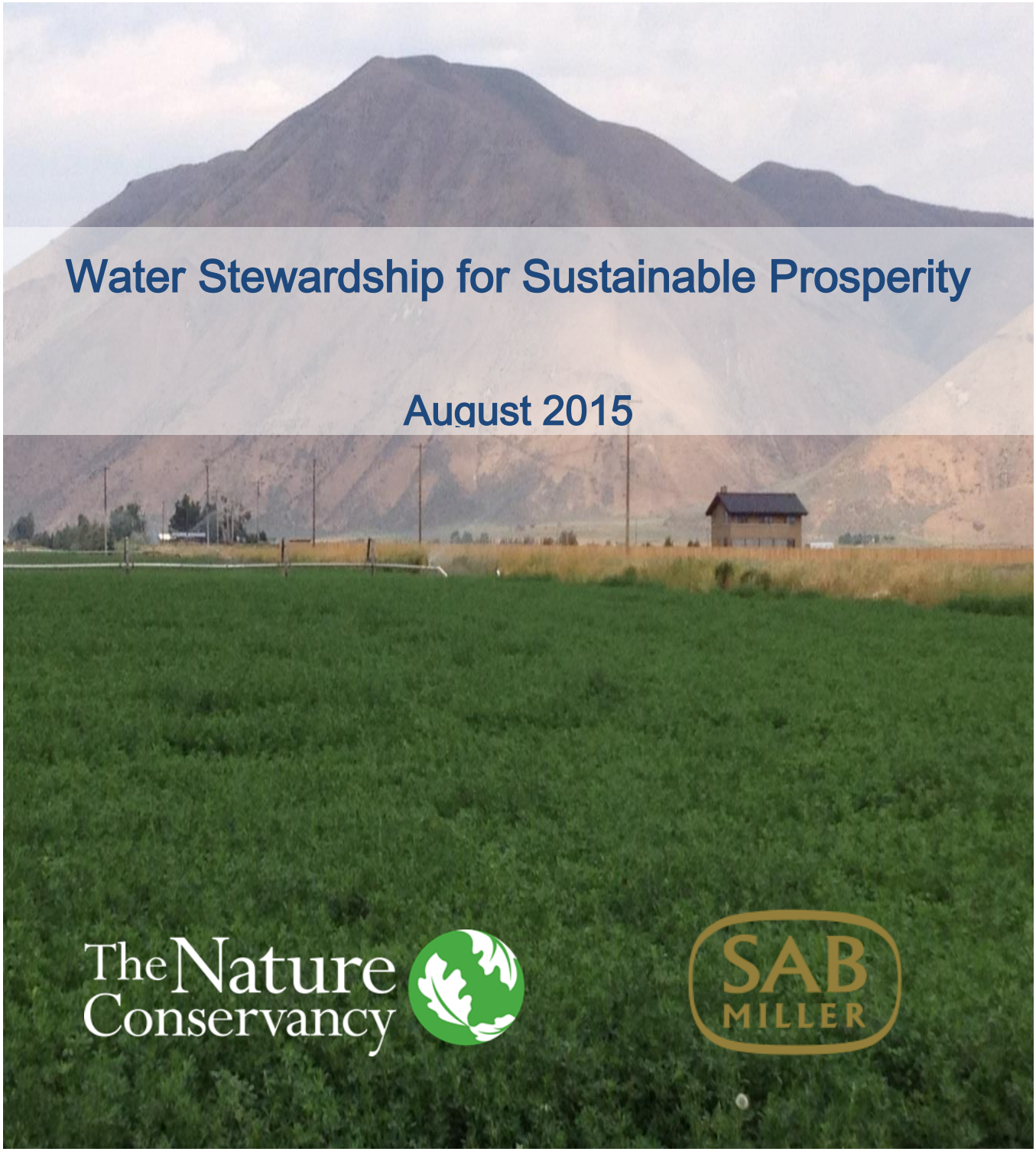

Water Stewardship for Sustainable Prosperity

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The Nature Conservancy

SAB MILLER

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Executive Summary

Water has always been a critical element for human survival and development — from its central role in basic human health, to nourishing the food we eat to powering communities and providing pathways for transportation. Despite its value to human prosperity, water is often under-valued and therefore taken for granted. As a result, in many places we find ourselves facing immense challenges around water depletion and water quality degradation, which has detrimental impacts on health, well-being and the economy. However, by understanding the value of water and its role in our society and economy, we can begin to develop strategies to serve the full range of water demands and support sustainable water systems.

This paper explores the connections between water and economic, social and environmental prosperity and introduces a suite of water stewardship actions that aim to optimize for these outcomes. It demonstrates why it is so critical to invest in the ecosystems, policies and actions that support healthy water systems, bring attention to the true value of water and meet the most critical water demands in an efficient manner. This will require protection and restoration of water source areas, water use limits and allocation systems that promote efficiency and reserve water for healthy communities and ecosystems, setting and enforcing water quality standards, and integrated management of water systems for multiple objectives. By choosing to invest in smart water stewardship policies and actions we have an opportunity to decouple water impacts from economic growth and help forge a more sustainable path of prosperity.

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Introduction

Water is critical for human life and is an essential input to almost all human activities. However critical a resource water may be, water is often undervalued. Probably the clearest indication of such undervaluation is the way water tends to be priced. In many instances water is an open access resource that is available for free even in very arid places and the (implicit) price that is charged for water does not reflect its scarcity. Because of this undervaluation, water is often used in wasteful ways and societies fail to safeguard their waterways and watersheds for future generations in spite of population growth or increased economic activity. Land use development in water supply basins routinely goes unchecked even as the demand for water increases. This has resulted in the degradation of water quality, water quantity depletion in dozens of basins around the world, and greater than 70% decline in aquatic biodiversity over the last 30 years[1]. The impacts of these changes can be severe for people and economies.

This report explores the connections between water and prosperity — including economics, health and well-being, and environmental resiliency. We place water stewardship in the context of water use and water stress in countries' and communities' evolving economies and societies. We emphasize the extraordinary challenge of water security, especially for less advanced economies and communities with growing populations that tend to be more exposed, or lack the means to adapt, to water stress. We acknowledge the need for limits on overall water use especially in water-stressed river basins and countries, as well as the ambition to achieve conservation objectives in a world that seeks to use increasingly scarce water resources more efficiently.

Our aim is to provide a broad, conceptual framework and strategy for water stewardship that goes beyond risk mitigation, is more forward-looking and geared towards creating sustainable prosperity that can be consistent with economic growth. We hope to provide a common background that contextualizes and motivates the many individual water stewardship actions by NGOs, firms, governmental organizations and individuals. We intend this exploration to serve as a starting point for a broader discussion as well as a stimulus for reviewing the connections between water and prosperity, and supporting future efforts to further describe and demonstrate the relevance of this framework for redefining our collective water future.

Defining Prosperity

The concept of prosperity provides important contextual value for discussions regarding societal well-being at large. A focus on prosperity allows for a comprehensive view that spans the full spectrum of water outcomes — from the divergent implications for individuals and households to the cumulative impacts for whole communities and societies. Prosperity captures the full complementarity of water-related beneficial outcomes across time, geographic space, and social hierarchies. We consciously define prosperity in a multi-faceted way since standard indicators of people's and countries' standard of living fail to capture all dimensions of their economic and social well- being and of the integrity of their

[1] WWF (2014)

environment. The advantage of our multifaceted approach that goes beyond one metric is breadth and nuance. The admitted challenge is that comparing prosperity over time or across locations is more cumbersome as it invariably depends on the weight or value one places on certain indicators compared to others. By way of example, it requires us not just to look at improvements in per capita GDP in isolation, but rather, in a world that is geared towards economic growth, to consider what makes economic growth possible without the depletion or degradation of water resources.

> *Prosperity* is that societal condition which supports the full potential of individuals and communities, as characterized by various indicators ranging from measures of standards of living and economic performance to measures of social well-being, and of environmental security and resiliency.

Building from frameworks for sustainable development and socially responsible accounting — including work by UN-HABITAT[2] and under the post-2015 Agenda 21 sustainable development goals (SDGs)[3] — this report focuses on three key elements of prosperity as they pertain to water: economic performance and in particular water productivity, social well-being , and environmental security and resiliency. These elements of prosperity are further defined in Box 1 below.

Box 1. Defining the elements of prosperity

> *Economic prosperity* — the capacity for an individual, company, or society to improve its economic performance and/or standards of living, with particular focus us on countries' economic performance including their overall productivity and in particular their water productivity as well as income equality.
>
> *Social well-being* — the sufficiency of water services for supporting the health and welfare of all individuals, including the provision of safe drinking water, food security, and cultural integrity, among others.
>
> *Environmental integrity*— the ability of the environment to maintain biophysical functions or services that support resiliency and security under changing climate and social conditions.

The definitions put forth here do not obviate alternative interpretations of prosperity. The proposed definitions primarily facilitate the identification and communication of patterns and causal linkages between water resource decision-making and economic and social outcomes. While different thematic groupings could be proposed, this would not alter the primary objective of this paper: elucidating the multitude of connections between water resources and our collective prosperity.

[2] Within the context of urban development, the UN has defined prosperity as comprising aspects of productivity, quality of life, infrastructure development, environmental sustainability, and equity and social inclusion. UN-HABITAT (2012).
[3] UN (2014)

Table 1 provides additional context for the elements of prosperity that will be explored within this white paper. Underlying all three elements of prosperity is a central role for sustainability — and in the case of water in particular, a foundational role for water stewardship. We propose a view of prosperity that identifies water stewardship not as a goal, but as an essential determinant of thriving societies.

