Part I
Global Context of Freshwater Resources

Chapter 1
Global Water Availability, Distribution and Use

Water is one of the most widely distributed substances across the world's surface and is crucial for a variety of aspects of human health, development and well-being as well as for the functioning of natural ecosystems. It has been recognised as a fundamental human right internationally and consequently needs to be managed both effectively and efficiently to ensure that global water needs are met. The distribution of water across the globe is uneven and the availability thereof becoming an increasingly major concern. The main water use sectors, grouped in terms of agriculture, industrial (includes industrial activities, mining and energy) as well as municipal/domestic, recreational and environmental water use, have an influence on water availability through physical water abstraction as well as through water degradation. Global challenges in terms of water availability and water use are highlighted. Focus is placed on the availability, distribution and use of freshwater resources on a global scale.

1.1 Introduction

Water is one of the most widely distributed substances to be found in the natural environment and constitutes the earth's oceans, seas, lakes, rivers and underground water sources. This substance is crucial for various aspects of human health, development and well-being. The United Nations has recognised the importance of this resource by incorporating it into the Millennium Development Goals (MDGs) and by proclaiming the years 2005–2015 as the International Decade for Action 'Water for Life' (UN Water 2011). The importance of water has continued to be recognised with the incorporation thereof into the new Sustainable Development Goals (SDGs) which are Global Goals primarily set to transform the world and part of the 2030 Agenda for sustainable development. Water has thus been

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continually recognised as a fundamental human right internationally and it is vital that it be managed effectively and efficiently on a global and national scale. This - Chapter will focus upon the availability, distribution and use of freshwater resources on a global scale.

1.2 Water Availability and Distribution

Approximately 75% of the Earth's surface is covered by water. However, this is just an estimate as the dynamic nature and permanent motion of water makes it difficult to reliably assess the total water stock/store of the earth. Current estimates are that the earth's hydrosphere contains approximately 1386 million km^3 of water. However, not all of these resources are potentially available to humans since freshwater is required by the agricultural sector, industries, and domestic and recreational users (Kibona et al. 2009; Cassardo and Jones 2011; Lui et al. 2011).

Figure 1.1 shows that 97% of the Earth's water occurs in oceans and is saline. Approximately three percent (3%) of the water on Earth is fresh water and its physical state varies from being a liquid, to becoming a gas or a solid. Approximately 69% of the Earth's fresh water is locked up in glaciers, ice caps and permanent snow cover in the polar regions. Groundwater accounts for 30% of the freshwater on Earth, while only 0.3% of all freshwater is contained in river systems, lakes and reservoirs (Kibona et al. 2009; Cassardo and Jones 2011; Lui et al. 2011).

As indicated in Fig. 1.2, approximately 99% of water is described as unfit or unavailable for human consumption. The remaining one percent (1%) consists mainly of groundwater, which can be difficult and costly to obtain. Only 0.0067% of the total water on Earth is fresh surface water that can be used. This leaves a total of around 2120 km^3 of freshwater that is available for human use and consumption (Cassardo and Jones 2011).

Numerous desalinisation plants, in fact more than 14,000, have been developed over the globe as a result of limited freshwater supplies. These plants produce over 60.5 billion litres of water daily and most of the Persian Gulf countries rely on such plants. Thus, without the implementation of these desalinisation plants or reverse osmosis technologies, the world's potable water supply would be very limited (Kibona et al. 2009; Curry 2010).

The most fundamental function of water is firstly as a prerequisite for life on Earth and secondly, as a commodity or economic resource. These two roles are constantly in conflict with each other in many areas of water usage. This has led to the exploitation of water through human activities which has in turn placed huge risks on aquatic ecosystems and the life that they support (Pimentel et al. 2010).

