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TOWARD UNIVERSAL ACCESS TO BASIC AND SAFELY MANAGED DRINKING WATER: REMAINING CHALLENGES AND NEW OPPORTUNITIES IN THE ERA OF SUSTAINABLE DEVELOPMENT GOALS

Mitsuaki Hirai[1] and Jay Graham[2]
[1] Milken Institute School of Public Health at the George Washington University, DC, USA
[2] Public Health Institute, Oakland, CA, USA

1.1 BACKGROUND

Improvements in water supply, sanitation, and hygiene have greatly advanced the health of industrialized countries [1], where diarrhea, cholera, and typhoid were once the leading causes of childhood illness and death. Access to safe drinking water, adequate sanitation, and good hygiene provides a wide range of explicit and implicit benefits, including increased time, reduced morbidity, and mortality from various diseases, augmented agriculture and commerce, improved school attendance, reduced healthcare costs, and reduced physical burden. The time savings can allow women to engage in non-illness-related tasks, provide more time for childcare and time for socialization and education activities [2]. Further, when water supplies are brought closer to homes, women's savings in energy expenditure can result in a reduction of energy intake. The energy savings may then be transferred to children's intake of food at no extra cost [3]. The implicit benefits of an improved water supply include improved quality of life through an available supply of drinking water and increased potential for communities to engage in other improvements once they have achieved improved access to a safe water supply (Figure 1.1).

Globally, an estimated 2.1 billion people lack access to safely managed water services, defined as "an improved drinking water source that is located on premises, available when needed and free from faecal and priority chemical contamination" [4]. Under the Sustainable Development Goals (SDGs), the proportion of the population using safely managed drinking water services will be promoted and monitored.

The lack of basic access to drinking water results in significant health impacts because of water-related diseases as well as lost productivity. Globally, under-five child mortality from diarrhea – linked to the lack of access to water and sanitation infrastructure and poor hygiene – was estimated at 0.58 million (95% confidence interval, 0.45–0.75), representing an estimated 9.2% of total deaths in 2013 [5].

Improvements to water supply – in terms of quantity, reliability, and quality – are an essential part of a country's overall development, but a number of obstacles may limit success.

Rapid population growth, degradation of the environment, increase of poverty, inequality in the distribution of resources, and misappropriation of funds are some of the factors that have prevented water supply interventions from producing optimal results [6]. Further, numerous studies have shown that resources and time are being spent in water supply interventions that do not take into account beneficiaries' needs, preferences, customs, beliefs, ways of thinking, and socioeconomic and political structures (i.e., the enabling environment).

Water and Sanitation-Related Diseases and the Changing Environment: Challenges, Interventions, and Preventive Measures, Second Edition. Edited by Janine M. H. Selendy.

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FIGURE 1.1 A woman fetching water in India. *Source*: License information: McKay Savage from London, UK (https://commons.wikimedia.org/wiki/File:India_-_Sights_&_Culture_-_32_-_woman_fetching_water_(2458024353).jpg), "India – Sights & Culture – 32 – woman fetching water (2458024353)," https://creativecommons.org/licenses/by/2.0/legalcode. (*See insert for color representation of this figure*.)

1.2 PAST EFFORTS TO IMPROVE ACCESS TO SAFE WATER

Development interventions began to flourish in the 1970s as disparities became evident in terms of quality of life and access to basic services between wealthy and poor countries. The original motivation for providing water and sanitation to the inhabitants of less developed countries was based upon the consideration of water and sanitation as a cornerstone to public health and as a basic human right [7]. As a human right, those services should be financed by the national government of each country. The governments of economically developing countries, however, did not have the resources needed to provide basic water and sanitation services to their entire population. Thus, developed countries and international organizations provided assistance in the provision of these services [8].

The approach utilized for the design and implementation of most early projects did not typically consider the preferences of beneficiaries as it was perceived that they did not have the knowledge and ability to contribute. Facilities constructed soon fell into disrepair due to the lack of operation and maintenance ensuing from a deficiency in organization, training, and sense of ownership by beneficiaries. Shortly after many water supply and sanitation interventions,

TABLE 1.1 Number of people who received improved water supplies (1981–2000).

Water supply category	Avg. number of people who gained access per day (1981–1990)	Avg. number of people who gained access per day (1991–2000)
Urban	100 000	130 000
Rural	270 000	90 000
Total	370 000	220 000

Source: Mara and Feacham [9].

communities often found themselves in the same conditions as before the project. The results were not promising and it became evident that community involvement was missing.

During the International Drinking Water Supply and Sanitation Decade (1981–1990), the international community established a common goal of providing safe water supplies and adequate sanitation services to all the communities around the world. This meant that by 1990 every person worldwide should have their basic water and sanitation needs met. In 1981, it was estimated that 2.4 billion people would need to gain access to improved water supplies – equal to connecting 660 000 people each day for 10 years [9]. Although the goal was far from accomplished, an estimated 370 000 people on average received access to improved water supplies each day (Table 1.1). Following the decade and after two world conferences (New Delhi in 1990 and Dublin in 1992), the international community determined that water and sanitation could no longer be regarded simply as a right. After the Dublin conference, there was a shift to consider water as an economic good because it had an environmental and a productive value. It was made clear that need was no longer a sufficient reason for the provision of water and sanitation to any community [7].

After the World Conference on Water and Sanitation held at the Hague, Netherlands, in March 2000, the international community set a new common goal and published "Vision 21: Water for People." Vision 21 proposed to achieve a world by 2025 where everybody knows the importance of hygiene and education and enjoys safe water and appropriate sanitation services. At the United Nation Summit in September 2000, 189 UN member States adopted the Millennium Declaration, from which the Millennium Development Goals (MDGs) emerged. Target 10 of MDG 7 was to "halve by 2015 the proportion of people without sustainable access to safe drinking water and basic sanitation" (over 1990 estimates) [10]. The MDGs were a significant force in garnering donor support and government commitment to increasing water supply and sanitation.

A very important aspect of Vision 21 and the MDGs, reflecting concerns of the international community, was the recognition of the need for a new approach. The new approach emphasized "buy-in" before the implementation of a water project in any community and a stronger focus on ensuring that improvements made are sustained. Another particular aspect of Vision 21 was the ratification of water and sanitation as basic human rights. After the Water Decade, the international community indicated that water and sanitation could not be seen as basic rights anymore because the beneficiaries of the projects did not value the improvements made and facilities constructed when they were not required to contribute monetarily. In other words, people will not appreciate, continue to utilize, and preserve something that they have not contributed to. Based on previous experiences, the Conference concluded that the lack of a sense of ownership and commitment to project improvements on the part of the beneficiaries was due to the inadequate and often neglected inclusion of beneficiaries' preferences into project design and implementation. Further, beneficiaries of water projects should be responsible for the costs of the operation and maintenance of the system but not for the costs of the water itself, based on the idea that all people on earth have the right to obtain and consume enough water to guarantee their survival.

