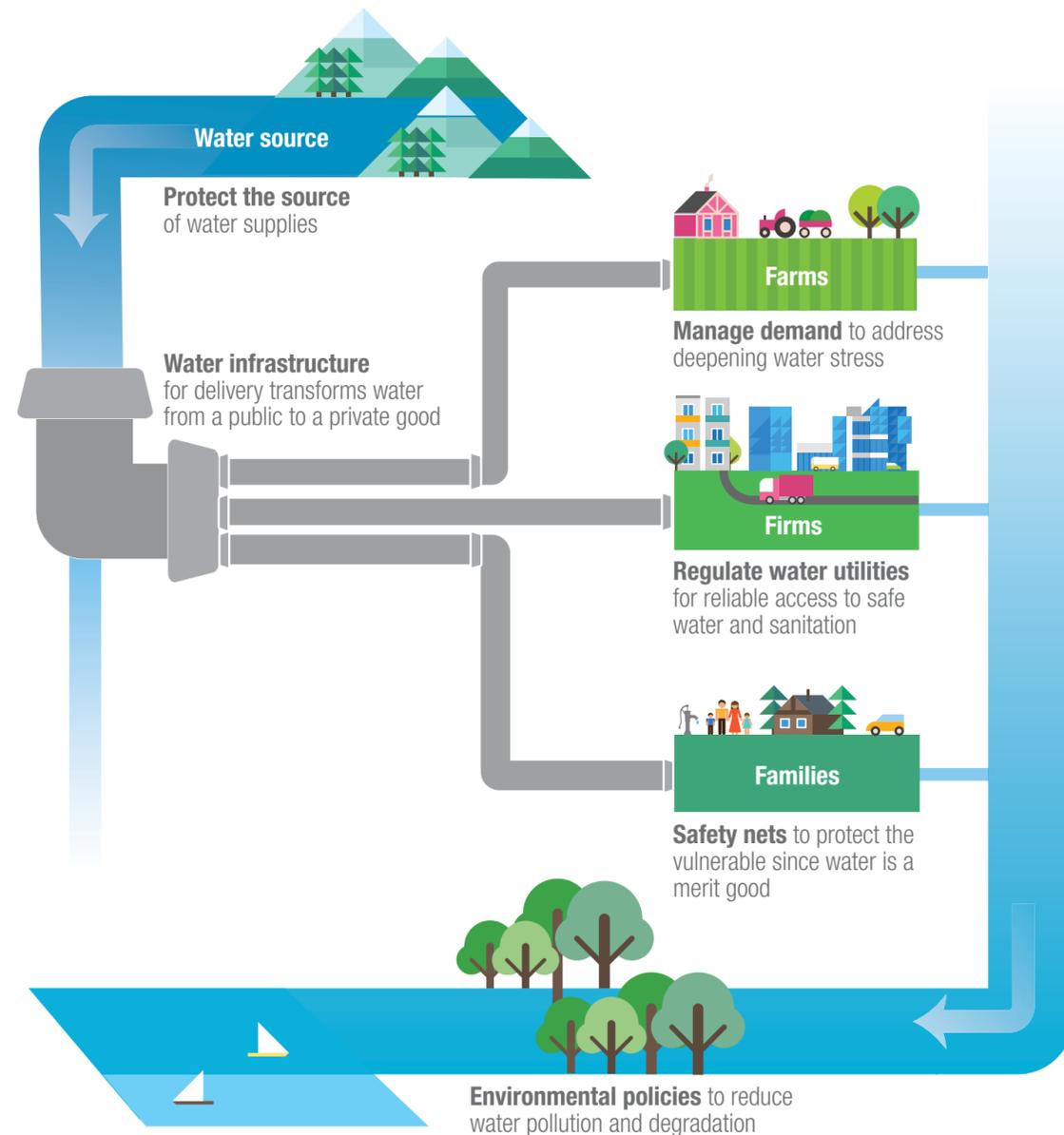




FIGURE 2 The Water Policy Cycle



Supply-side approaches, though necessary, are seldom sufficient to build adequate resilience to fickle rainfall patterns. Without proper economic signals, increasing the supply of water often also increases demand. The result is a vicious cycle where water supplies are expanded only to see that water consumed inefficiently; eventually returning the region to worsening levels of water stress. This *paradox of supply* forcefully illustrates the need for combining investments that expand water supplies with policies that manage demand and allocate water efficiently. Such policies include water pricing, water trading exchanges, and quotas on overall water use to ensure enough is left over for the environment. Water trading schemes are a promising approach that allows for the sale of water to higher-valued uses. The result is a win-win because a transfer occurs only if buyer and seller both benefit from the transaction. Efficiency of use rises and conservation improves. The institutional architecture required for a well-functioning water trading system is complex. But even if the obstacles seem significant, this is an instrument whose time has come for consideration, if not immediate implementation in all contexts.