The distribution of water across the world's surface also plays a role. It is important to note that both the human population and water resources are unevenly distributed across the Earth's surface. Areas that are densely populated by human populations do not necessarily coincide with regions that are rich in water supplies. The minimum basic water requirement for human health is 50 L per capita per day and the minimum amount of water required per capita for food is approximately

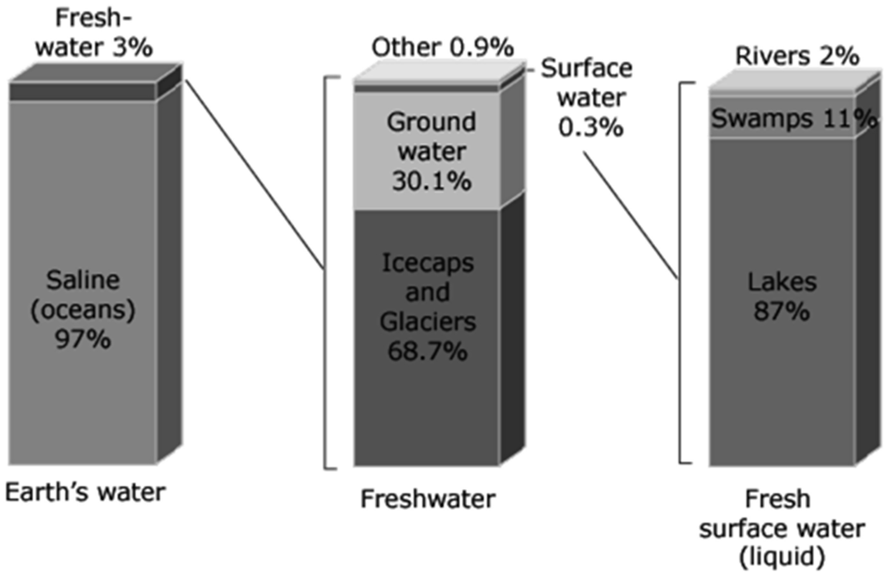

Fig. 1.1 Distribution of the Earth's water (Lui et al. 2011)

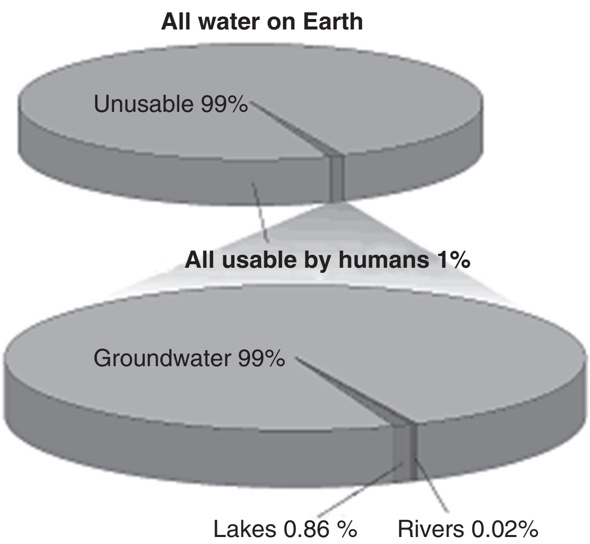

Fig. 1.2 Water available on Earth for human consumption (Lui et al. 2011)

400,000 L per year, as estimated by the World Business Council for Sustainable Development. However, regions such as the United States of America (USA) consume more than eight times that amount for human consumption and four times that amount per year for food production. This confirms the fact that water resources are unevenly distributed across the world (Kibona et al. 2009; Pimentel et al. 2010; Cassardo and Jones 2011). According to these minimum requirements, the total amount of water available on Earth is sufficient to provide for the whole population. However, most of the total freshwater is concentrated in specific regions, such as North America, while other regions such as the Middle East and North Africa face a water deficit (Cassardo and Jones 2011).

The changes that are currently being experienced in the further development of regions across the world have resulted in a pandemic array of changes in the terrestrial component of the water cycle. These changes relate in part to universal transformations in the global water system and are not isolated. Amongst others, they include the universal changes in freshwater systems in terms of the following.