1.3 TRANSITION FROM THE MILLENNIUM DEVELOPMENT GOALS TO THE SUSTAINABLE DEVELOPMENT GOALS

Under the MDGs, global access to improved water sources increased from 76% of the population in 1990 to 91% in 2015. By reducing the number of people who rely on unimproved water sources from 1.3 billion in 1990 to 663 million in 2015, the MDG target of halving the proportion of the population without access to safe drinking water was met [10]. A major lesson learned from the MDG implementation was that the progress toward and attainment of the MDG target was not equal across regions. While 93% of the population in Southern Asia had gained access to improved water supply by 2015, it was only 68 and 56% in Sub-Saharan Africa and Oceania, respectively (Figure 1.2). Use of unimproved water sources and surface water was also disproportionately higher in rural populations than urban populations (Figure 1.3). Furthermore, the MDG mostly focused on household access to drinking water while people need safe drinking water in all settings.

In September 2015, UN Member States set the 2030 Agenda for Sustainable Development with 17 SDG goals and 169 targets [4]. The SDG Goals 1, 4, and 6 address drinking water, sanitation, and hygiene with respective targets and indicators (Table 1.2) [11]. The SDGs create a number of new opportunities to accelerate global efforts to promote access to water, sanitation, and hygiene (WASH). First, the SDGs address hygiene by monitoring the availability of handwashing facilities and resources while the MDGs only focused on water and sanitation. This addition allows the WASH sector to provide a more holistic picture of access to WASH services at the national, regional, and global

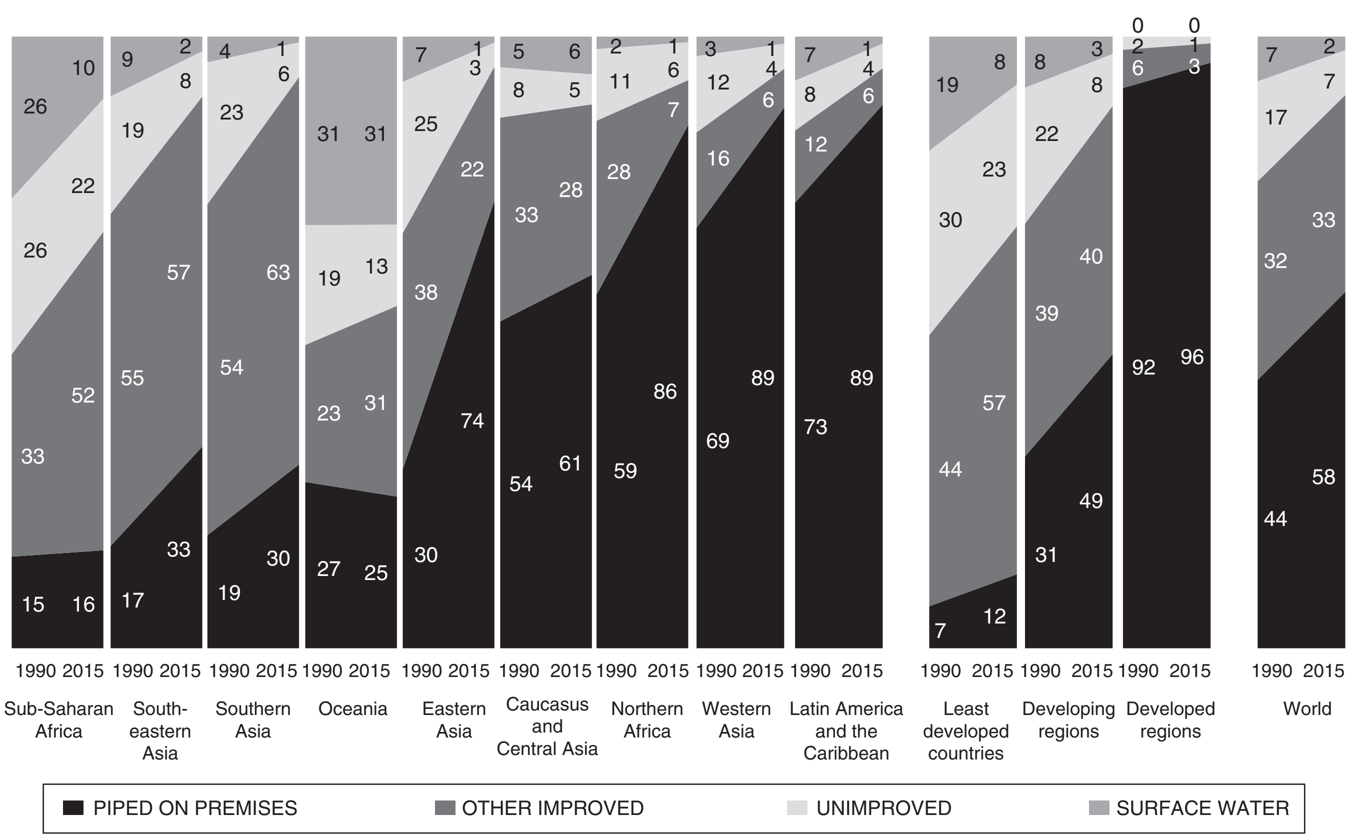

FIGURE 1.2 Regional trends in the percentage of population by drinking water service levels. *Source*: UNICEF/WHO [10].

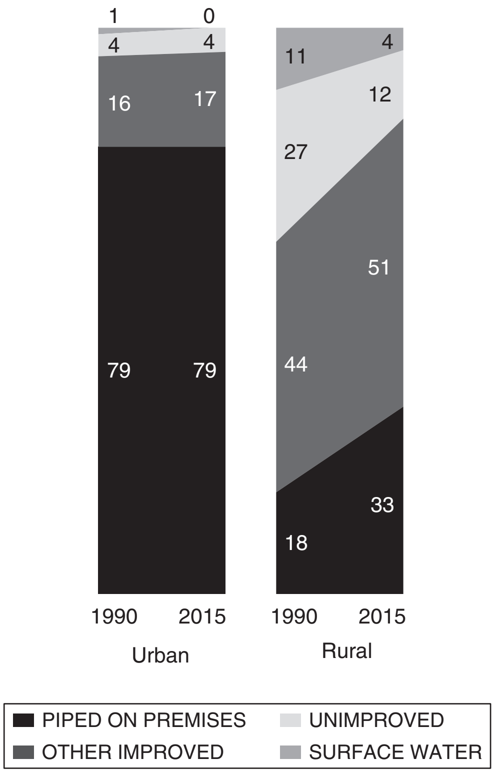

FIGURE 1.3 Trends in the percentage of population by drinking water service levels for urban and rural areas. *Source*: UNICEF/WHO [10].

levels. Second, the SDGs place more emphasis on reducing inequalities in access to WASH services than the MDGs. The MDGs achieved halving the proportion of the global population without access to safe drinking water and basic sanitation, but universal access or equity was not attained. The SDG targets therefore expanded the scope by specifically calling for *universal* and *equitable* access for all. Eliminating spatial and social inequalities is of vital importance to achieve the SDG targets. Third, the SDGs monitor and expand access to WASH services at some institutional settings, including schools and healthcare facilities. Compared to the MDGs, which only addressed household access to water and sanitation services, the SDGs can inform the accessibility, availability, and/or quality of WASH in other key locations.