Elements of prosperity	Connections to water
Economic prosperity	GDP (Gross Domestic Product) and Per capita GDP Water productivity Economic structure: - Agricultural production - Manufacturing production - Service production Energy generation
Social wellbeing	Health and well-being Education Food security Gender equality Cultural integrity
Environmental integrity	Biodiversity conservation Green infrastructure Future resiliency

Table 1. Elements of prosperity and the connections to water examined in this report

Economic Prosperity

A complex interaction

Characterizing the interactions between water and economic activity is critical to lay the ground for the development of effective water stewardship that can lead to higher prosperity. At the same time, the relationship between economic activity and water is extremely complex, in large part because of the myriad of roles that water plays in the economy.[4]

Water is an input to production, a cooling agent, a transportation mechanism, an energy producer and a tourism attraction. Figure 1 is a simple visualization of some of the sectors that depend directly on water quantity and water quality, and those that impact water quantity and quality. Many both depend on and impact our water resources. For example, water for household use both depends on the quantity of high-quality water available and can have an impact on these factors for other uses.

[4] Hanemann (2006)

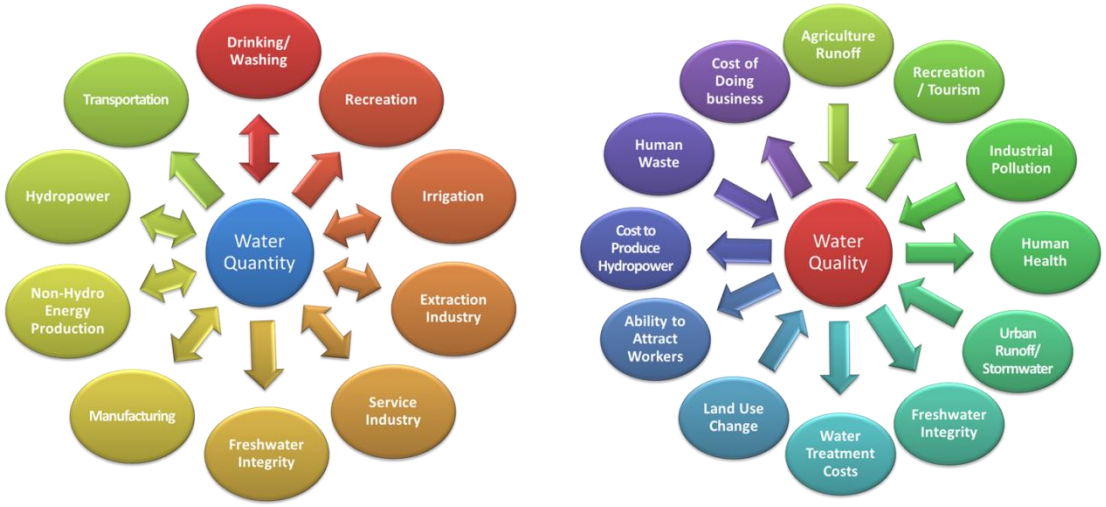

Figure 1. Examples of relationships of water in the economy

To emphasize the vital role of water in a country's economy, water is often referred to as an essential component in an economy's water-food-energy nexus[5]. The nexus that ties food production, energy generation and water supply is the lifeline of any economy. Without water there is no food, no water for production and no energy to power an economy, which is why the nexus is intimately linked to food, water and energy security. Positioning water as part of the nexus is very much in line with what many national water use statistics reveal. They identify three very water-intensive sectors that are responsible for virtually all water use: the energy/electricity-generating industry, agriculture and the water industry itself. A huge volume of water is needed for energy extraction, refining, transportation, generation and cooling. The water industry also requires a lot of energy for water supply, distribution and treatment.[6] And food production requires both water and energy to be successful. Irrigation in particular accounts for 70% of global water withdrawals.[7] Moreover, agriculture also produces energy via crops such as corn and soy used for ethanol and biodiesel.

To understand the interaction between water and the economy more fully, however, it is advisable to go beyond the water-food-energy nexus, especially since the key nexus sectors tend to be small in economic terms. Focusing on agriculture plus water and energy supply fails to connect water use to the changing economic structure of countries and ignores the majority of the sectors that generate the bulk of countries' income. In most countries, for example, the very water-intensive water supply and electricity generation sectors account for just a few percent point GDP. Add to this the relatively small agricultural sector of the United States, Europe or Japan and the three sectors amount to barely 5 percent of GDP in advanced economies. Even for emerging economies such as India or China with agriculture that is respectively 17 % and 9 % of GDP, a focus on agriculture, energy and water sectors leaves out three quarters of the income generation sectors.[8] In the first subsection below, therefore, we

[5] FAO (2014)
[6] US Dept of Energy (2006)
[7] UN Water (2015)
[8] Data from The World Bank: http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS

explicitly tie water availability and use to measures of economic performance such as GDP, per capita GDP and the sectoral composition of an economy and we study how these evolve over time. Such an approach ensures a better understanding of how the unpredictability of the hydrological cycle impacts advanced and less advanced economies in different ways. As is well known, climate modeling shows that water-related natural disasters such as floods and droughts could increase in frequency and intensity in some areas of the world.[9]

In a second and third subsection we link the pattern of water use to the changing economic structure of countries and communities as well as to globalization. In doing so, we more accurately assess how increased economic activity, in turn, impacts the availability and quality of water. All too often, societies' water use is not sustainable. In fact, already half of all large cities (100,000 people or more) are located in depleted water basins, [10] and 1.8 billion people are predicted to be living in with water scarcity by 2025. [11] As water *quality* degrades in some cases, it can amplify a water *quantity* problem if it becomes too dirty for specific uses. Finally, water quantity and quality changes resulting from economic activities can have severe impacts on fish populations with direct impacts on human health, livelihoods, and fishing industry revenues. In the second and third section below we focus on what it takes to decouple economic activity from actual water use, which is important from a water security and conservation standpoint. We explicitly rely here on the unique long-run water use data for the United States.

Inevitably, we face the question why water is prone to overuse and depletion. Hence we address water as an open access resource, the tragedy of the commons and ways to overcome it in subsection four. It is here also that investigate capping overall water use in a country and/or in a river basin in order to secure sufficient water for communities and the environment.

Standards of Living and water availability

While water is essential for virtually all economic activities, it is not the case that a country's economic success depends solely on its water availability. Without question, water availability is necessary for economic activity. History illustrates how people, when given a choice, tend to settle wherever water is plentiful, and avoid locations without water. Water availability is, however, not sufficient for economic prosperity.

Figure 2 demonstrates the lack of an obvious relationship between water availability and a country's per capita GDP. It is not the case that limited water availability per person implies a country's poverty, or, conversely, that poor countries tend to be water poor. Very water-scarce countries such as Singapore or Saudi Arabia and other oil-exporting countries are well-off in terms of per capita GDP[12]. Alternatively, the developing nations Tanzania, Niger or Madagascar with a per capita GDP that is 10 to 20 times lower

[9] IPCC (2012)
[10] Richter et al. (2013)
[11] UN (2015)
[12] To be explicit, the water challenges that very arid Saudi Arabia faces are very different from the ways in which Singapore struggles to capture and store sufficient water.

than that of Singapore or Saudi Arabia have between 20 to 100 times more water. One may wonder why there is no obvious relationship between a country's per capita GDP and its water availability.

However critical water is for economic activity, the main drivers of economic growth, and therefore of a country's standard of living, tend to be of a different nature. Human capital accumulation that characterizes a skilled labor force, technological innovation and research and development (R&D) that enhances countries' overall productivity, and access to machines and equipment are the primary drivers of economic growth and the guarantors of higher standards of living, not water.[13] It is, therefore, not surprising that the significant economic hardship associated with the California drought, estimated for this year in the order of 3 billion dollars is relatively small in the context of the large annual 2 trillion dollar high-tech California economy.

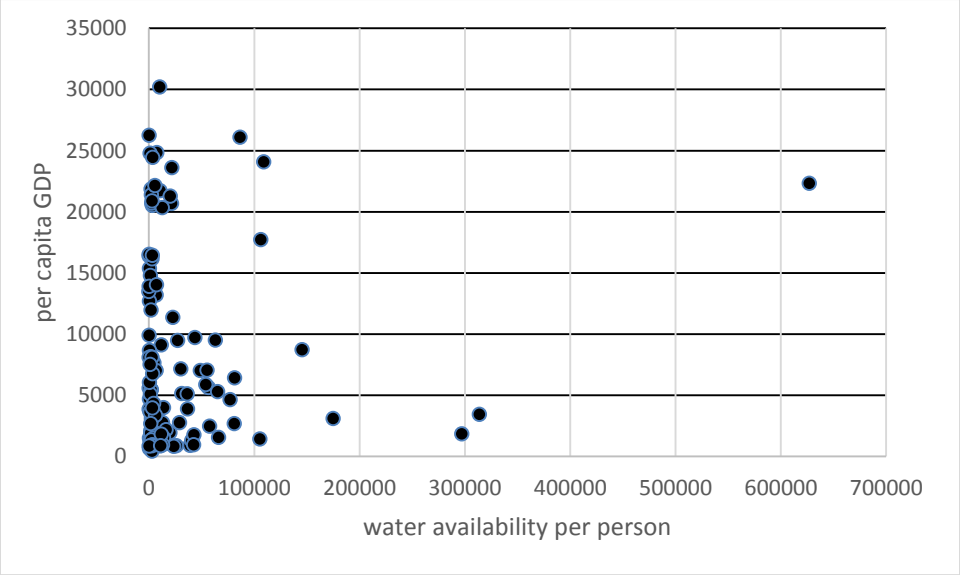

Figure 2. Per Capita GDP ($) vs. Water availability (m^3) per person

Note that water's limited role in generating per capita GDP does not prove its irrelevance for economic prosperity. For one, it implies that water availability does not affect economic performance in a uniform way: Some countries tend to be more exposed and vulnerable to adverse weather/water events than others. Recent research has pointed out how the variability in water availability across space and time and especially the frequency of extreme weather events have a statistically significant negative impact on economic growth. While this impact is on average relatively small, floods and droughts tend to affect less advanced economies more severely (see Miguel et al (2004) and Brown et al (2011)).[14] Similarly,

[13] In the seminal Solow growth model (Solow (1956)), there is no mention of water. As a matter of fact, very few papers explicitly incorporate water. As for the empirical literature, see OECD (2015), Brown et al. (2011, 2006) discussed below.