Improved management in the water sector, while necessary for building efficiency and resilience, may not protect the poor from erratic rains nor assure that water is used sustainably. Safety net programs and insurance schemes are needed to protect the most vulnerable populations from the torments of droughts and floods. In rural areas, these safety nets could take the form of crop insurance schemes, while in cities, careful utility regulation is needed to ensure affordable access to clean water. Adequate safeguards, such as quotas and water quality standards, are required to ensure more sustainable water use, to protect water sources, and to prevent over-use and abuse of these public goods. This mix of policy tools is needed to protect those most vulnerable to water shocks, and ensure that rainfall does not become destiny, perpetuating poverty.

The future will be thirsty and uncertain. Already more than 60 percent of humanity live in areas of water stress where available supplies cannot sustainably meet demand. If water is not managed more prudently—from source, to tap, and back to source—the crises observed today will become the catastrophes of tomorrow.

Executive Summary

When the rains withered and the forests turned into parched savannahs, the earliest humans drifted out of Africa in their quest for water. Farms, settlements, and eventually cities clustered along riverbanks and gave rise to great civilizations. Now, as then, economic activity remains tied to water availability. But this relationship will undergo unprecedented pressures, as the 21st century witnesses the collision of two powerful forces—burgeoning population growth, together with a changing climate. With population growth, water scarcity will proliferate to new areas across the globe. And with climate change, rainfall will become more fickle, with longer and deeper periods of droughts and deluges.

Erratic rains weigh heavily on communities and economies. Floods are so powerful a metaphor of the human experience that nearly every civilization—from classical antiquity, to the Abrahamic religions, to ancient Mesopotamia—tells of a deluge epic that changed the world. Although it is debated whether these myths have a basis in historical events, extreme weather events still reshape societies and permanently mark the lives of those who experience them. Over the past two decades, extreme rainfall events have affected about 300 million people on average every year. With climate change, such extreme episodes of rainfall are expected to increase in frequency. Adapting to changing trends in rainfall, although difficult in its own right, is a gradual and predictable process. Knowing how to address unpredictable rainfall shocks, of uncertain frequency and unknowable magnitude, presents an additional challenge brought by climate change.

Whereas floods are spectacular weather events that cause sensational damage, droughts are misery

in slow motion with impacts that are deeper and longer lasting than previously believed. Although overflowing riverbanks and storm surges certainly pose major economic threats, this book demonstrates that the impacts of water scarcity and drought may be even greater, causing long-term harm in ways that are poorly understood and inadequately documented. Droughts can have health impacts, hamper firm productivity, accelerate the destruction of forests, and compromise agricultural systems.

This book presents new evidence to advance understanding on how rainfall shocks coupled with water scarcity impact farms, firms, and families. On farms, the largest consumers of water in the world, impacts are channeled from declining yields to changing landscapes. In cities, water extremes, especially when combined with unreliable infrastructure, can stall firm production, sales, and revenue. At the center of this are families, who feel the effects of this uncertainty on their incomes, jobs, and long-term health and welfare (figure 1).

Parched Farms, Shriveling Yields, and Shrinking Forests

Throughout much of the world, even moderate deviations from normal rainfall levels can cause large changes in crop yields. The driest regions are most sensitive to rainfall variability, although extreme rains can also bring crop losses to regions with more bountiful precipitation and productivity. Such variability is responsible for a considerable net loss of food production every year—enough to feed 81 million people every day, a population the size of

Germany's. Many of the affected regions overlap with areas that are already facing large food deficits and are classified as fragile, heightening the urgency of finding and implementing solutions.

Rainfall shocks cascade consequences from declining agricultural yields to shrinking forest cover. Faced with declining agricultural productivity due to rainfall shocks, farmers often seek to recoup these losses by expanding cropland, at the expense of natural habitats. Rainfall variability can account for as much as 60 percent of the increase in the average rate of cropland expansion, and, as a result, is responsible for much of the pressure on forested areas. Climate change may accelerate this pattern, leading to a harmful cycle where rainfall shocks induce deforestation, thereby increasing carbon dioxide emissions, and, in turn, further exacerbating rainfall extremes.