The Joint Monitoring Programme for Water Supply and Sanitation (JMP) will use service ladders to monitor progress on access to drinking water under the SDGs. The JMP ladder for the MDGs used water piped to premises, other improved sources, unimproved sources, and surface water as the main rungs [10]. The new ladder for the SDGs consists of safely managed, basic, limited, unimproved, and surface water as the service levels [4] (Table 1.3). Drinking water from an improved source can be regarded as safely managed if it is accessible, available, and free from contamination at the same time. More specifically, a drinking water source should be located within the house, yard, or plot (accessibility), drinking water should be sufficiently available in the last

TABLE 1.2 Relevant SDG goals, targets, and indicators to drinking water, sanitation, and hygiene.

Goals	Targets	Indicators
Goal 1: End poverty in all its forms everywhere	Target 1.4: By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership, and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance	Indicator 1.4.1: Proportion of the population living in households with access to basic services
Goal 4: Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all	Target 4.a: Build and upgrade education facilities that are child, disability, and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all	Indicator 4.a.1: Proportion of schools with access to (a) electricity; (b) the Internet for pedagogical purposes; (c) computers for pedagogical purposes; (d) adapted infrastructure and materials for students with disabilities; (e) basic drinking water; (f) single-sex basic sanitation facilities; and (g) basic handwashing facilities (as per the WASH indicator definitions)
Goal 6: Ensure availability and sustainable management of water and sanitation for all	Target 6.1: By 2030, achieve universal and equitable access to safe and affordable drinking water for all	Indicator 6.1.1: Proportion of population using safely managed drinking water services
	SDG Target 6.2: By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations	Indicator 6.2.1: Proportion of population using safely managed sanitation services, including a handwashing facility with soap and water

TABLE 1.3 JMP ladder and SDG baseline for drinking water.

Service level	Definitions	2015 global baseline
Safely managed	Drinking water from an improved water source that is located on premises, available when needed and free from fecal and priority chemical contamination	71% (5.2 billion)
Basic	Drinking water from an improved source, provided collection time is not more than 30 minutes for a round trip, including queuing	17% (1.3 billion)
Limited	Drinking water from an improved source for which collection time exceeds 30 minutes for a round trip, including queuing	4% (263 million)
Unimproved	Drinking water from an unprotected dug well or unprotected spring	6% (422 million)
Surface water	Drinking water directly from a river, dam, lake, pond, stream, canal or irrigation canal	2% (159 million)

week or available for at least 12 hours each day (availability), and a drinking water source should be compliant with standards to claim to be contamination free (quality). Access to safely managed drinking water is a key data element for SDG Target 6.1. A basic service includes drinking water from an improved source, and the water collection time should not be more than 30 minutes. Drinking water with a partial fulfillment of safely managed drinking water (e.g., one of three conditions met) will also be included in the basic category. Further, the basic service level will be monitored to assess the attainment of SDG Target 1.4. A limited service means that drinking water comes from an improved water source, but it requires more than 30 minutes for water collection. As with the previous ladder, the new ladder includes unimproved and surface water categories.

As a key update, improved water sources under the MDGs and the SDGs are not the same. Improved sources in the updated ladder include piped water, protected springs, protected dug wells, boreholes or tubewells, rainwater, and packaged or delivered water. Packaged or delivered water was considered an unimproved water source in the previous JMP ladder because data on accessibility, availability, and quality were missing. However, the JMP suggests that packaged or delivered water may be safely managed, so it has been added as an improved source [4]. Another update was the explicit use of water collection time as a determinant of service levels in the updated ladder.

The SDG baseline assessment estimated that 5.2 billion people worldwide have access to safely managed drinking water services. Over 1.3 billion people use basic drinking water services. However, 263 million people spend over 30 minutes to collect drinking water, 422 million people collect drinking water from unimproved sources, and 159 million people drink surface water.

TABLE 1.4 JMP ladders for monitoring access to water in schools and healthcare facilities.

Service level	Schools	Healthcare facilities
Advanced	To be defined at national level	To be defined at national level
Basic (SDG)	Drinking water from an improved source is available at the school	Water from an improved source is available on premises
Limited	There is an improved source, but water was not available at time of survey	Water from an improved source is available off premises or an improved source is on-site, but no water was available
No service	No water source or unimproved source	Unprotected dug well or spring, surface water, or no water source

The JMP ladders have been developed for monitoring access to WASH in schools and healthcare facilities [4]. The service levels consist of advanced, basic, limited, and no service (Table 1.4). For both schools and healthcare facilities, the advanced service level is to be defined by each country, but the definition is not available as of January 2018. The JMP is in the process of establishing the global baseline for WASH in schools and healthcare facilities to be published in the near future.

1.4 IMPACTS OF WATER SUPPLY INTERVENTIONS

A great deal of evidence and literature addresses the impacts associated with improved quality and quantity of water supplies. Between 1980 and 2000, most studies of water quality assessed only the source of water and not the point at which users actually consumed the water (point of use). A review of 67 studies to determine the health impact of water supplies found that the median reduction in diarrheal morbidity from improvements in water availability was 25% and the median reduction based on improvements to water quality at the source, not at the point-of-use, was 16%, with a range of 0–90% [12]. Combinations of water quality at the source and water quantity resulted in a 37% median reduction in diarrheal morbidity. In 1991, the study was updated and covered 144 studies and looked more carefully at studies and the rigor with which they were conducted [13]. In the 1991 analysis, looking only at studies deemed rigorous, improvements in water quantity resulted in a median reduction of 30%, improvements to water quality at the source was 15%, and combinations of water quality at the source and water quantity resulted in a 17% median reduction in diarrheal morbidity. These reviews helped set the agenda for specific interventions that the global community would pursue. There was, however, a growing interest in assessing water quality at the point of use. In 2003, an analysis of 21 controlled field trials dealing with interventions designed to improve the microbiological water quality at the point of use showed a median reduction in endemic diarrheal disease of 42% compared to control groups [14]. Nine studies used chlorine as a method of treating water, five used filtering, four used solar disinfection, and three used a combination of flocculation and disinfection. The results of this study and subsequent studies resulted in donor investments to improve drinking water quality at the point of use and a large number of economically developing countries now have point-of-use products that are being socially marketed.

The impact of water, sanitation, and/or hygiene interventions on diarrhea morbidity among children in low- and middle-income countries has been examined in more recent reviews of studies using experimental and quasi-experimental methods [15, 16]. Waddington et al. analyzed 65 rigorous impact evaluations from 71 distinct interventions for quantitative synthesis and assessed across 130 000 children in 35 developing countries during the past three decades. These studies were evaluated for a range of factors, such as type of intervention, effect size and precision, internal validity, and external validity. The interventions were grouped into five categories: (i) water supply improvements, (ii) water quality, (iii) sanitation, (iv) hygiene, and (v) multiple interventions involving a combination of water and sanitation and/or hygiene. The results challenged the notion that interventions to improve water quality treatment at the point of use are necessarily the most efficacious and sustainable interventions for promoting the reduction of diarrhea. The analysis suggested that while point-of-use water quality interventions appear to be highly effective, and generally more effective than water supply or improving water quality at the source, much of the evidence is from small trials conducted over short periods of time. The review indicated that point-of-use interventions conducted over longer periods of time demonstrated smaller effects as compliance rates fell. The study found that hygiene interventions, particularly the promotion of handwashing with soap, were effective in reducing diarrhea morbidity, even over longer periods of time.

