Infrastructure for Climate Change
Drains, Taps, and Canals

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Infrastructure is a powerful tool for managing climate change and its distributional consequences. Irrigation infrastructure lowers rainfall risks and expands the frequency of planting seasons, potentially reducing uncertainty, and increasing revenues. Drainage infrastructure lowers the risk of flooding and erosion, improving health outcomes and the environmental sustainability of soils. Water infrastructure improves access to drinking water while managing risks associated with decreased precipitation and runoff.

Infrastructure investments are urgently needed to address inequalities in access and associated opportunities. Only 7 percent of cultivated land in Sub-Saharan Africa is irrigated;[1] one billion people will be at risk of displacement due to flooding and other disasters by 2050,[2] and two billion people lack safely managed drinking water.[3] While investments in water

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1 "Africa," International Water Management Institute, https://www.iwmi.cgiar.org/issues/irrigation/africa/.

2 "IEP: Over one billion people at threat of being displaced by 2050 due to environmental change, conflict, and civil unrest," PRNewswire, September 9 2020, https://www.prnewswire.com/ae/news-releases/iep-over-one-billion-people-at-threat-of-being-displaced-by-2050-due-to-environmental-change-conflict-and-civil-unrest-301125350.html.

3 "2.1 billion people lack safe drinking water at home, more than twice as many as lack safe sanitation," World Health Organization, July 12 2017, https://www.who.int/news/item/12-07-2017-2-1-billion-people-lack-safe-drinking-water-at-home-more-than-twice-as-many-lack-safe-sanitation.

infrastructure are a first-order necessity, the costs are high and the realized returns are often low: not because of the inherent value of the infrastructure, but because of the lack of attention to factors that secure use, adoption, operations, and maintenance.

In this chapter, we show how market constraints can cap the adoption of extremely profitable irrigation technologies at a mere one-third of farmers. We show that overuse of irrigation water by some can create artificial scarcities for others, lowering agricultural productivity and exacerbating food crises. We also show how inadequate maintenance of water points can render as many as half inoperable. Finally, we show how a lack of waste collection services can undermine the usefulness of expensive drainage infrastructure.

The solutions to doubling or tripling the impact of infrastructure are just an arm's length away. Complementing the billions a year spent on water infrastructure with relatively low-cost interventions can help increase and sustain economic impact. Our economic research has tested and documented how critical, low-cost interventions improve usage and technology adoption and optimize the institutions needed for operation and maintenance.

The four studies we present below exemplify issues of global significance in infrastructure. They tell us how embedding data and experimentation can optimize the sustainability of impacts and increase the cost-effectiveness of expensive, but potentially transformative, infrastructure by large margins. We offer four critical lessons:

1. **How to triple returns to irrigation:** Access to irrigated land is a huge constraint in Africa. Irrigation infrastructure investments must be accompanied by reforms in land markets and the introduction of labor-saving technologies. Supply-side interventions that provide inputs, insurance, credit, and information might be necessary, but are not sufficient to induce farmers to adopt profitable technologies that improve livelihoods and increase agricultural productivity. The Rwanda case study, a multi-year national research program, convincingly demonstrates that labor and land market constraints are binding for two-thirds of farmers with irrigation access. When farmers cannot take advantage of the economic opportunity offered by the infrastructure or the inputs provided by development programs, the returns to expensive irrigation infrastructure can be less than a third of their potential.
2. **How to halve water scarcity:** When institutions surrounding water usage are missing, farmers might use water inefficiently and cause negative externalities for other users. For example, farmers closer to the source might over-irrigate at the expense of other farmers. In so doing, they might lower the impact and sustainability of irrigation investments. The Mozambique case study develops solutions to Pareto improvements in the distribution of water usage that reduced reported water scarcity by half, while improving the distribution of water usage to benefit both the farmers that were over- and under-using water, thus increasing returns on irrigation infrastructure overall. Optimizing the role played by institutions in regulating, monitoring, and enforcing water usage can potentially increase returns on irrigation investment by large margins.
3. **Increasing the returns to investing in water access by two-thirds:** Access to water in rural areas emphasizes the construction of new infrastructure. Little attention, however, is placed on sustainability. The lack of institutional arrangements for operation and maintenance can reduce the life expectancy of

water infrastructure, its cost-effectiveness, and its impact on communities. In the Tanzania case study, we find that more than half of the communal water infrastructure is not functioning—with many of these water points breaking down within a year of construction. This means that focusing on water point maintenance could effectively expand access to reliable water services at a fraction of the cost of new capital investments. Many water points fail because of simple hardware issues such as broken taps. Addressing this technical breakdown may be straightforward. However, the fact that water points remain in disrepair for months, or even years, points to structural, institutional challenges that need to be resolved, such as strengthening own-source revenue at the community level and strengthening the coordination between communities and local government.

4. **Low-cost solutions can be viable alternatives to infrastructure investments:** Drainage infrastructure can be critical in preventing flooding, related erosion, and negative impacts on human health. Like other infrastructure examples in this chapter, drainage canals are a public resource that can be overutilized by private actors (for example, for waste disposal) who do not internalize the cost. The impact and sustainability of drainage infrastructure is thus critically linked to understanding collective action in operations and maintenance, and the provision of waste collection services. In the Senegal case study, we show that a low-cost intervention that provides local organizations with know-how and resources to manage waste surrounding existing drainage infrastructure can be as effective as new drainage infrastructure in averting floods and their devastating consequences on property and health.

The overall lesson of this chapter is that while infrastructure construction is expensive, returns and sustainability can be enhanced by lowering constraints to adoption, optimizing usage, and building or strengthening institutions that address collective action in operations and maintenance. These low-cost, complementary solutions can greatly increase the return on and the sustainability of water infrastructure and its impact on the economy.

In the next stage of our research, we will explore ways to improve norms and behaviors around water conservation (for example, using entertainment media to change water conservation practices on a global scale); the power of innovations in urban design (for example, recycling water instead of draining it); address market constraints (for example, introducing land rental markets to spur adoption of irrigation technologies and using digital tools to speed up land titling); and the role of institutions to improve water governance and the protection of national aquifers.