Physical characteristics: These include long-term changes in surface and subsurface moisture storage and runoff, and persistent changes in precipitation and hydrological patterns. It is said that researchers generally have a limited understanding of the global scale manifestation of local hydrological mechanisms, as well as the intensity of such changes in the different regions. The altercation of physical characteristics of freshwater systems through developments such as mining operations can change characteristics such as the system's soils, wetland hydrology and geomorphology within one region and have unintended altering effects or cumulative impacts such as increased sedimentation or the altercation of a different freshwater system in another connected region or area (Alcamo et al. 2008).

Chemistry and biology: These include long-term alterations in the flow of nutrients and sediments toward the oceans, as well as the key levels of water quality and habitat parameters. The over utilization of freshwater systems through various human activities can be accompanied with an influx of nutrients within aquatic habitats and consequently greatly reduce aquatic organisms and hold severe consequences for aquatic ecosystems. An example of this could include the continued increase of waste water in the degradation of water quality on aquatic ecosystems and freshwater fisheries which remain an important protein for the poor population (Alcamo et al. 2008).

Anthropogenic water use and withdrawal: These include rapidly changing patterns of water consumption across different economic sectors and regions. Industrialised countries now tend to be associated with reduced withdrawals of water while the volumes of water withdrawn in the developing regions are increasing. These trends have caused changes in water stress patterns with uncertain global implications (Alcamo et al. 2008).

1.3 Water Use

Fresh surface water is mainly used across the globe as it can be easily extracted. It has recently been estimated that the approximately 69% of worldwide usage of water is for agriculture, mainly in the form of irrigation; 22% for industrial purposes, eight percent (8%) for domestic purposes, and one percent (1%) for recreational use (Kibona et al. 2009; Rosegrant et al. 2009; Cassardo and Jones 2011).

Many water usage sectors are facing increased competition between themselves in respect of water rights and withdrawals. For the business risk to be mitigated for industries and to ensure that the needs of future generations can be met, trade-offs need to be made and water management strategies and technologies should be developed or improved upon within the global, national and regional contexts. Business as Usual is no longer an option, but the capacity to develop Business Unusual models that are financially viable, socially acceptable and ecologically sustainable, remains a persistent constraint due to different visions, priorities and perspectives of water within the different sectors, regions and populations of the world.

1.3.1 Agriculture

In terms of water usage, agricultural activities dominate over all the other sectors on Earth. The agricultural sector's usage of water resources includes the water used for irrigation, for livestock, for fisheries and for aquaculture. The water removed for agricultural purposes is used solely for irrigation. The percentage of agricultural water used for irrigation is relatively higher in low- and middle-income countries. An alarming fact is that between 15 and 35% of the water that is withdrawn for irrigation purposes in low and middle-income countries is used in an unsustainable manner. To highlight this point is the fact that the amount of cultivated land in these countries increased by 24% since 1964, whereas the size of irrigated areas more than doubled between 1970 and 1995 (Kibona et al. 2009; Rosegrant et al. 2009; Lui et al. 2011; UN 2012).

As indicated in Fig. 1.3, approximately 70% of the world's irrigated land occurs in Asia, which accounts for approximately 35% of the area of cultivated land. The highest proportion of irrigated cultivated land occurs in the Democratic Peoples' Republic of Korea, which has a total of approximately 73%. Japan follows with 65%, China with 55%, while the proportions for irrigated land in other countries range from 20 to 40%. The agricultural water usage proportion for South Africa ranges from 47 to 63% and as such also follows the trend of agricultural water usage being the dominant sector (Kibona et al. 2009; Rosegrant et al. 2009; Lui et al. 2011; UN 2012).