Calculations of the cost-effectiveness of the interventions described above have shown point-of-use and hygiene interventions to be highly efficient for health improvements [17, 18]. In terms of the costs per disability-adjusted life year (DALY) averted, a community connection to improved water supplies results in $94USD/DALY averted, which is less than half that for household water connection, but substantially higher than estimates for point-of-use water quality interventions, estimated at $53USD/DALY averted using chlorination. Estimates from improved hygiene and sanitation suggest that hygiene promotion is the most cost-effective, at $3USD/DALY averted, followed by sanitation promotion, at $11USD/DALY [17].

Water supply interventions have a large number of benefits. For example, improved water supplies enable improved hygiene practices, such as handwashing and better home hygiene, and there are likely considerable spillover effects in terms of environmental health benefits. In Lesotho, use of smaller quantities of water was related to higher rates of *Giardia lamblia* infection [19]. In Taiwan, a reduction of 45% in rates of trachoma was noted, when the water supply was attached to the home compared to a water supply that was 500 or more meters away [20]. Time savings associated with water supply interventions are also significant. In rural Nigeria, the installation of water systems was estimated to reduce collection time from 6 hours to 45 minutes per household per day during the dry season, mainly benefiting adolescent girls and young women [21]. Another study also estimated a time savings of 20 minutes per household per day from a village water supply improvement in China [22]. In the Philippines, water quantity was strongly associated with nutritional status. Children in households that averaged less than 6 l per capita per day were significantly more malnourished than children in households that averaged 6–20 l or more than 20 l per capita per day [23]. A study of Pakistan households showed that increased quantity of water available at the household level was associated with reduced stunting in children [24].

The public health gains stemming from access to increased quantities of water typically occur in steps. The first step relates to overcoming a lack of basic access, where distance, time, and costs involved in water collection result in the use of volumes inadequate to support basic personal hygiene and may be marginally adequate for human consumption. Significant health gains occur largely when water is available at the household level. Other benefits derived from the second step in improving access include increased time available for other purposes. The availability of new or improved supplies does not always translate directly into a significant increase in use. In East Africa, after new water supplies were placed in proximity to households, the amount of water usage did not increase if the original water source was less than 1 km from the home [25].

In practice, the use of water for domestic purposes cannot easily be distinguished from productive use, particularly among very poor communities. When communities design their own water systems, they invariably plan for multiple-use water systems, and this is especially the case if the livelihoods of households depend on livestock [26]. In multiple-use approach interventions, it is critical to: (i) work with the community to assess the range of water needs in collaboration with end users; (ii) examine the water sources available; and (iii) match water supplies to needs based on the quantity, quality, and reliability required for various purposes. There may also be important health and social gains from ensuring adequate quality of service to support small-scale productive use, especially when this involves food production. Access to water used for small-scale productive activity in such areas is therefore important as part of economic growth and may deliver significant indirect health benefits as a result [27].

The water-related indicators in the MDGs and SDGs have tracked people's access to improved water sources. The technologies considered "improved," however, often do not consistently result in high-quality water. There are certain sources of water that the public health community condemns as risky (e.g., unprotected wells) and others they deem safe (e.g., protected wells). Comparing water quality from protected and unprotected supplies across countries, however, has demonstrated that in many cases protected supplies often provide lower water quality than protected wells in other countries. This suggests that certain practices – not certain types of water sources – may be more important for improving water quality [28]. As mentioned above, it is now generally accepted that providing safe water at the source does not imply that water is safe at the point of use. A study by Gundry et al. found that about 40% of water samples from microbiologically safe sources of water were contaminated at the point of consumption. Household water treatment at the point-of-use for most communities is an important intervention, regardless of whether the water comes from an improved source [29, 30].

Boiling is currently one of the most accessible means for water treatment to most populations and has been shown to be effective [31]. However, in the absence of safe storage, boiled water is immediately vulnerable to recontamination, especially when the environment is unhygienic. Further, this mode of treatment can have serious side effects, such as indoor air pollution and depleting environmental resources if biofuels (e.g., wood) are used for boiling.

1.5 RESOURCE REQUIREMENTS

To achieve SDG targets on WASH, adequate and continued financial investment for infrastructure, operation, and maintenance is essential. Hutton and Varughese estimated that \$6.9 billion (range: \$3.6–\$11.6 billion) is required each year from 2015 to 2030 to achieve universal access to basic drinking water services (Figure 1.4). Compared to the provision of basic sanitation and hygiene services, basic drinking water services are less costly than sanitation (\$19.5 billion) and more costly than hygiene (\$2.0 billion). Provision of universal access to safely managed drinking water was estimated to be five times more expensive than that of basic drinking water at \$37.6 billion per year (range: \$29.4–\$45.6 billion). In the initial stage of SDG implementation, capital costs for infrastructure may account for the significant majority of investment while operation and maintenance costs are expected to increase over years [32].

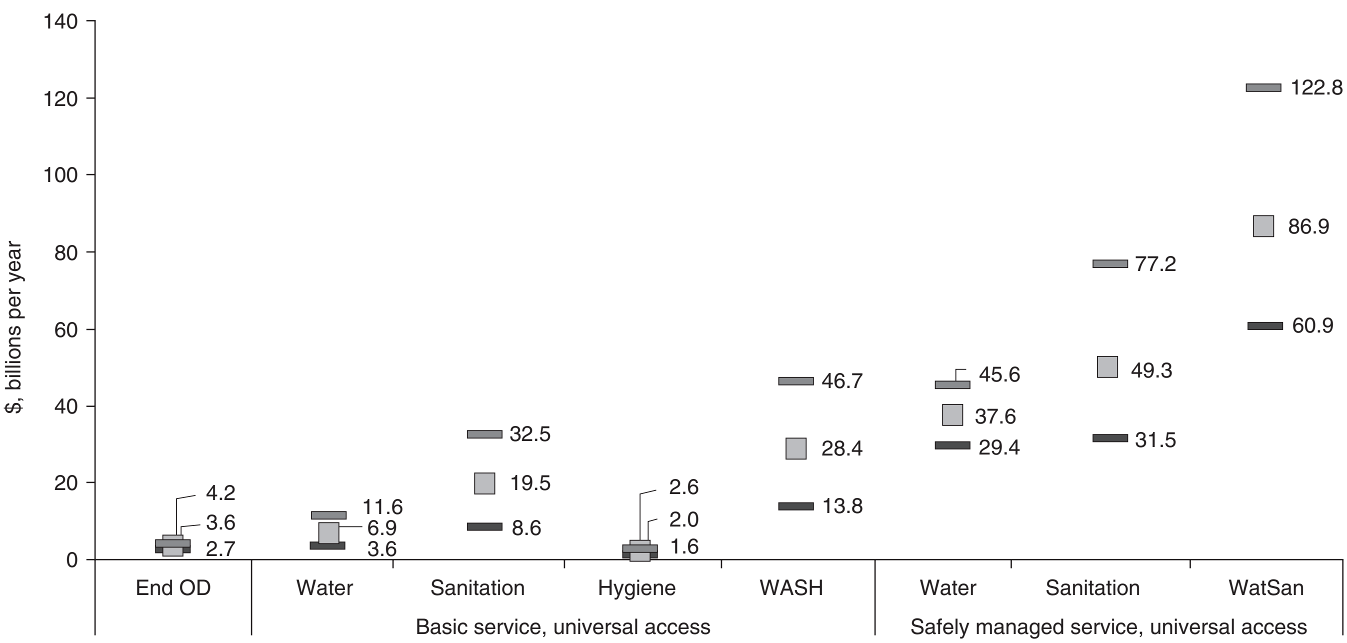

FIGURE 1.4 Estimated annual costs to achieve universal access to basic WASH services and safely managed drinking water and sanitation. Notes: OD = Open Defecation. WASH = Water, Sanitation, and Hygiene. WatSan = Water and Sanitation. *Source*: Hutton and Varughese [32].