[14] Most studies focus on statistical significance rather than the size of the impact of extreme water events. The OECD (2015) study, points out on p. 58 that "The statistical significance of multiple hydroclimatic variables does

while advanced economies may shield themselves better from more extreme weather events than less advanced countries, behind the limited impact of adverse water events there can be pockets of more vulnerable communities. Smart water stewardship should take the very different context of developed and developing countries into account or, for that matter, consider vulnerable communities within advanced economies. Finally, and more broadly, that factors other than water play an essential role in generating economic prosperity suggest that water stewardship should have a keen eye for the interaction between water and those other drivers of economic growth. Water scarcity not only affects human health negatively, it also keeps children away from school as they are hauling water, which both interfere with building a productive labor force. Also the interaction between water and the availability of capital is key. The wealth of resources enables well-off countries to mitigate adverse effects of droughts or floods through capital-intensive investments in dams, canals, reservoirs, water treatment facilities, etc. Note that we will discuss this link between water and the other drivers of economic growth more extensively under social prosperity below.

Water Use and Economic Structure

Human capital, physical capital, R&D and land are the primary drivers of countries' economic prosperity. They also play an important role in determining the economic structure of a country and the types of goods it ends up producing. In doing so, the primary production factors influence a country's water use as well as its vulnerability to water shocks. In advanced economies the sectors that constitute the water-food-energy nexus only account for a few percent of their GDP, whereas the far less water-intensive service and manufacturing sector generate the vast majority of their GDP, and employ the vast majority of its population. While it is true that water, electricity and agricultural products are intermediate goods used in those sectors, advanced, service-oriented economies — and even predominantly manufacturing economies — will be less vulnerable to water-related events. Conversely, the more important the very water-intensive agricultural sector is, the more vulnerable a country is to water stress. The latter holds especially true for developing countries with large subsistence agriculture that employs a significant fraction of its population that typically does not have many alternative options.[15] While it is hard to make changing the economic structure a policy prescription, it is important that water stewardship explicitly takes the changing economic structure into account, and draws on the water-saving lessons embedded in structural changes. In the absence of reliable (and detailed) long-term water use data for most countries of the global economy, we exploit the unique, long-term water use data for the United States in this section to study the link with a changing economy.

U.S. water use since 1950 displays a remarkable pattern. Rapid economic growth between 1950 and 1980 doubled water use. However, between 1980 and 2010, water withdrawals stagnated and even decreased by 19 percent in spite of GDP more than doubling. In sum, U.S. water use since 1980 illustrates that

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not imply that economic growth is solely determined by water, and water-related hazards. The magnitude of the effect on economic growth across the dataset is small, because there are many factors that affect economic growth. By way of example, on p. 57, "On average, a major drought (affecting 50 % or more of a country's area) was found to reduce economic growth as measured by per capita GDP by half a percentage point in that year.

[15] Nobel laureate Thomas Schelling early on made a comparable assessment w.r.t. the vulnerability of advanced vs. less advanced countries to climate change, see Schelling (1992).

countries have the ability to decouple their economic growth from water use. The dramatic increases in water productivity in the United States allowed the country to generate more GDP with less water and break the link between water use and economic activity. For the United States, about 50 to 65 % of the water productivity improvements can be explained by innovative technology and better operations and policies. The remaining 35 to 50 % comes from the changing structure of the U.S. economy, away from water-intensive sectors such as agriculture toward far less water-intensive sectors such as services and manufacturing. Interesting to note is that Debaere and Kurzendoerfer (2014) point out that water efficiency gains in electricity generation in the wake of the Clean Water Act are associated with the majority of the productivity gains attributed to technology.

The U.S. water use trajectory follows a familiar pattern observed in many advanced and emerging economies around the world for other phenomena such as pollution.[16] Initially, pollution increases as countries develop. However, as their per capita GDP increases, they reach an inflection point where pollution starts declining. Applied to water, a changing economic structure that moves away from water-intensive agriculture to less-water intensive services and/or manufacturing can together with technological improvements slowdown and decrease water use. This observation is all the more important in light of a worldwide declining share of agriculture as a share of world GDP, and the steady increase of services.

In step with improving conditions of material well-being, the call for economic development that has a more limited impact on the environment may also become louder. We see this in countries such as China and India, where governments also have the means to invest in natural resources. Needless to say, this shift is also informed by growing levels of local (water) pollution. The U.S. experience illustrates this point once more. Control of point source pollution has improved the water quality of lakes and rivers that before 1972 were so polluted from industrial and wastewater discharge that one river, the Cuyahoga River, actually set on fire[17]. The Clean Water Act required every discharge point to obtain a permit and to track their effluent to ensure it met established water quality standards. [18] However, the U.S. and all countries around the world still struggle with the harder to track and regulate nonpoint source pollution.

Finally, the U.S. experience may be relevant for water stewardship in still another way. While the current water crisis in California may well indicate that water is still over allocated, the remarkable pattern of U.S. water use does illustrate how a major economy can decouple its water use from GDP growth. The latter sheds light on the feasibility of Australia's initiative to explicitly cap overall water use and underscores that limiting water use can be reconciled with solid growth. Indeed, in the wake of a decade of severe drought ("the Big Dry"), Australia has imposed a cap on the water use in its economic heartland, the Murray-Darling basin.[19] By constraining water use, Australia guarantees sufficient water for the environment. At the same time, it has taken measures that should facilitate the transfer of water between different sectors of the economy. Some of these measures relate to water markets that let farmers, cities,

[16] This refers to the Environmental Kuznets Curve (EKC). There is a large literature documenting the presence or absence of EKCs, detracting, to some extent, from the more important question as to what their drivers are.
[17] American Rivers (2015)
[18] U.S. EPA (2015)
[19] Herberger (2011)

corporations and individuals trade the right to use water at a market price. Later in the report we discuss capping water use more in depth, since it, combined with ways of transferring water between sectors, is likely to be an integral tool of water conservation and stewardship in the future.

Globalization and virtual water trade

In today's global economy about one quarter of the world's GDP is traded. From the point of view of domestic water use and stress, this international environment is both a challenge and an opportunity. The ability to trade for one, can insure a country against domestic water stress. Water-scarce countries, one might hypothesize, should be able to limit domestic water use by imports of water-intensive goods such as foodstuffs. Conversely, a relatively water-abundant country could do the opposite and export such goods. In other words, through their imports and exports of goods, countries could trade "virtual water.[20]"

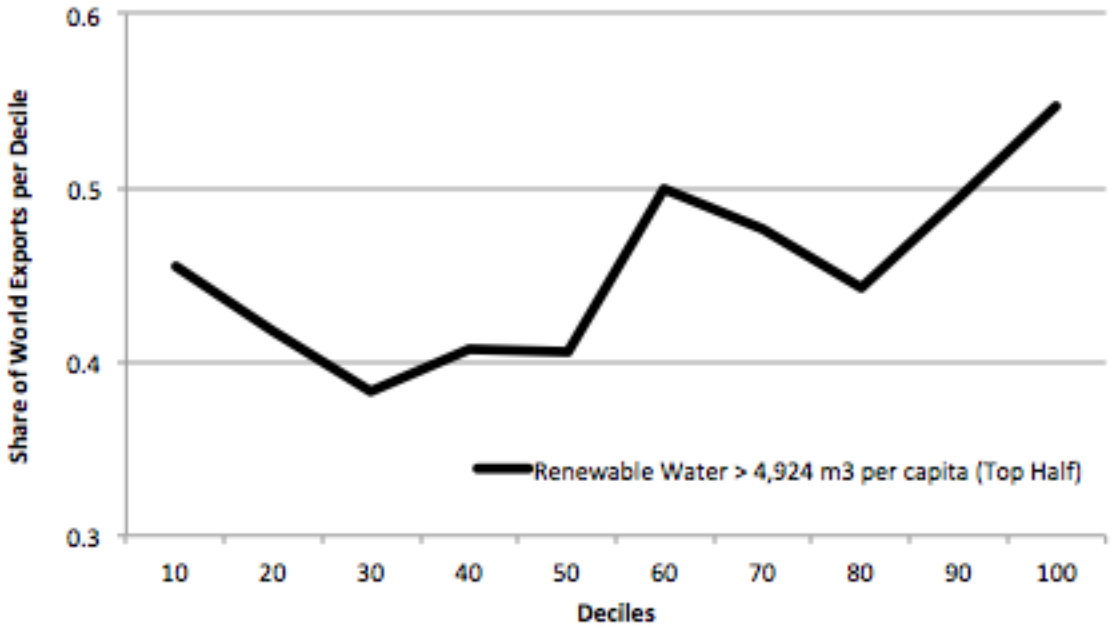

Figure 3. Share of Most Water-Abundant Exporters in World Export to US vs. Decile of Water Intensity
Notes: Products are split into deciles of green and blue water intensity. The share of world exports is calculated by dividing the exports of the most water-abundant countries (half the countries in the sample have more than 4,924m^3 per capita renewable water resources) by total world exports in each decile. *Source:* Using BHV (2010) data.[21]

There exist significant differences in the relative scarcity of water across countries and those differences partially explain why countries produce different types of goods. Figure 3, for example, indicates that countries with relatively more water per person tend to produce and export goods that are more water intensive – the x axis gives deciles of increasing water intensity. The slightly upward sloping line illustrates that more water-abundant countries of the world export increasingly more water-intensive goods to the

[20] Debaere (2014a)

[21] Ibid.