Irrigation systems usually insulate agriculture from the adverse effects of rainfall variability, but these systems may also paradoxically amplify the impacts of shocks. The availability of irrigation typically provides both a buffer against rainfall variability and a significant boost to crop yields in normal years. However, in many dry regions of the world these systems fail to protect farmers from the impacts of droughts. Free irrigation water creates the illusion of abundance, which buoys the cultivation of water-intensive crops such as rice and sugarcane that are ultimately unsuited to these regions. The ironclad laws of demand and supply then dictate that when water is provided too cheaply, it is also consumed recklessly. As a result, crop productivity suffers disproportionately in times of dry shocks due to extraordinary water needs that cannot be met. This book demonstrates that this *paradox of supply* is a widespread problem in areas where water is scarce and its demand is uncontrolled.

When Rainfall Becomes Destiny

Although a rainfall shock may be fleeting, its consequences can shape the destiny of those who experience it in infancy. Deprivations, such as a lack of food, endured in early life impede the physical and mental development of a child with significant and often irreversible consequences.

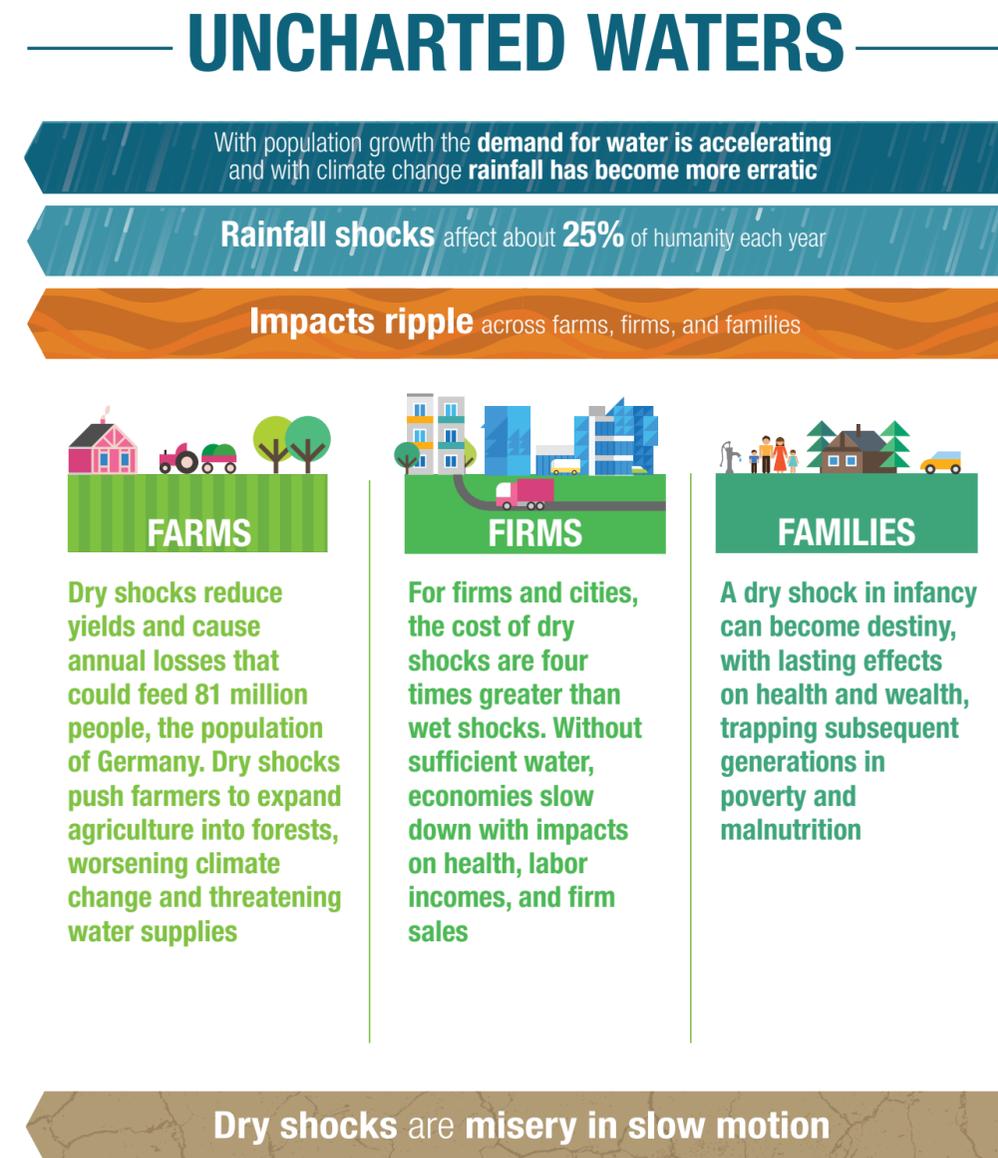
In rural Africa, women born during severe droughts bear the marks throughout their lives, growing up physically shorter, receiving less education, and ultimately, becoming less wealthy. They may also be less empowered to make household financial decisions and more accepting of domestic violence. Droughts tend to be viewed as short-term events that end as soon as the rains start falling again, but their effects can haunt individuals throughout their lives, causing impacts that go undetected.