The projections for global population growth are approximately two to three billion people over the next 40 years. Food demand will increase by 70% by 2050. With the increase in the demand for food and the fixed water supply, food products will need to be produced using less water. This can only be achieved by improving irrigation methods and technologies. There is the potential to increase the areas of cropland over the globe. However, approximately five to seven million hectares (0.6%) of this farmland is lost annually as a result of accelerating land degradation and urbanisation. This has caused the amount of cultivated land per person to decline even further from 0.4 ha in 1961 to only 0.2 ha in 2005 (Kibona et al. 2009; Rosegrant et al. 2009; Lui et al. 2011; UN 2012).

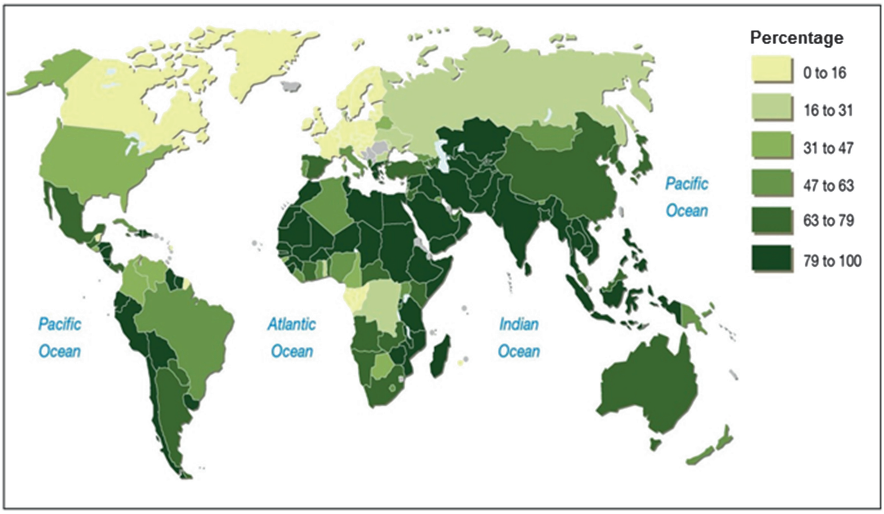

Fig. 1.3 Agricultural water usage across the world (FAO 2008)

In order to increase agricultural outputs, one needs to increase both the water and energy consumption of the world—which would in turn lead to intensified competition between the different water-usage sectors and place more pressure on the world's water resources. The main challenge that is facing the agricultural sector is not so much to grow 70% more food in 40 years, but rather to make 70% more food available to the world's growing population.

1.3.2 Industries, Mining and Energy

Industrial water usage is the second-largest consumer of water in the world. The consumers include economic entities such as mines, oil refineries, manufacturing plants, as well as energy installations using water for the cooling of power plants. The demand for water by the industrial sector of a country is generally proportional to the average income level of its people. Industrial water withdrawals constitute five percent (5%) in low-income countries as opposed to the above 40% in some high income countries (Refer to Fig. 1.4). A number of countries in Asia are now developing their economies around industrial development so that water usage in this sector will increase over subsequent years (Kibona et al. 2009; Lui et al. 2011).

The industry that uses the most water is the energy sector. Energy and water are intricately connected. All sources of energy and electricity require water in the production process, while energy is also required to make water available for human consumption through pumping, transportation, treatment, desalinisation and irrigation.