United States compared to relatively water scarce countries. Note, however, that the relationship between water availability and the type of products that countries produce is rather weak. There are two explanations for why this is the case:

- As described previously, factors other than water have a significant impact on the development of specific sectors. More advanced economies with an abundance of skilled labor and capital will tend to produce goods and services that by their very nature are less water intensive. Here again, the more limited role of water does not prove water's irrelevance. To the contrary, for specific countries, in particular those that export agricultural products, less available water resources can have non-negligible effects. Hence, a water conservation strategy should be in tune with a world economy in which the international division of labor and trade can alleviate local water stress.

- The very special nature of water and the persistent undervaluation of water.[22] The price of water tends to be highly distorted, not reflecting its true cost and relative scarcity. The latter makes it possible that countries with limited water resources export water-intensive products and crops, while depleting their aquifers. The most telling example in this context is arid Saudi Arabia that was in the early 1990s was a net exporter of wheat.[23] Such misallocation of water use highlights the importance of proper water pricing. As we will argue below, the explicit recognition of a cap on water use that leaves enough water for the environment is important to guide water stewardship. To be explicit, by imposing an explicit water supply restriction, the (implicit) price of water will rise and water-intensive activities in arid areas will become uncompetitive.

The observation that water is mispriced, however, gives way to a broader issue: why is water amenable to mispricing and why is it prone to being an undervalued resource? In the next section we address this question which relates to the tragedy of the commons. A sound understanding of the specific nature of water as an open access resource should be a guide for water conservation and management.

Pricing Water and Tragedy of the Commons

Water in lakes, rivers and aquifers tends to be an open-access resource that is freely available for everyone to use. Because of this free access, water tends to be over-used and aquifers or other water reservoirs can become depleted. Indeed, with unlimited access and no price to pay, nobody has an incentive to save water or to consider its future availability. This is the well-known tragedy of the commons that applies to water in the same way that it does to overfishing the oceans of the world.[24]

There are different ways to address the tragedy of the commons and its implied overuse. It is here that adequate water stewardship can play an essential role. One can, for example, reduce access to the water source, by, as we discuss in the water stewardship section, putting a cap on how much water can be

[22] Ibid.
[23] Debaere (2014b)
[24] Hardin (1968) and Gordon (1954).

withdrawn for commercial, agricultural and residential purposes. Limiting the amount of water that can be withdrawn will safeguard enough water for the environment and by limiting water supply raise the (implicit) price of water. One way to restrict water access is to have a public or private entity limit access. An alternative one that is receiving more and more attention is to define and distribute individual water use rights, and to let them be traded in water markets independent of the land titles.[25] Examples of such water markets can be found in Chile, Australia, the United States, Spain etc. [26] It is critical that ways are found to price water properly even if there is no actual water trading taking place and that water stewardship interventions are aware of which water reallocations are efficient and which ones are not.

Even more significant, a proper price of water will not only improve the efficiency of water use. At the same time, adequately pricing water will make it worthwhile for all water users to save water, to invest in water-saving devices, or to consider using alternative water sources of water that may come at significant capital expense such as desalination or water treatment and recycling. Moreover, a proper price of water will guarantee a return on investment that should stimulate innovation in water-saving technologies, which in turn will make water conservation easier and help decouple water use from economic growth. Where water is available for free, there is no incentive to save it. The comparison of irrigation technology implementation in India and Israel is a case in point. Because water is available for free in India, farmers have been willing to adopt water saving technology only when subsidized; this is a stark contrast to Israel, a water scarce nation that takes into account every drop of water used and leads the world not only in water recycling and use of alternative water resources as well as in irrigation innovation. [27]

Needless to say, since water is essential for life, pricing water raises questions of fairness that can be addressed through a variety of solutions. One option is to follow the Singapore supply model that, on the one hand, prices water at marginal costs, so that the price of water rises with the additional expense needed for every additional unit of water used. Singapore, on the other hand, offers its less-affluent citizens an account for water expenses up to a certain limit. More generally, one could provide each citizen with a low-price water allotment for essentials and charge an increasingly higher price for quantities in excess of this allotment. Unfortunately, too often, water is provided for a fixed fee (independent of the quantity of water used), or at water tariffs that either remain constant or even decrease per unit of water used. [28]

[25] Dinar et al. (2005), Debaere et al. (2014)

[26] Water markets in India, however, typically arise due to technical indivisibilities (in pumping investments) and the need to cope with power shortages, see Saleth (1998).

[27] Debaere and Elias (2014)

[28] In 2012, 18% of U.S. residential water rate structures are still decreasing, which is down from 35% in 2000. Thirty percent are linear, and 52% are increasing. See AWWA (2013).

Social Well-Being

As defined previously, *social prosperity* entails the well-being and livelihoods of individuals and communities. We consider several measures of social prosperity here, since economic measures such a per capita GDP only capture a country- or region-wide average that may insufficiently describe inequalities in outcomes. The connections to and dependencies on water are several — here we explore a subset of those with significant relevancy for social well-being. Note that many of the issues discussed here will also have a direct impact on individuals' and countries' economic outcomes. As noted before, water-related health and educational deficiencies that prevail especially in less advanced countries or in disadvantaged pockets within advanced economies have an immediate impact on countries', regions', and individuals' productivity, and their economic prosperity.

Health and well-being

Some of the most direct and significant linkages between water and prosperity relate to the provision of water for public health needs. Since providing for adequate water infrastructure requires significant capital expenditures, lacking water infrastructure and the adverse health outcomes associated with this deficiency, tend to be a problem especially in less-advanced countries. Consequently, we should not be surprised that less-advanced countries will be more exposed to the adverse impacts of extreme weather events as mentioned in the economic prosperity section.

One of the successful outcomes of the Millennium Development Goals is that between 1990 and 2010 over two billion people gained access to improved drinking water sources. However three-quarters of a billion people still lack adequate access to safe drinking sources.[29] Even more critical, a further 2.5 billion people — half of the global population of the developing world[30] — lack access to safe sanitation. These social development inequities result in stark measures of the extent of shortfalls in prosperity: nearly 2.4 million deaths annually are attributable to water-related deficiencies in water, sanitation and hygiene access, with most of this burden borne by children (Figure 4).[31] .[32] Low-income countries — such as Cambodia and Uganda — are particularly susceptible to the impacts of waterborne illness where diarrheal disease is the third leading cause of death for all persons.[33]

[29] USAID (2013)
[30] WHO (2015)
[31] Batram and Cairncross (2010)
[32] Ibid.
[33] WHO (2012)

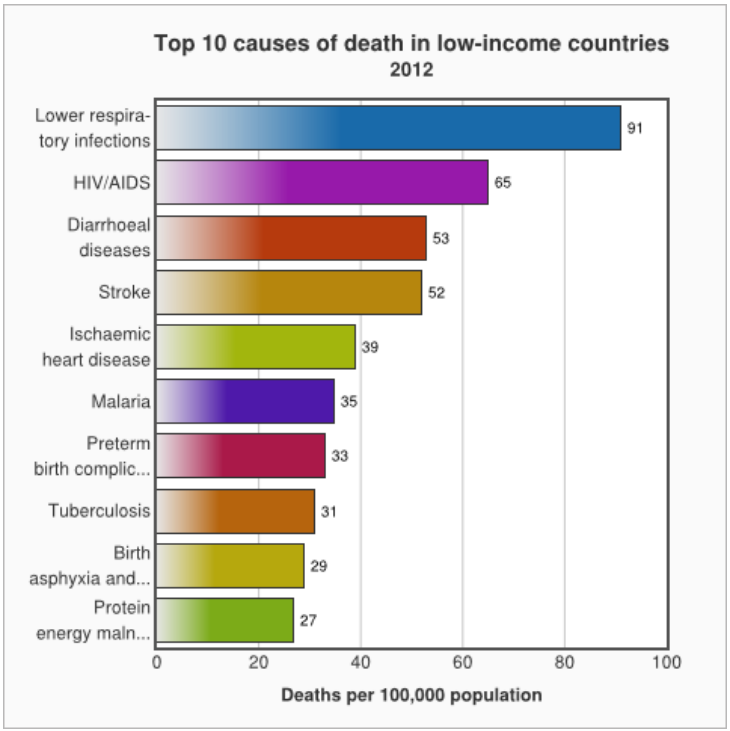

Figure 4. Water and sanitation related diarrheal disease is the third leading cause of death in low income countries. Addressing inadequate water, sanitation and hygiene could reduce the global disease burden by nearly 10%. Figure from WHO (2012).

