low- and middle-income countries these real, big, and urgent challenges come on top of the large challenges they have long faced, resulting from their exposure to a multitude of market imperfections. The tool kit development economists have developed for studying such market imperfections, and the impact of interventions addressing them, are increasingly being used to study possible policy responses to the climate and environment related challenges. This editorial reviews some of the insights from this literature. It zooms in on a few specific areas where evidence points to clear policy responses, with a focus on climate adaptation in the agricultural sector, as it is particularly vulnerable to changes in weather patterns and environmental degradation. It is at the same time the sector that continues to provide the livelihood of many of the world's poorest, and in a world of imperfect markets and inseparability between consumption and production decisions, also directly links to the food security of many others.

We'll consider the role of agricultural research and development (R&D) to provide new technological solutions, and the incredibly complex learning challenges farmers face to understand potential returns to such solutions, pointing to questions around subsidies, information and insurance interventions to help overcome demand constraints. Going beyond the focus on agriculture, facing the adaptation challenges also raises big questions around human capital policies, while social protection, including cash transfers, may be best suited to help vulnerable households deal with increasing frequency of shocks. Lessons from a large literature point to possible policy responses. Such policy responses necessary will require large investments, pointing to the important debates on climate justice and ongoing efforts to mobilize resources. Research addressing the many open questions on optimal designs of adaptation policies that account for the constraints faced by vulnerable households, can contribute by improving the returns to such public investments.

Issue N°1: Agricultural R&D and the complexity of farmer's learning about technological innovations

The majority of the population in low- and lower middle-income countries live in rural areas where livelihoods depend on agriculture. In many of the poorest parts of the world, and notably in Sub-Saharan Africa, this is almost uniquely rainfed agriculture. With irrigation infrastructure never been developed, rural households' income remain extremely sensitive to rainfall and temperature fluctuations. This is not a new situation, and a long literature in development economics studies how farmers cope and manage weather shocks. The shocks have become, however, much more extreme, with changes in both the mean and variance of rainfall and temperature during traditional growing seasons. Equally devastating, the seasons themselves have become unpredictable with the start of the rains needed to start planting no longer following historical patterns, and rainfall interruptions, temperature hikes or extreme winds affecting crops during critical points in their growth cycle leading to yield loss or crop failure. Strategies farmers have developed over centuries involving sequencing of crops and livestock activities in function of traditional seasons have often become completely obsolete. The unpredictability of events makes new maximization, needed to decide on what to plant when and where, and which inputs to buy, an incredibly difficult task. The increasing occurrence of ever-changing crop and animal pests and diseases further complicates the farmer's decision-making problem.

The magnitude of the challenges calls for a multi-tier public policy approach to help rural households adapt. Public good investments in breeding more resilient crops through international research efforts have long been seen as a necessary component of such an approach, and have indeed resulted in the release of drought, temperature, or flood-tolerant staple crop varieties, with parallel efforts focused on pest and disease resistance. Yet, while high yielding crop varieties released in the 70s spread rapidly across Asia and Latin America, resulting in economic growth and poverty reduction known as the "Green Revolution", more recent climate-resilient varieties often diffuse slowly, resulting in decade-old varieties on farmers' fields. There are several possible reasons for this, including under- investment in breeding, inappropriate breeding, lack of the right complementary public policies, or absence of the right scaling models.[1] While more and better crop breeding may be needed to improve the pipeline, given the urgency of the challenges, it is equally important to

[1] See Gollin *et al.*, *Journal of Political Economy* (2021) on the positive impacts of the Green Revolution and Moscona and Sastry (2022) on inappropriate technologies.

test and provide evidence on strategies that can help scale existing varieties with resilience traits.

A similar argument holds for the broader category of climate adaptation innovations. As for crop varieties, agricultural R&D investments have led to a set of "technological" solutions, including improved practices for soil fertility, water conservation and/or pest and disease management, sometimes referred to as "climate-smart" practices. These typically involve a bundle of inputs and practices, and sometimes require large labor or capital investments. They are also often very knowledge intensive. Despite extensive development through biophysical research, adoption levels of such packages often stay low. This too raises questions about whether the innovation model that is being pursued to develop those packages is the right one. Evidence points, for instance, to both overestimation and underestimation of returns when scientific testing of new packages occurs under conditions far removed from farmers "real world" conditions.[2] On the other hand, farmers' learning about new technological packages, even if they are profitable, can be an intrinsically complex task. Farmers simultaneously need to sort out complementarities between different inputs and practices, while gleaning very imperfect signals from every season's realization of output, which is being affected by soils, pests, diseases, weather and other factors outside of their control.[3]

Issue N°2: Public policy to facilitate adaptation: information, subsidies and insurance

Given the complexity of this multidimensional learning, farmer's learning through experimentation and interventions encouraging citizen science are potentially particularly suitable to the climate adaptation needs. When information about new technological solutions is the binding constraint, but local customization is needed to optimize returns to those technologies, there is an open question on the right mix of learning from experts versus learning from local experience. Evidence points to the potential of different scalable models involving AI-powered customized advice through information technology, or models of farmer-to-farmer learning that crowd in both local knowledge and technical expertise. In other circumstances, where tipping points have been reached, such as the desertification of previous agricultural land, and technological solutions exist to reverse this process and obtain almost immediate private returns, intensive training by experts may be sufficient to shift towards new production practices.[4]

Whether and how public policies can facilitate these learning and adaptation

[2] See Laajaj *et al.*, 2020, *Scientific Reports.*

[3] Laajaj and Macours (2024) show that after intensive exposure to scientific trials allowing farmers in Kenya to directly observe returns to new inputs in a treatment-control setting for 3 seasons in a row, learning was imperfect and most farmers continue to pay exploration costs related to trying the new technologies in subsequent seasons.