1.6 NATURALLY OCCURRING AND ANTHROPOGENIC WATER POLLUTION

While microbiological contamination of water is the main emphasis of this chapter, naturally occurring and anthropogenic sources of chemical pollution can pose serious human health risks. Although no published estimates are available on the global burden of disease resulting from chemically polluted water [33], a number of countries with a growing industry sector have faced water pollution challenges. In addition to anthropogenic pollutants, groundwater commonly contains naturally occurring toxic chemicals, including arsenic and fluoride, which dissolve into the water from soil or rock layers. The most extensive problem of this category is arsenic contamination of groundwater, which has been observed in Argentina, Bangladesh, Chile, China, India, Mexico, Nepal, Taiwan, and parts of Eastern Europe and the United States [34]. Arsenic in Bangladesh's groundwater was first highlighted in 1993 as a result of promoting protected wells in an effort to eliminate diarrheal diseases caused by fecally contaminated surface waters. Millions of shallow wells were drilled into the Ganges delta alluvium in Bangladesh and estimates indicate that an estimated 40 million people were put at risk of arsenic poisoning-related diseases because of high arsenic levels in the groundwater [35]. Fluoride is another naturally occurring pollutant that causes health effects and exposure to high levels in drinking water can detrimentally affect bone development and in some cases can cause crippling skeletal fluorosis. The burden of disease from chemical pollution in specific areas can be large. There are a number of events that have underscored the high levels of disease burden from chemical pollution, including methylmercury poisoning, chronic cadmium poisoning, and diseases of nitrate exposure, as well as lead exposure [33, 36, 37].

1.7 SPATIAL AND SOCIAL INEQUITIES IN ACCESS TO DRINKING WATER

Equity relates closely to the idea of fairness and that all members of a society have equal rights. Perfect equity in intra-country budgets, for example, would be a situation where every citizen is allocated an equal amount of the investment regardless of what part of the country they live in. From this perspective, water supply interventions can be considered equitable if they benefit all parts of society equally. Equal levels of access to clean and safe water would be an equitable outcome [38].

Equity is also concerned with comparing different parts and groups of society. Geography, social or health status, gender, and ethnicity can be used for comparison. Two types of equity – spatial and social – are useful for considering different levels of access to water supply and sanitation [38]. Social equity addresses groups or communities formed by geographic areas of residence, such as urban versus rural or administrative boundaries within a country. Social equity is concerned with groups defined by attributes linked to their identity and traverses spatial boundaries. Particularly vulnerable groups may include women, people living with HIV/AIDS, the elderly, the poor, the disabled, orphans, and widows.

Social and spatial inequities may overlap with each other. A large percentage of urban populations without access to basic water and sanitation services are also poor and a larger proportion of the rural population who spend time collecting water is women. Additionally, equitable investments do not necessarily equate to equitable outcomes and water supply costs may vary according to many factors, such as population density, distance from water sources, and the geology [38]. A number of spatial and social inequities persist and there are many challenges facing efforts to improve equitable access. Population growth is a major barrier to current efforts in the water sector to reduce the number of people living without access to basic or safely managed drinking water. In the last several decades, the population of the world has increased from 3.6 billion in 1970 to roughly 7.3 billion people in 2015. In 1980, the United Nations estimated that 1.8 billion people lacked access to safe water supplies and in 2015, there were still 844 million people without a basic drinking water service [4].

Spatially, more than 9 out of 10 people who drink surface water live in rural areas, with Sub-Saharan Africa and Oceania being the regions most behind in drinking water coverage (Figure 1.5). Just 58% of the population in Sub-Saharan Africa and 52% of the population in Oceania are estimated to use a basic drinking water service. At the country level, the proportion of population with a basic drinking water service was less than 50% in 10 countries, including Angola (41%), Chad (43%), Democratic Republic of the Congo (42%), Eritrea (19%), Ethiopia (39%), Mozambique (47%), Niger (46%), Papua New Guinea (37%), Somalia (40%), and Uganda (39%) (Figure 1.5). Within many countries, disparities in access to basic drinking water can be revealed by comparing urban and rural residence, wealth levels, and subnational regions (Figures 1.6 and 1.7) [4].

Even when a piped supply becomes accessible, typically in urban areas, unreliable water availability can be an issue. Less than 10% of people in many South Asian cities receive a 24-hour piped water supply. While governments and international institutions have provided financial and technical assistance with the goal of making water more accessible to the poor, many municipal pipelines reach wealthiest clients first. Thus, a significant number of urban populations without utility connections must rely on alternatives, such as service from Small-Scale Water Providers (SSWPs). Currently SSWPs are most prevalent in Southeast Asia

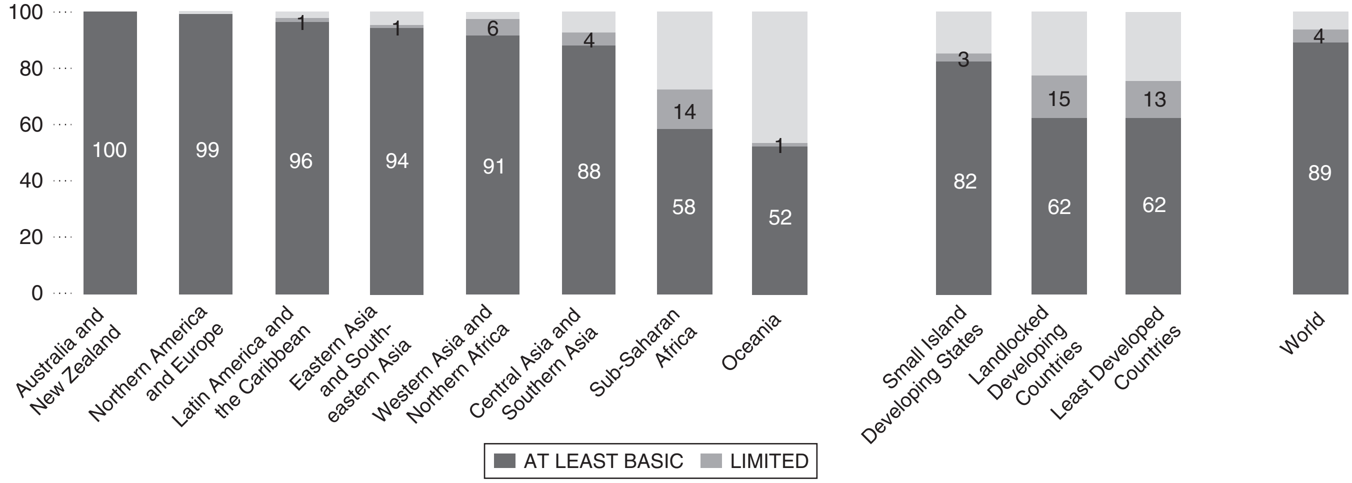

FIGURE 1.5 Regions represented by the percentage of population using at least basic drinking water services in 2015. *Source*: WHO/UNICEF [4].