Water is critical not only for the immediate health outcomes of individuals but has major significance for societies and economies. Beyond mortality, water-related illnesses could account for nearly 6% of the global disease burden.[34] This disease burden can translate into both household and national level poverty impacts.[35] At the household level, there are significant costs associated with treating water-related illnesses. Cumulative, longer-term impacts are also possible with reduced life expectancies and lost income. At the national and local level, water-related illness can adversely affect current and future labor productivity —through lost working hours, and through lowered school performance[36]. A global assessment by WHO estimated the global economic benefits of providing of safe water and sanitation for all persons at 263 billion USD annually (benefit-to-cost ratio of 7.5)[37]. Africa alone could benefit some 22 billion USD annually by halving the proportion of people without improved water and sanitation (see Figure 5).

[34] Ibid.
[35] Hussain et al. (2002)
[36] Maliki et al. (2009)
[37] SIWI (2004)

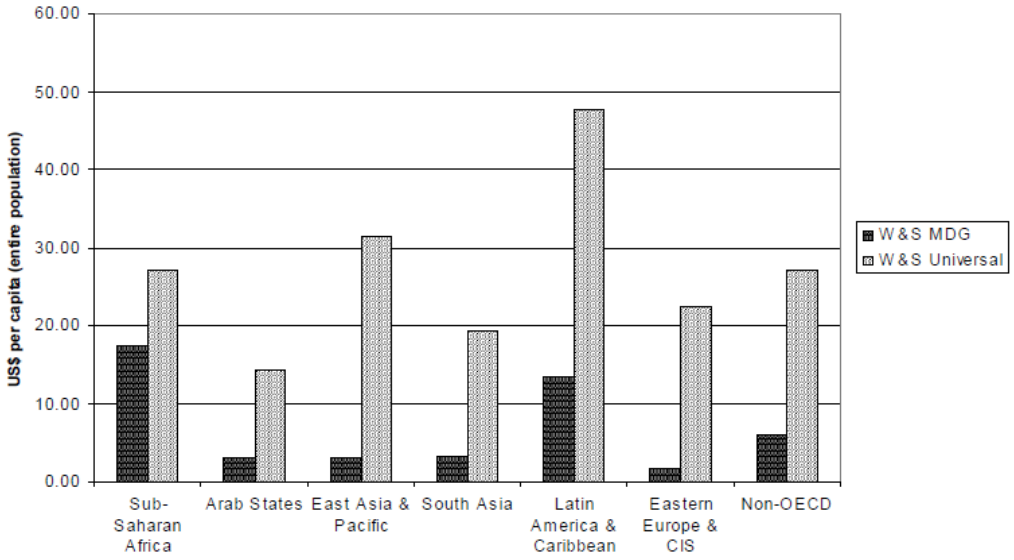

Figure 5. Estimated per capita annual economic benefits of low-cost improved water and sanitation under two coverage scenarios (Millennium Development Goal (MDG) attainment and universal coverage). Figure from WHO (2007).[38]

There is overwhelming evidence that water is vital to health and sanitation.[39] Further, as illustrated by the global disease burden and its impact on households and countries, the failure to achieve universal access to safe drinking water and sanitation is of global detriment. In the absence of stewardship that supports water for health and sanitation, there will remain huge shortfalls in our ability to achieve global prosperity.

Food security

Connected to the water-related elements of food production discussed previously, water has related implications for the food security of households and individuals. Here again, these security issues are most pronounced in less-advanced economies. For one, those countries experience higher population growth and increased food consumption, and ensuing water scarcity. In addition, they often lack the means for capital-intensive investments to mitigate water scarcity.

One reason for this disparity is that household in developing countries spend a far larger fraction of their income on food than their counterparts in advanced economies. Because of this, they will be particularly vulnerable to the fluctuations in food availability and access to water.[40, 41] Where food prices increase, households face potential malnutrition and increased poverty.[42] For example, in 2012 during extended droughts in the US and Europe, global food prices for maize and soybean were significantly impacted,

[38] WHO (2007)
[39] Fewtrell et al. (2005)
[40] Rosegrant et al. (2009)
[41] FAO (2008)
[42] CGAAER (2012)

with important implications for those households already living at the economic margins.[43] Such food insecurity has further implications for social and economic elements of prosperity — driving further health impacts and decreasing economic growth.

In developing countries, subsistence agriculture and fishing can comprise a significant proportion of food production. By their very nature, these tend to be low-productivity undertakings, and people active in those sectors have few alternative modes of employment. A failure of adequate water provision or degradation of water quality can directly impact households active in and dependent on subsistence agriculture and fishing.[44] For example, a more narrow approach in the Mekong basin that focuses only on energy production or off-stream uses could have devastating consequences for the estimated 60 million people from local communities dependent upon fish consumption.[45]

There is an important opportunity for water stewardship to support food security and the many related elements of social, economic, and environmental prosperity. At the same time, subsistence agriculture and low levels of economic development persists for many reasons beyond water availability. Therefore, successful water stewardship has to be an integral part of a development strategy that is informed about the particular circumstances of the agricultural sector. [46] Because of food security concerns (and lobbying), agriculture is traditionally one of the most heavily subsidized and regulated sectors. It most often has significant import restrictions in terms of high tariffs and import quotas. As a matter of fact, until recently, agriculture was entirely excluded from all multinational trade liberalization talks since WW II that take place under the auspices of the GATT and the WTO.[47]

Education

Related to prosperity in health and well-being, the provision of improved water supply and sanitation has direct effects on education outcomes, particularly in developing countries. School attendance can be adversely impacted by insufficient water supply or sanitation — either through illness-related impacts or the physical and time burden of transporting water which often falls to children. As a result, clean water availability both at home and in schools is associated with improved school attendance (see Figure 6).[48] As illustrated in the figure below, the global burden of school absenteeism due to water-related diarrheal disease is immense.

[43] World Bank (2012)
[44] SIWI (2004)
[45] Ibid.
[46] Ibid.
[47] Debaere et al. (2015)
[48] UNICEF (2010)

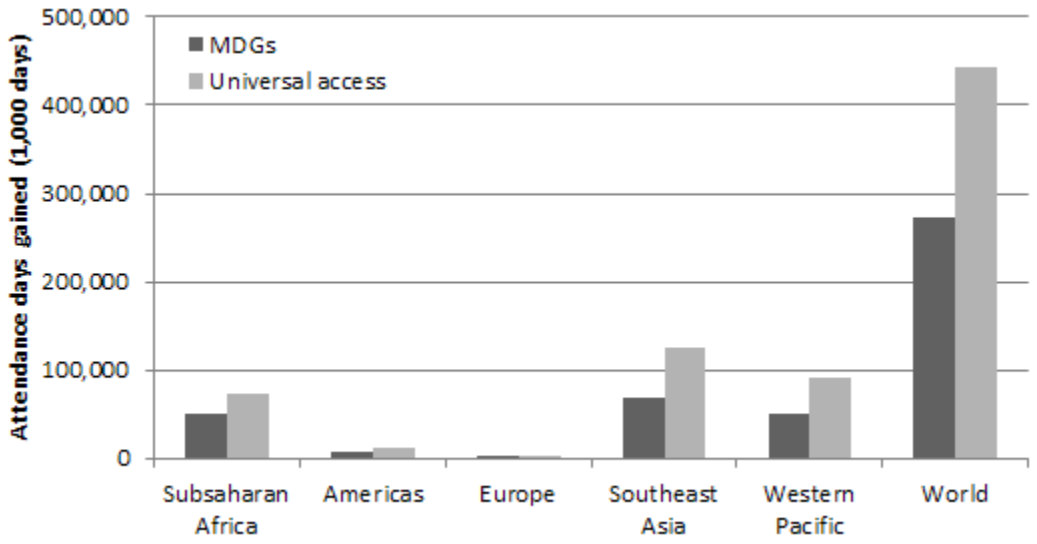

Figure 6. Estimated gain in school attendance days due to avoided diarrheal disease resulting from improved water and sanitation under two coverage scenarios (Millennium Development Goal (MDG) attainment and universal coverage). Data for sampled sub-regional areas, from Tropp and Bertrell, 2004.

Even given school attendance, children may experience reduced learning potential due to water-related illness. There are both potential short and long-term consequences for school performance that can result from exposure to water-related pathogens.[49]

Given the important role of education for social well-being, approaches to water stewardship should incorporate school performance objectives. Human capital accumulation through learning is an essential driver of economic growth.

Gender equality

That water is multifaceted and diversely connected to prosperity is well exemplified by connections to gender equality. Women and girls in developing countries are the primary water stewards at the household level — in nearly two-thirds of households in these countries, women and girls are responsible for water collection.[50] The contributions of women and girls to water provision have important consequences for their prosperity. The time burden of traveling long distances to collect water has very significant opportunity costs as it results in decreased school attendance and fewer work opportunities.

[49] Lorntz et al. (2006)
[50] UNICEF (2015)

This inequality is further exacerbated by the disproportionate impacts of poor sanitation access for women and girls.[51, 52, 53] With connections to education, health and well-being, a lack of sufficient sanitation can not only negatively impact female school attendance, but also impair healthcare and hygiene, and threaten personal security.