Perhaps most troubling, the legacy of rainfall shocks can ripple through generations, harming not just the women who experienced them, but also their children. Rainfall shocks experienced by a mother in her own infancy can significantly impact the health of her children, who are more likely to suffer from malnutrition. These findings add to the urgency of addressing the effects of adversity in infancy through steps such as drought insurance or social safety nets.

Vulnerability in the City

In cities, the economic impacts of a dry shock are often greater than those of a wet shock. While urban infrastructure is generally able to buffer residents against the effects of moderate rainfall shocks, cities are still at the mercy of large rainfall shocks. Further, while the immediate devastation caused by floods attracts much attention, droughts in cities may have the longer-lasting, more severe impact on firms and

FIGURE 1 Some Results at a Glance



their employees. In Latin America, losses in income caused by a dry shock are four times greater than that of a wet shock. Droughts have poorly understood consequences within cities, causing higher incidences of diarrheal diseases, health impacts on young children, and an increased frequency of power outages.

The performance of firms in cities is also affected by the availability of water. While the private sector's reliance on transport and energy infrastructure is well established, little is known about the significance of water to firms. Findings in this book show that when urban water services are disrupted, whether by climate, inadequate infrastructure, or both, firms suffer significant reductions in their sales and employment. Particularly vulnerable are small and informal firms, a major source of employment in developing countries. The impacts of water supply and sanitation services in cities therefore extend beyond the widely documented effects on human health.

Avoiding the Parched Path

Pursuing business as usual will lead many countries down a "parched path" where droughts shape destinies. Avoiding this misery in slow motion will call for fundamental changes to how water is managed. It will require using different policy instruments to address the multiple economic attributes of water, through its cycle of use (figure 2).

At its source, in rivers, forests, and aquifers, water is a public good subject to all the mismanagement and overexploitation problems of a common-property resource. As water moves into pipes to quench the thirst of cities, or into irrigation canals to grow food, it becomes simultaneously a private good and a merit good—one to which people have a right as a necessity for life and health. In cities, this dual challenge is compounded by the fact that the costs of building multiple water systems is prohibitive and

impractical. Water must therefore be supplied to consumers through a single network, which must have a single owner—a monopolist—that needs to be regulated to ensure adequate access to water at a price that people can afford. Finally, the water passes through sewers and reenters the ecosystem where, if untreated, it can pose major health and environmental risks. These multiple, and at times competing, attributes often cause policy makers, economists, environmentalists, and water experts alike to disagree on how best to regulate, distribute, and use water. But neglecting these linkages can result in policy decisions that are at best less effective than they could be, and at worst downright harmful.

At its source, supply-side measures are needed to deliver water to users. These may encompass investments in infrastructure like reservoirs, irrigation systems, and wastewater reuse technologies. "Natural capital" solutions, which draw on such features of nature as the water-retaining abilities of forests, offer relatively inexpensive means of addressing some water scarcity issues as well. Investments in technologies that improve the efficiency of water used and consumed may be helpful too and offer the tantalizing prospect of creating "new" water, without depriving any existing users. Adoption of these solutions has been slow due to misaligned incentives. A large proportion of the benefits of efficiency improvements are public, while technology adoption costs are private. This implies that sharper incentives are required for technology uptake that might include a change in the subsidy regime, improved access to credit, or public investments in infrastructure. The challenge of managing water in cities is fundamentally different, demanding better performance from water utilities through appropriate forms of regulation and incentives to assure a balance between quality services for consumers, and a rate of return that assures cost recovery and further investment in the sector.