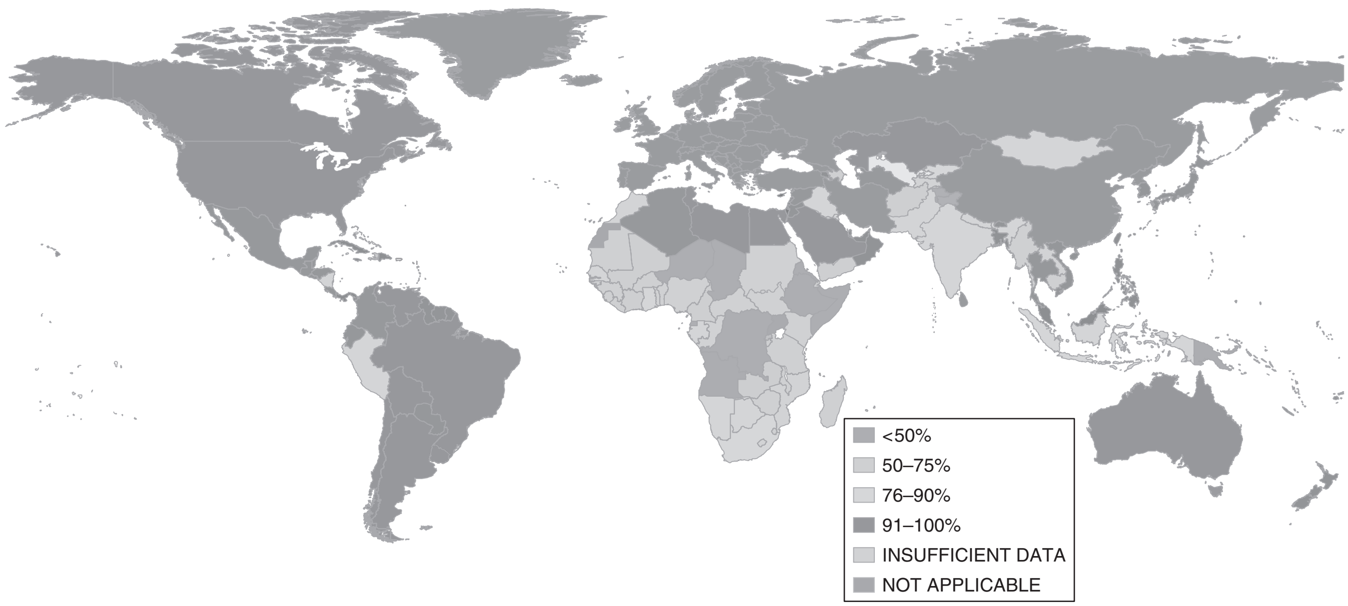

FIGURE 1.6 Countries represented by the percentage of population using at least basic drinking water services in 2015. *Source*: WHO/UNICEF [4]. (*See insert for color representation of this figure.*)

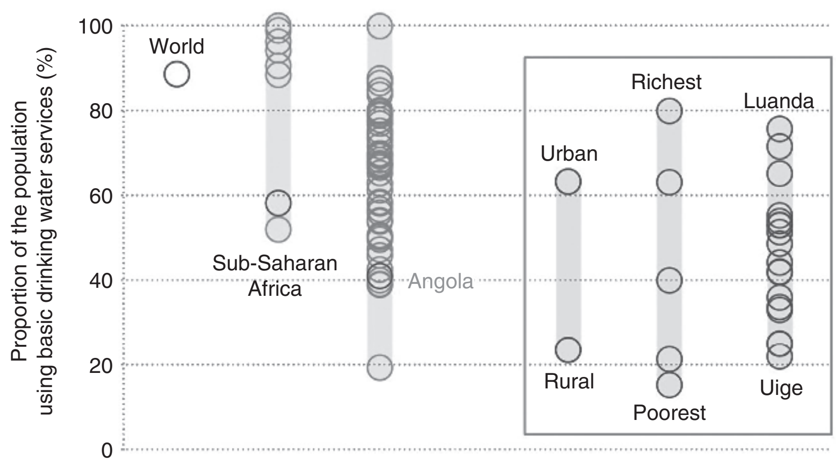

FIGURE 1.7 A summary of the percentage of population using at least basic drinking water services in 2015 by region, country, urban and rural residence, wealth levels, and subnational region. *Source*: WHO/UNICEF [4].

where a quarter of households in Cebu (Philippines), Ho Chi Minn City, Jakarta, and Manila may use these services [39].

In urban areas of the developing world, governments have favored large water utilities. Unfortunately, existing tariffs and management structures have caused these systems to fail to provide piped water coverage to entire populations. Connection fees are frequently too high or total available water is insufficient to support an urban area. Many utilities choose not to equip poor neighborhoods because of the high percentage of unpaid bills, fraudulent consumption, low levels of individual consumption, and because network maintenance costs are high. Additionally, people who occupy land illegally may also be excluded from public services. In cases where water companies are allowed or mandated to serve poor households, water is not always affordable or payment schedules may not be feasible. Thus, many people are forced to illegally draw their water from "spaghetti networks" that connect to the border of a municipal grid system or to purchase expensive, and commonly contaminated, water from SSWPs.

Of further importance are the inequalities surrounding the cost of water for the urban poor. While SSWPs offer a more flexible payment schedule, their water is usually more costly and consumes a large portion of household expenses. In some cities, the poor pay huge premiums to water vendors over the standard water price of those hooked up to municipal systems: 60 times more in Jakarta, Indonesia; 83 times more in Karachi, Pakistan; and 100 times more in both Port-au-Prince, Haiti and Nouakchott, Mauritania.