[4] See Fabregas, Kremer and Schillbach, *Science* (2019) on using IT for customization, Behaghel *et al.* (2020) on farmer-to-farmer learning in Uganda and Aker and Jack, *Review of Economics and Statistics* (2023) on training on water harvesting techniques in the Niger.

process is an active area of research. Traditional models of "smart" input subsidies start from the idea that time-limited subsidies can give farmers an opportunity to learn about the return to new technologies.[5] There is an interesting set of questions on how to maintain private sector incentives for diffusion of the new inputs, while also providing opportunities to farmers to learn through subsidized access. These questions become more complex when the returns to the input depend on the realization of a particular weather or pest event, as it then may take multiple years of exposure for farmers to learn the benefit. When encouraging adoption of certain technologies is motivated by environmental externalities, stemming from more sustainable practices or resource conservation, the relevant subsidy model may well be different than when subsidies are only meant to help farmers learn about positive private returns.

Low levels of adoption, and hence low demand, have also plagued the design of many weather insurance instruments in LMIC. Yet weather insurance would seem to provide an obvious answer to the climate challenges poor farmers face. A large body of research, while making great advances on optimal design for different index insurance products, has shown that demand for such insurance products tends to be low. This is in part due to the remaining inherent imperfections in the insurance products themselves, but also due to lack of trust in the providers and other possible behavioral constraints limiting the type of ex-ante commitment such products require. Subsidized weather index insurance on the other hand has been shown to make a big difference for production decisions and livelihoods, and research testing how to build insurance principles into existing social protection programs, private sector vertical contracts or credit lines show promising avenues forward.[6]

Issue N°3: Innovations in social protection and human capital policies

Social protection programs possibly are some of the most attractive vehicles to facilitate climate adaptation. This is an area with a lot of social innovation over the last 25-30 years in LMIC.[7] Development economics research has been integral to these developments not only by providing evidence on the impact and cost-effectiveness of various innovations, but also by proposing new approaches and new design features, and by facilitating evidence-based scaling. There is a large literature on the positive impacts of cash transfers program in particular, which by providing regular income streams to vulnerable households, can play an important *de facto* insurance rule. As opposed to weather insurance, they don't require upfront investment by vulnerable households allowing them to target the

[5] When implemented in a context with many other market imperfections, they may however have the opposite effect, as shown in Haiti (Gignoux *et al.*, *American Journal of Agricultural Economics*, 2023), or lead to complex trade-offs between forest conservation and agricultural productivity as found in DRC (Bernard *et al.*, *Nature Communications*, 2023)

[6] See, for instance, Casaburi and Willis, *American Economic Review*, 2018, and Lane, *Econometrica,* 2024.

[7] Banerjee *et al.*, *Journal of Economic Literature*, 2024.

most vulnerable.[8] As many adaptation strategies require some initial investment and risk taking while learning the return to the new activity, having assured access to income streams can help facilitate adaptation. There is a large literature showing that information or nudges that come together with cash transfers can be effective at shifting households' investments behavior. While more is to be learned on how to optimally design transfer programs that include components that specifically target climate adaptation, a promising avenue is to facilitate income diversification strategies, as they can reduce vulnerability to climate and environmental shocks.[9] Similarly, a large literature has studied the effectiveness of ultra-poor graduation programs, workfare programs or village livelihood and saving associations, which all can play an important role in either making the poor less vulnerable to shocks or helping them to cope with shocks once they occur. Whether and how to best build on the designs of these social innovations to tailor them to adaptation needs is an important area for new research.

While social protection can help respond to short-term adaptation needs, needs are likely to only intensify over time, and with them the complexity of the adaptation challenges. Technical and social innovations will likely not be sufficient, as long as those most affected by environmental and climate deterioration are not better equipped to find local solutions to the ever-changing environment. Some encouraging evidence suggests that educational approaches that focus on how to learn like scientists can be a win-win.[10] A new generation trained to experiment, to test hypotheses and to derive more accurate signals from observations may be better prepared to adapt to the ever-changing environments they will be facing, and to find local solutions to the challenges this poses. There are many open questions on whether and how such educational approaches can translate in real-world returns. As this is an area in which there is a lot of local innovations happening, rigorous evaluations can help identify which approaches are more successful and scalable.

Conclusion

The cost imposed by climate change and environmental degradation on the poorest populations of the world are enormous, making public policy action to facilitate adaptation an urgent priority. A body of research shows promising avenues for the design of possible adaptation policies, but much more evidence is needed given the complex challenges the rapidly changing

[8] As long as these can be properly identified, not always an easy task in context where most of the poor operate in the informal sector and where movements in an out of poverty are frequent - see Teschke and Willis in this issue.

[9] In Nicaragua, a cash transfer program combined with business grants or vocational training, targeted to households with large exposure to drought shocks and labeled as such, helped poor rural households to smooth income and consumption when the next droughts hit (Macours *et al.*, *Economic Journal*, 2022).

[10] Ashraf, Banerjee and Nourani (2023) show that inviting teachers to learn how to learn like scientists (posing sharp questions, framing specific hypotheses, using evidence and data gathered from everyday life) led to large improvements in both students' academic learning and their scientific capabilities and creativity.

environments impose, in particular for the decision making of rural populations in LMIC. As they are both the most directly affected, while also being the guardians of many of the worlds' most valuable natural resources, research that carefully investigates trade-offs and possibly helps identify and scale win-win innovations can have high returns.

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