There is further evidence of other important connections between water and gender equity. Women also comprise a significant proportion of farmers in developing countries (around 40% globally, and up to 80% in some countries).[54] Without commensurate access to financing and agronomic support — particularly the support for access to irrigation water — women farmers face food insecurity and decreased productivity.

Without a comprehensive view of these water connections, efforts towards water stewardship can fail to address this important component of social prosperity. Even where other water challenges are adequately addressed through sustainable water management, gender inequality can still result in adverse outcomes. Within this space, there is both an opportunity to support greater prosperity, and great potential to leverage the significant capacity and knowledge of women for more sustainable water management.

Cultural integrity

While difficult to distill into economic terms, water has significant value beyond direct consumptive use.[55] Within the framework of "ecosystem services", there are several such categories of cultural value, including landscape aesthetics, cultural heritage, recreation, and spiritual and religious significance.[56]

Both within urban and rural geographies, lakes, streams and other water bodies can constitute an important component of well-being, place and cultural identity.[57] The importance of the aesthetics of water has a rich history across the world and cultures, from ancient Egypt to modern day cities.[58] Recent efforts to uncover and restore previously paved-over urban waterways illustrate the importance of "cultural and ecological corridors, [for] creating a cultural rejuvenation."[59] While the context of aesthetic and recreation significance varies significantly, a common theme is the importance of having access — whether perceptive or physical — to water of sufficient quantity and quality.

Relatedly, water-dependent recreation is also important for cultural heritage and social well-being, and recreationists have a strong interest in maintaining water availability and minimizing pollution. Swimming, boating, fishing, and other recreation activities can provide important cultural and economic

[51] Ibid.
[52] UN Water (2015)
[53] UN Water (2006)
[54] FAO (2012)
[55] Daily (1997)
[56] Daniel et al. (2012)
[57] Ibid.
[58] UNESCO-IHP (2011)
[59] Ibid.

benefits.[60] While these benefits vary globally, and it can be difficult to estimate the perceived size of the benefits, in many locations they can be significant. For example, in the United States, research has found that, in monetary terms, a given volume of water can sometimes provide even greater recreation benefits than an equivalent volume for irrigation use.[61]

In many places across the world, water also has important religious and spiritual value. For many indigenous cultures, water has great spiritual significance in all its physical forms (lakes, rivers, rain, snow), forming an important component of both spirituality as a practice and the spiritual world as a place.[62] In India, the management of dams and water pollution has led to a "reduction in the quality and quantity of the water available for public use" including Hindu ritual practices.[63] For indigenous peoples of the Northwest Coast of North America, waterways are critical not only for the maintenance of important fisheries, but also define many aspects of cultural identity. Such cultural water "uses" have significant dependency on sustaining healthy freshwater systems.

While it can be difficult to translate these benefits into quantitative terms, there is substantial qualitative evidence and narrative to illustrate the importance of water for maintaining cultural integrity. These "non-use" connections to water shed light on the need for water stewardship to adopt an integrative approach.

Environmental Security and Resiliency

As defined previously, environmental prosperity is concerned with the ability of the environment to support healthy, resilient natural systems. The following sections examine the water-related elements of environmental prosperity, illustrating the key role for water stewardship that supports the environment.

Biodiversity conservation

Biodiversity connotes the variety of species and ecosystems within a given place.[64] This ecological diversity represents both direct and indirect benefits for individuals and societies.[65, 66, 67] Direct benefits of species diversity include the harvest of plants and animals for consumptive human uses or scientific research; indirect benefits could include a variety of benefits such as carbon sequestration, cultural use, and, importantly, maintaining the possibility of future benefits.

These biodiversity benefits are comprehensively connected to water. Freshwater drives an entire suite of ecological conditions, both within aquatic environments and across landscapes. Freshwater comprises the immediate habitat for species within rivers, lakes, and wetlands, and influences a range of

[60] Daily (1997)
[61] Ibid.
[62] Groenfeldt (2003)
[63] UNESCO-IHP (2012)
[64] Convention on Biological Diversity (2015)
[65] Pearce and Moran (1994)
[66] Straver and Dudgeon (2005)
[67] Daily (1997)

environmental processes that help define the health and function of terrestrial and coastal habitats. Given the ability of humans to intervene within the hydrologic cycle, the species that depends on these freshwater processes are comprehensively connected to the stewardship of our water resources.

Within lakes and streams, fish and other aquatic species are heavily impacted by changes in both water quantity and quality.[68] The majority of the world's large rivers have already been greatly impacted by human activities. Globally, some 10,000–20,000 aquatic species are already extinct or at risk of extinction. These threats derive from several anthropogenic changes to aquatic habitat, including water withdrawals which reduce stream flows, dam construction which blocks fish passage, and numerous landscape changes that affect the timing and quality of water.[69] Further, threats to both human water security and freshwater biodiversity are closely connected in many places across the world (see Figure 7).[70] In many locations, particularly Africa and Asia, addressing the water-related threats to biodiversity would have important benefits for human well-being.

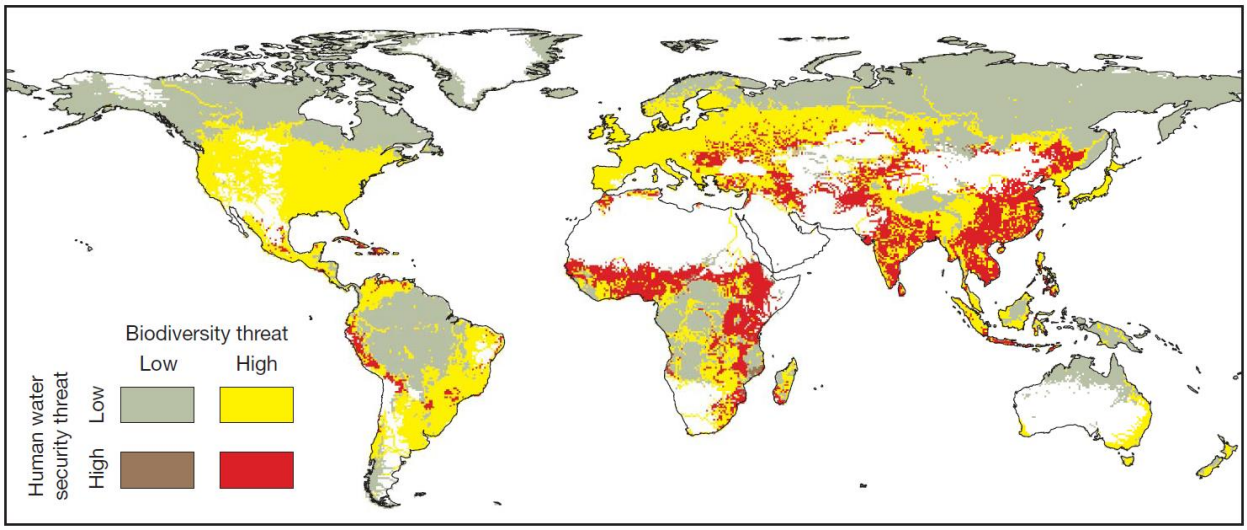

Figure 7. Estimated threat levels for both human water security and aquatic biodiversity. Figure from Vörösmarty et. al, 2010.

Besides directly supporting wildlife and ecosystems, water-related environmental processes also define habitats and species that extend beyond the confines of freshwater lakes, rivers, and wetlands.[71] Terrestrial landscapes are influenced by the management of water through changes in habitat and ecology. For example, floodplains in Pacific Northwestern United States are critically important both for migratory fish species, but also for upland plants and animals that depend vitally on the influx of nutrients and protein from migrating salmon.[72] Coastal estuaries are similarly connected to hydrological

[68] Vörösmarty et al. (2010)
[69] Anisfeld (2010)
[70] Vörösmarty et al. (2010).
[71] Ibid.
[72] Naiman et al. (2002)

and freshwater ecological processes. Near-coastal species across the world are threatened with low-oxygen conditions that result in part due to agricultural and other anthropogenic practices.[73]

The connections between water and biodiversity outcomes are extensive — the limited examples presented here illustrate the scope and magnitude of this interdependency. With potential to directly and indirectly shape both current and future prosperity, it is necessary to incorporate biodiversity within an integrative water stewardship framework.

Green infrastructure

The previous section highlighted the dependency of species diversity on water stewardship efforts. Further environmental connections to human prosperity are evident by looking at the significance of "green infrastructure." For the purposes of this report, we define green infrastructure as those elements of natural ecosystems that can support, augment, or replace the function of built infrastructure. Such green infrastructure can been found within both urban and rural geographies. Green infrastructure has particular relevance to water resources, with potential to affect the timing, quantity, and quality of water. These alterations can in turn affect a number of the other components of prosperity discussed previously, including economic and social elements. Recognizing the importance of these connections, in recent decades The Nature Conservancy and other institutions have begun to focus on identifying and describing potential green infrastructure solutions.[74]

Flooding and floodplain management well demonstrates the significance of green infrastructure. In the United States and throughout much of the developed world, flood control has typically consisted of built infrastructure: dams, reservoirs, levies, tidal gates, and other engineering technology. Much of this infrastructure is necessary in order to accommodate changes in land use development which put people at risk of flooding.[75] There are green infrastructure approaches that can mitigate the impacts of floods and at lower costs than built alternatives. This understanding has begun to inform the work of agencies tasked with managing built infrastructure. The US Army Corps of Engineers has partnered with organizations, including TNC, to understand the potential mitigation capacity and cost savings associated with a combined green/built infrastructure approach.[76]

Further upstream in the watershed, water supply is also highly dependent on green infrastructure. As land use changes, the landscape may lose the ability to filter or store water, and some practices may actually contribute additional pollutants to the system. For example, as forest is converted to agricultural land, water will flow more quickly off the landscape, while at the same time soil will erode more quickly and the application of fertilizers and pesticides can result in these chemicals running off into the water system. In this way, downstream users are connected — hydrologically and financially — to upstream activities. Demonstrating this connection between water source and supply, a recent global analysis found that one in four cities could profitably reduce water treatment costs by making

[73] Diaz (2002)
[74] TNC (2013)
[75] Anisfeld (2010)
[76] TNC (2013)

investments in these upstream areas, potentially benefitting some 350 million people.[77] Another report focused on the United States indicated that natural infrastructure compares favorably in terms of costs relative to more traditional gray infrastructure (see Figure 8). Such water stewardship opportunities — integrating the value of natural systems within water management decisions — hold great potential for supporting both rural and urban outcomes.