Socially, the poor, women, and children suffer disproportionately. In most developing countries, the provision of water and sanitation are women's responsibility [40]. Often, rural women from poor households must walk long distances to provide their families with water for drinking, cooking, and domestic and personal hygiene. Interventions to increase access often diminish the time that women spend gathering water and have provided participants with opportunities to learn new skills and spend more time cultivating crops in the time they had previously used for water collection. These classes of changes can have positive impacts on the local

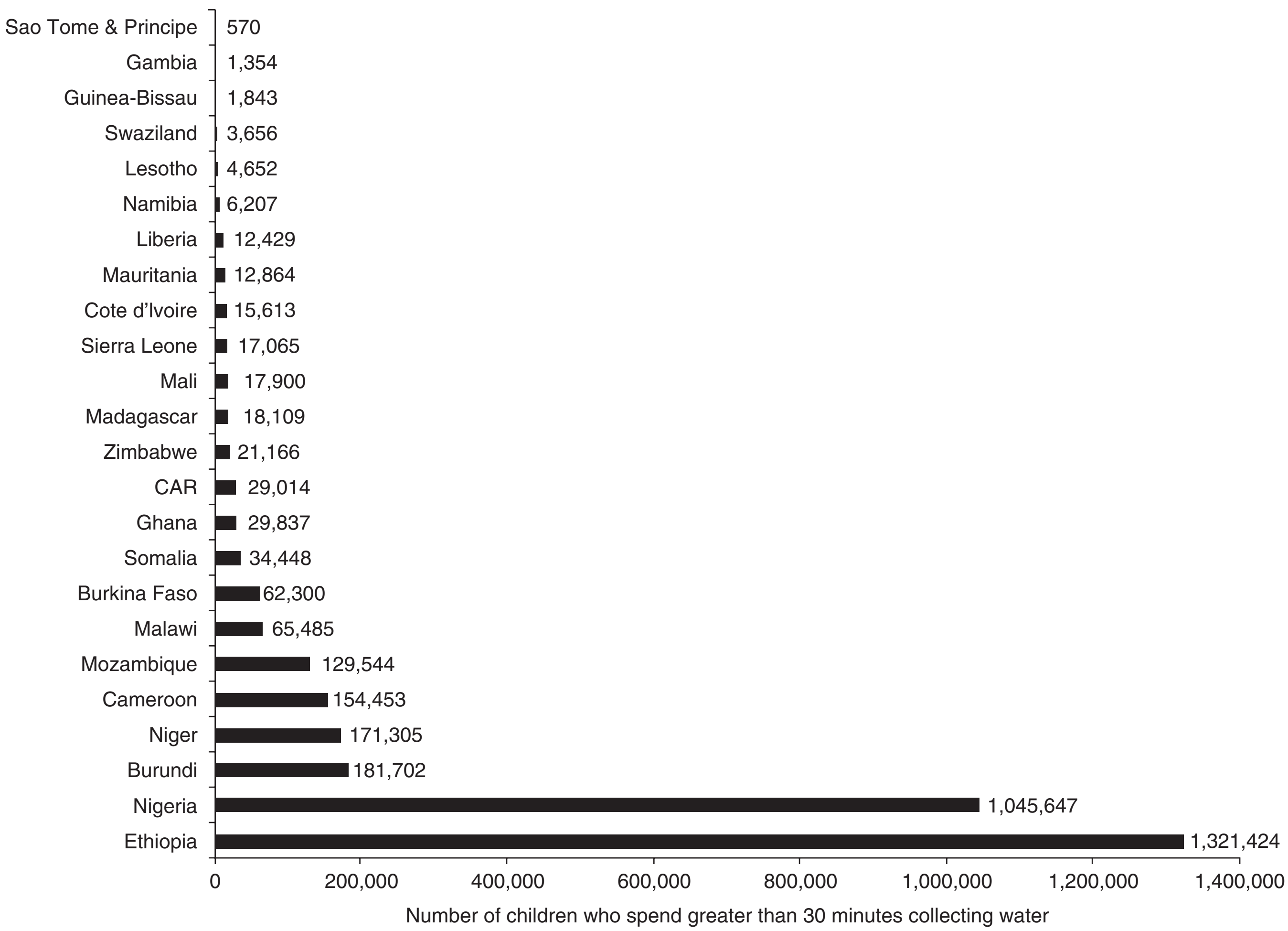

FIGURE 1.8 Number of children who spend more than 30 minutes for household drinking water in 24 countries in Sub-Saharan Africa. *Source*: Graham et al. [42].

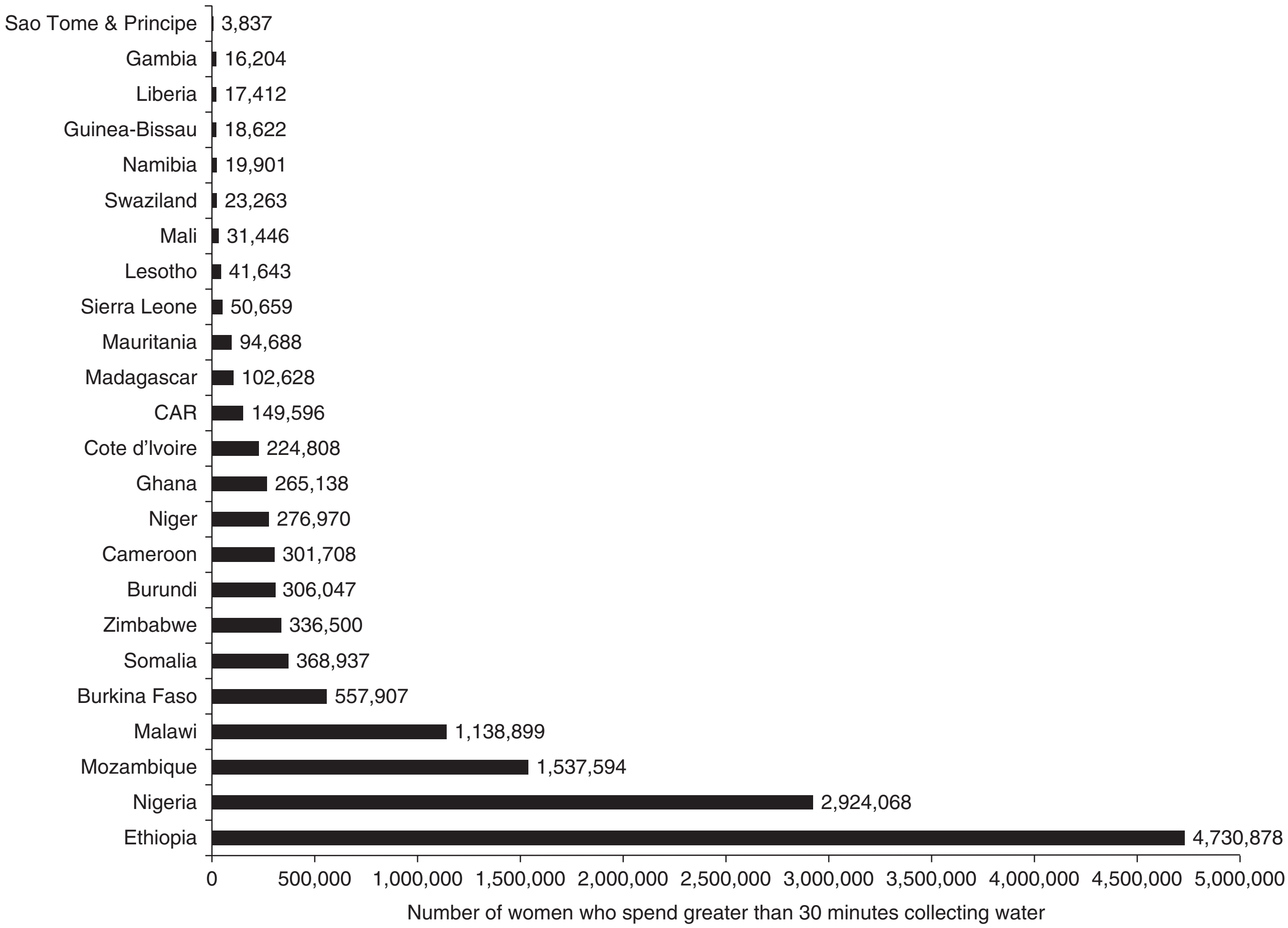

FIGURE 1.9 Number of adult women who spend more than 30 minutes for household drinking water in 24 countries in Sub-Saharan Africa. *Source*: Graham et al. [42].

economy, especially when income-earning involves tasks such as laundry work and other types of activities that use water. By decreasing the time for water collection, new opportunities enable women to effectively contribute to the communities' economic growth.

In an analysis, of more than 40 developing countries, women collected water for almost two-thirds of homes, versus a quarter of households where men collected water. In 12% of homes, children were responsible for collecting water and girls under 15 years of age were twice as likely to collect water as boys of the same age category [40, 41]. A recent study of 24 countries in Sub-Saharan Africa also revealed that 3.36 million children and 13.54 million women were responsible for water collection, which required more than 30 minutes per trip (Figures 1.8 and 1.9) [42]. Burundi, Cameroon, Ethiopia, Mozambique, Niger, and Nigeria included more than 100 000 households where children were responsible for water collection and spent more than 30 minutes for this task.

1.8 SUSTAINABILITY

Sustainability of water supplies is especially difficult in rural areas because of the lack of support through monitoring systems, training, human resource back-up support and availability of spare parts and services. Throughout rural Sub-Saharan Africa, numerous water systems have been developed every year, such as boreholes equipped with motorized or hand/foot pumps. These systems often fall into disrepair shortly after installation. Over 50 000 water supply systems were once estimated to be non-functional across Africa – representing an investment of nearly $300 million USD. This problem resulted from one reason, lack of operations and maintenance. Operations and maintenance, however, is multifaceted.

Many of the negative results in past interventions were linked to: (i) lack of community participation; (ii) utilization of inappropriate technologies; (iii) lack of a sense of ownership on the part of the beneficiaries; (iv) failure to provide the institutional support required for the project; and (v) dissatisfaction of the community with project outcomes [43]. In order to design a more effective and responsive approach for the provision of water and sanitation, development organizations and donor agencies are utilizing a series of participatory methodologies and techniques that focus on getting intended users actively involved in all stages of the project cycle. Fundamentally, community participation increases the probability of success and the sustainability of the projects implemented.

Participatory approaches evolved from disciplines such as anthropology and sociology, which have tried to fill in the existing gap between technology (hardware) and operations and maintenance (software). These approaches were based on the flaws identified and the lessons learned while implementing the supply-driven approach for the provision of safe water and sanitation services. The underlying principle was, and continues to be, the involvement of all stakeholders, especially the main users of the system, in all the phases of water and sanitation programs or projects, with the intention of improving their sustainability and probability of success. The primary objective was to be more responsive to the needs and preferences of users and more appropriate to given local conditions and the environment. Another important characteristic of these participatory methodologies was the significant change in the role that users of the system played during the design, implementation, construction, operation, and maintenance of the systems. Participatory methodologies were developed to facilitate the process of empowerment and capacity building of the communities benefiting from development interventions [44].

Community participation can bring about numerous benefits to development interventions but must be weighed against the time and costs related to their implementation. For effective participation and commitment on the part of the community, availability of financial and human resources at the beginning of the process is vital for success [45]. At the same time, no single approach for community participation can work in all situations. The approaches utilized in the water sector have to be flexible enough to incorporate site-specific information about environmental, social, and cultural factors as well as stakeholders' needs and priorities into the design and implementation of water and sanitation projects.

One of the most commonly used models for developing rural water interventions involves village-level coordination and the development of a system for cost recovery for operations and maintenance. Typically, a community bank account is opened and a community member is appointed to collect the fees. The selection of the technology and who has the skills to operate and maintain it are also part of the operations and maintenance system in place. Other models have been developed and experimented with and include public and private sector arrangements that aim to provide support to community systems following construction.

The community management model has brought many benefits, but it has not always resulted in a sustainable water supply at scale. It became evident that communities often cannot manage the variety of tasks that arise after the construction of water systems, including repairs, accounting, conflict resolution, legal issues, and system replacement. A relatively recent model, the Service Delivery Approach, was developed for improving rural water services and aims to better incorporate enabling environment factors to increase sustainability and scale. The approach considers the whole life cycle of service, from design, day-to-day operations and maintenance, to eventual replacement. For millions of rural people, the top half of Figure 1.10 represents a standard water supply intervention. Following construction of a new system, users have access to an improved source, but due to lack of follow-up support, the system quickly deteriorates until it is non-functional. In the Service Delivery Approach, once the water supply access is improved, it will be maintained through a proper understanding of the full life-cycle costs and institutional support needs [46].

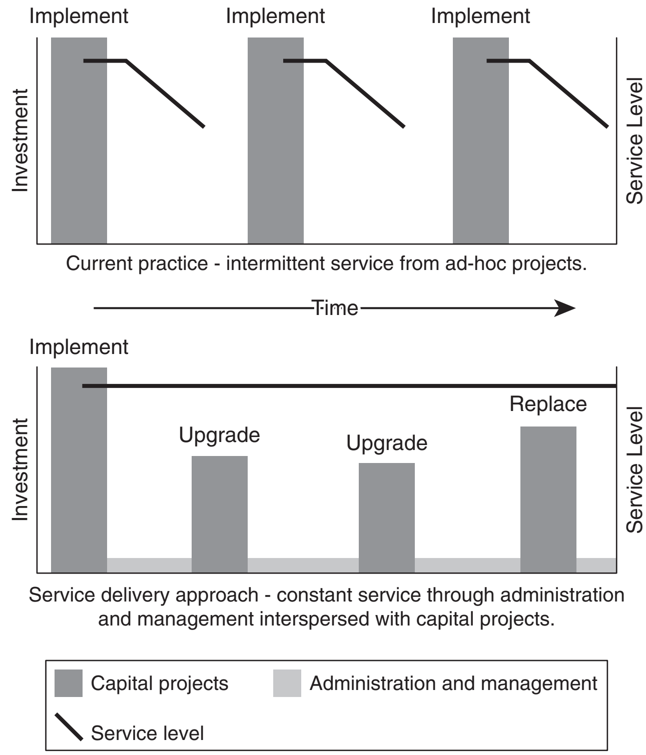

FIGURE 1.10 A model of rural water supply interventions (top half) versus the service delivery approach (bottom half) that provides for constant service through ongoing support interspersed with capital projects.

1.9 FINAL REMARKS

Drinking water, adequate sanitation, and good hygiene are essential requirements for the well-being of all humanity. Global efforts under the Millennium Development Goals reduced the number of population who relied on unimproved water sources from 1.3 billion people in 1990 to 663 million people in 2015 [10]. The Sustainable Development Goals will further expand access to drinking water, sanitation services, and hygiene facilities by aiming for universal and equitable access in household and institutional settings, including schools and healthcare facilities. A great deal of financial investment is necessary to ensure accessible, available, and safe drinking water everywhere. Spatial and social inequities also persist and need to be addressed through context-specific approaches with adequate stakeholder participation. Significant progress toward universal access to basic and safely managed drinking water can be made through collective actions at the individual, household, communal, social, international, and global levels.

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