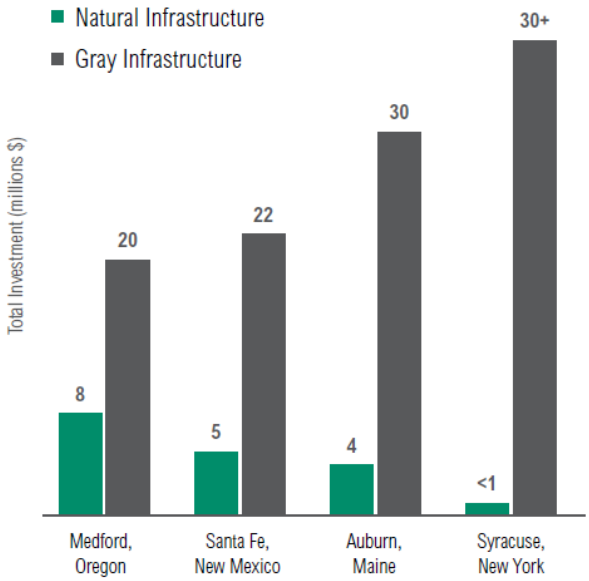

Figure 8. Comparison of green versus gray infrastructure investment scenarios for cities in the United States. Figure from World Resources Institute.[78]

The environmental services provided by natural systems are extensive and far reaching. Given the strength of these connections to water, including the capacity to support economic growth and social well-being, green infrastructure should be considered a foundational element of water stewardship. Without this recognition, efforts towards prosperity will be critically impaired.

Future resiliency

Included within the scope of environmental prosperity is a focus on future resiliency in the face of changing social and natural systems. For water, the challenges posed by increasing demand and land use development and a changing climate are particularly significant.

As the world population continues to grow in number and the intensity of resource use increases, ensuring the security and resiliency of our natural environment will become even more challenging. For example, demand-related water infrastructure investments will require some additional 800 billion US

[77] TNC (2014)
[78] World Resources Institute (2013)

dollars per year.[79] As described previously, population and demand growth will also have important implications for food security and water stewardship. Ensuring that our environmental systems can accommodate this growth while continuing to provide the benefits of green infrastructure will be key.

Similarly, the capacity to mitigate and adapt to climate-related water resource changes is relevant to environmental prosperity. In the absence of adequate carbon emissions mitigation, global changes in temperature will drive changes in precipitation and water availability in several places where water resources are already stressed.[8081] One continental study of Africa predicted that more than a quarter of all areas would experience decreases in precipitation, including many places where water is already scarce such as South Africa.[82] Changes in snowpack, rainfall, and drought frequency all threaten the capacity of communities to thrive, with connections to other elements of prosperity discussed previously.

Importantly, not all geographies face the same future challenges. Science and stakeholder-driven planning can be important tools to help mitigate adverse impacts. Water stewardship, as mechanism for ensuring integrative and forward-looking management, has a key role to play.

Water Stewardship

Understanding the connections between water and the economic, social and environmental context provides a critical base on which to develop strategies that manage water resources for a more prosperous world. All stakeholders, including governments, businesses, and individuals, can take actions that ideally should aim to decouple growth from water use, acknowledge explicitly the limit on total water use in a river basin, region or area, and optimize the value that available water generates. The following section briefly explores the concept of water stewardship and introduces a range of water policy, management and collective action efforts that help move towards a more sustainable prosperity.

Water Stewardship Defined

Water stewardship describes programs, goals, initiatives, projects or individual actions that help support the viability of water resources in a given location. The Alliance for Water Stewardship, which has garnered input from hundreds of water-related professionals from around the world, defines water stewardship as "*The use of water that is socially equitable, environmentally sustainable and economically beneficial. '*[83] It is a concept that has existed in various forms for centuries, and has grown under the auspices of environmental management departments in federal and more localized government agencies over the last half century.

A new wave of water stewardship has arisen in the last decade that has brought on additional interest and investment, particularly by the private sector. In non-financial reporting under the heading of

[79] Vörösmarty et. al. (2010)
[80] Vörösmarty et al. (2000).
[81] Ibid.
[82] De Wit and Stankiewicz (2007)
[83] Alliance for Water Stewardship (2014)

corporate social responsibility, corporations increasingly pay more attention towards water resource management.[84] [85]As water resources become increasingly stressed, and informed by the growing interest of the investor community in disclosure of water-related metrics, corporations have focused on business-related water questions through the lens of risk. Interruption of operations following water shortage, for example, can pose a physical risk. Changing water use standards or restrictions on water use pose a regulatory risk. And perception of a company's role in areas of water stress can pose significant reputational costs. Water is quickly becoming a factor in siting, sourcing and operations business decisions, particularly for the most water intensive industries and especially also for those companies that are market-facing and in direct contact with the consumer.

Several companies have led the way in developing global water stewardship strategies and implementing projects on the ground aimed at reducing water risks. [86,87,88] These efforts have resulted in a range of positive impacts, but there is a greater opportunity for the private sector, the public sector and together through Public Private Partnerships (PPPs) to more holistic design water stewardship strategies that optimize for economic, social and environmental prosperity alongside the more immediate business risk mitigation objectives.

Water Stewardship Mechanisms

There are a number of mechanisms under the auspices of 'water stewardship' that can help support the sustainable prosperity of a community, country or region. The applicability of individual or a suite of water stewardship strategies depends on a number of factors, including economic stage of development and structure, existing water policies, specific water challenges and stakeholder interests and resources. Here we present several water stewardship mechanisms that are categorized as appropriate into policy, management and collective action strategies. These mechanisms can be implemented as stand-alone efforts or as part of a strategic plan that aims to close a watershed's water quantity and quality sufficiency gap. More detail on each mechanism can be found in Appendix A and will be explored in further detail, including through a number of case studies, in the second phase of this work.

Policy mechanisms

- Human right to water
- Water use limits / creation of a water rights system
- Water market
- Water quality standards and enforcement
- Smart land use planning[89]

[84] Morikawa et al. (2009)
[85] Schulte et al. (2012)
[86] SABMiller (2015)
[87] General Mills (2015)
[88] The Coca-Cola Company (2015)
[89] Smart land use planning considers the full impacts of various land uses on the economic, social and environment well-being of a region. This includes consideration of both terrestrial and aquatic impacts of land use changes.

Management mechanisms

- Water access and sanitation or update of existing water systems
- Promote innovation and incentivize efficient water use and re-use.
- Green infrastructure investment
- Conjunctive management for multiple objectives[90]
- Data collection and transparency

Collective action

- Bring stakeholders to the table
- Create a sustainable payment for ecosystem services framework
- Promote innovation and incentives
- Share information and data
- Pool resources for investment or program support

For example, in some watersheds investing in the natural systems that regulate and filter runoff can be more cost-effective than investing in advanced water treatments systems, while providing a variety of social and environmental co-benefits. Critically important in this context is setting a limit on total water use, as it directly addresses the tragedy of the commons by restricting unlimited access to water. In doing so, a cap will raise the (implicit) price of water closer to its true value. Since limiting the supply of water that is available for residential, agricultural and commercial use will most likely require a redistribution of water across its various uses, imposing a cap on water is, at least conceptually, easily married with implementing water markets that allow for the sale of water rights to the most productive users. Equally important is implementing water quality standards that help safeguard water resources for future generations. There are also several policies that lay the groundwork for effective water management that helps meet demand to support economic prosperity without creating negative impacts on social and environmental prosperity. Finally, incentivizing development and implementation of innovative solutions for improving water efficiency and reducing water quality impacts is a proven strategy for meeting sustainability goals. These strategies are also tied to the presence of realistic price for water. When water is free, there will be no investment in water saving technology, and limited R&D in water innovations.

Figure 9 provides an illustration as to how a suite of water stewardship strategies could be combined to achieve a gap between an unsustainable and sustainable management of the watershed. In this example there is an average annual deficit due to overuse of water of 255 million cubic meters. In order to ensure prosperity for the economy and society in this area, a number of solutions must be implemented to close this gap. The alternative is a continued decline in groundwater levels, which could over time result in more costly pumping, degraded water quality and, eventually, an inability to use this water resource for irrigation or water supply. Loss of this groundwater aquifer as a resource could, in the long

[90] Conjunctive management is the design and operation of water-related infrastructure for multiple objectives such as water supply, energy generation, flooding and instream flows for people and ecosystems.

term, produce a variety of adverse economic and social impacts. In this case, a combination of policy, management and collective action strategies could be employed to achieve a goal of no net decline in aquifer levels and help protect the prosperity of this area. In many instances, explicitly recognizing what the sustainable cap on total water use in a river basin is and charging an adequate price for water will have to be an element of the strategies in order to provide an incentive for water saving and innovation in water saving strategies.[91]

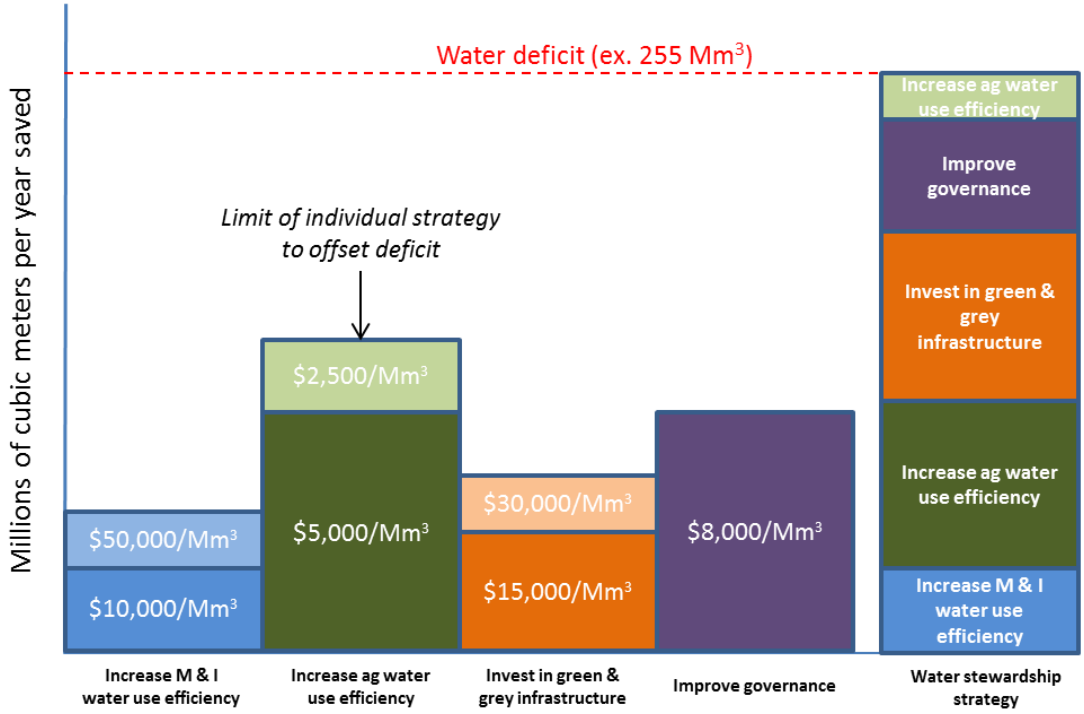

Figure 9. Illustration of how water stewardship can help close a sufficiency gap[92]

Conclusions and Next Steps

Without sufficient clean water people, nature and society cannot thrive. In a world that is geared towards economic growth, it is imperative that we protect and restore our water resources and water-related ecosystem services so that they continue to support our health, well-being, resiliency and economic prosperity. The world is facing growing water scarcity and water quality challenges due to policies and activities that aim for short-term economic development. As we realize the impacts of this trajectory on health and well-being, business risks and the ability to secure water supply, and food and energy for a growing population, we consider the important role of water stewardship strategies in supporting a more sustainable future.

[91] To be explicit, since putting a limit on the water that is available for non-environmental purposes will often amount to a reduction in water supply for non-environmental water use, the (implicit) price of water is bound to increase.

[92] CEO Water Mandate (2014)

The following provides recommendations, based on the research presented in this report, on development of forward-thinking water stewardship strategies that aim to optimize for sustainable prosperity:

- Effective water stewardship requires an understanding of the complex connections between water use and the economic, social and environmental prosperity of the region. This includes consideration of the changing nature of the economy, and opportunities for economic growth without increasing impacts on water quantity and quality.
- A critical element of sustainable prosperity is limiting total water use for a specific water basin or aquifer based on an assessment of annual and seasonal water availability and water needs for local communities and the environment. Where applicable, the development of a water market can encourage more efficient use of water and trading between water uses to meet needs in any given water year. Within this system it is important to set aside water allocations for those who cannot afford to pay to meet basic water needs and to support aquatic ecosystems.
- Water stewardship should aim to protect the biodiversity of watersheds and aquatic systems, and help sustain the ecosystem services that these systems provide. Consider the role of green infrastructure in sustaining both terrestrial and freshwater ecosystems, while meeting water security objectives.
- Integrated water management should include strategies to address the health and well-being related elements of water, including reduction of water-borne diseases and the burden of time to collect water, which can impact ability to attend school and improve individual livelihoods.
- Water policies and management should also consider the impacts of water management on food security, including water for agriculture and healthy ecosystems for fisheries.
- Water stewardship efforts should incorporate awareness of cultural integrity of the water resources, including the spiritual and recreational values of water to local communities.
- Finally, water stewardship strategies should aim to improve the resiliency of watersheds and aquatic systems, including under changing climate conditions.

The second phase of this work will focus on the collection and assessment of a number of water stewardship examples with an eye towards their impact on economic prosperity, social well-being and environmental integrity. It is our hope that through exploration of on the ground examples we can develop more specific recommendation and guidance for future water stewardship efforts to help support sustainable prosperity.

Appendix A: Water Stewardship Mechanisms

Type	Name	Description	Actors
Policy	Human right to water	Make the human right to water a baseline for other water policies. This requires a commitment to working towards 100% of the population with access to clean water as well as long-term protection of water supplies	National government, corporations
	Water use limits / water rights	To ensure sustainable water use it is critical to set a limit on total water use for a watershed or aquifer and allocate water rights based on this limit. Water use should be tracked over time to ensure total use remains below the sustainable limit.	National & provincial governments
	Water market	Water markets can help encourage efficient use and the allocation of water to the highest value. The applicability of a water market depends on many factors, the most important of which is a strong, transparent water rights system.	National & provincial governments, a variety of water users, investors
	Water quality standards	In order to protect and restore the quality of lakes and rivers for desired uses, water quality standards need to be set and enforced. Water users must be required to return wastewater to freshwater systems at a specific minimum quality.	National & provincial governments
	Smart land use planning	Due to the strong connections between land use and water flow regulation and quality, land and water resources must be managed conjunctively to achieve sustainable prosperity.	Provincial and local (county & city) governments
Management	Water access & sanitation / update of existing infrastructure	As part of the commitment to the human right to water, providing access to a clean source of water and implementing sanitation helps improve health and productivity, as well as protecting water quality from human bacteria. For locations where water systems are in place, infrastructure should be periodically updated to ensure continued quality water services and to avoid huge water quantity losses due to leakage.	National, provincial and local governments, water utilities, development NGOs
	Promote innovation & incentivize efficiency	Technological innovations should be promoted that can help achieve improved water efficiency and more cost-effective water quality solutions. Incentives should also be used to help encourage improved water efficiency and best management practices that reduce water quality impacts.	National, provincial and local governments, NGOs and corporations

	Green infrastructure investments	Our natural ecosystems provide a wide variety of critical water-related ecosystem services, including better regulated, cleaner water supply. Investment in protection and restoration of green infrastructure provides a sustainable, cost-effective way of ensuring the sustainability of water resources.	National, provincial and local governments, water utilities, NGOs, corporations, investors
	Conjunctive management for multiple objectives	Our water infrastructure should be designed and operated to achieve multiple objectives, such as flooding, power generation, water supply and sufficient flows for freshwater ecosystems at critical times of the year.	National and provincial government, energy providers, emergency management agencies, water utilities
	Data collection & transparency	Data collection is an often under-funded but critical tool that helps support a water rights system and water market, ensures water quality standards are being met, measures the progress of innovative solutions and tracks general trends in water quantity and quality for adaptive management.	National, provincial and local governments, water utilities, universities
Collective action	Bring stakeholders to the table	An important benefit of collective action is the engagement of a variety of stakeholders, who bring with them different perspectives, ideas and resources. In order to achieve sustainable water management, buy-in from key stakeholders is essential.	All stakeholders (government, corporations, NGOs, community groups, farmers, etc.)
	Create a sustainable PES framework	One strategy for addressing the lack of investment from water users in their water source is to create a payment for ecosystem services framework, such as a water fund, that provides a sustainable governance and funding mechanism for such investments.	NGOs, corporations, water utilities, community groups, investors
	Promote innovation & incentives	Private sector is often at the forefront of development and implementation of innovative solutions to save water or improve wastewater discharge. Testing and sharing successful solutions with other stakeholders can help improve the overall sustainability of water use in a watershed. Stakeholders can also help bring other actors to the table (such as food and beverage companies and farmers) and help incentivize implementation of improved technologies and practices.	Corporations, universities, agriculture, water utilities, NGOs, government programs

	Share information and data	Collective action platforms can serve as a great place for sharing non-confidential data, information and solutions. Indeed sharing information forms a strong basis for collaboration.	Corporations, NGOs, universities, community groups, government
	Combine resources	One of the strengths of collective action is the ability for multiple actors to combine resources to have a much greater impact on improving the sustainability of water resources in a shared area of interest.	Corporations, NGOs, community groups

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