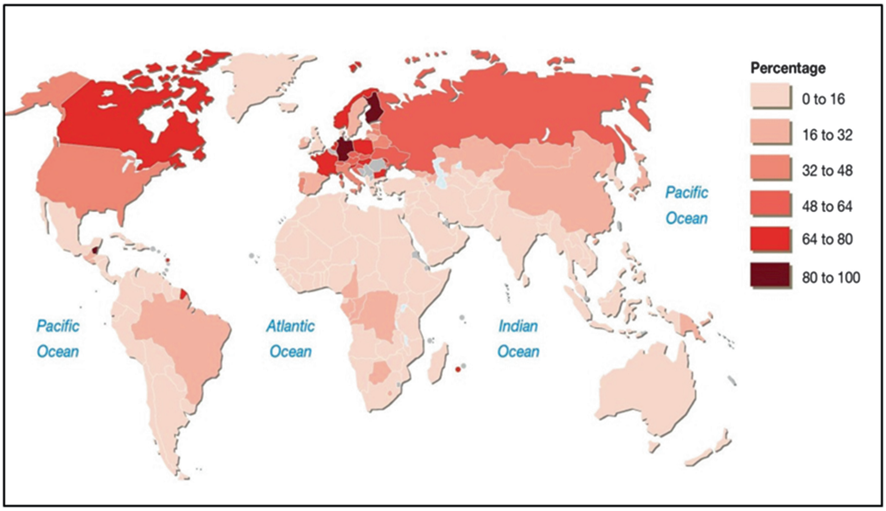

Fig. 1.4 Industrial water usage across the world (FAO 2008)

The EIA (2010) has predicted that global energy consumption will increase by approximately 49% from 2007 to 2035. This increase in energy consumption will place pressure on the energy sectors of the world and in turn also on water resources (UN 2012). In terms of South Africa, the energy situation is following the same trend. More coal-powered stations are being developed by Eskom in order to meet the needs of the growing population and the economic sector. This holds significant environmental impacts for the future if the precautionary principles are not taken into account.

1.3.3 Domestic, Recreational and Environmental

Domestic activities account for eight percent (8%) of the world's water consumption and constitute the third-largest water consumer across the globe. This category includes drinking water, bathing, cooking, sanitation and gardening activities. The estimated basic household water requirements are at around 50 L per person per day but excluding water for gardens (Gleick 2006; Kibona et al. 2009). Approximately 2 L of the 50 are used for drinking, 20 L for sanitation, 15 L for bathing, and 10 L for cooking. This estimate is however exceeded by most countries.

Recreational water use accounts for only one percent (1%) of the world's water consumption but this proportion is increasing slowly. This type of water use is associated with reservoirs. The water is categorised as recreational if the reservoir is kept fuller for storage purposes than it would otherwise be. Recreational activities include boating, angling, water skiing, as well as swimming, to name a few. The aforementioned types of water use are usually non-consumptive. However, sportsfields, such as golf courses, can be considered as consumptive.

Recreational water usage can have further consequences for other water usage sectors such as agriculture as it can reduce the availability of water for users at specific times. A good example of this is in the event of water being retained in a reservoir to allow for boating in late winter. The storage of water in the specific reservoir may cause this water to be unavailable to farmers during the spring planting season (Kibona et al. 2009; Lui et al. 2011). Even though recreational water use accounts for very little water withdrawal, it does compete with other water users such as the agricultural sector. As in the case of industries, recreational activities will have to compete for water in the future as a result of the increase in the world's population.

Lastly, environmental water usage uses the least water of all the categories mentioned previously and benefits ecosystems rather than human beings. The percentage of environmental water usage is very small. Notwithstanding this, the total water usage is increasing as a result of artificial wetlands and lakes that are intended for creating habitats for various wildlife species. As in the case of recreational water usage, environmental water usage is non-consumptive but may reduce the total volume of water that can be made available to other users at specific times and locations. With an increase in the adoption of ecocentric and biocentric value systems, we can expect more water to be directed in the future to ecosystems and nature reserves than to human needs (Kibona et al. 2009; Lui et al. 2011; UN 2012).

Widespread physical evidence suggests that human activities have already reached or even exceeded the renewable water limits in numerous regions across the globe. The chronic over-extraction of groundwater, which is now a common practice in many important food-producing regions and in large urban areas, is the clearest indicator of unsustainable water usage. Much of China's North Plain, the USA's Great Plains and California's Central Valley, parts of the Middle East and North Africa, the valley of Mexico and parts of South-east Asia are exceeding their groundwater recharge levels (Kibona et al. 2009).

The lower reach of China's Yellow River has run dry every year this decade with an entire section extending for 600 km from the river mouth upwards. China's Yellow River is just one example, as many other rivers across the world are currently running dry during all or part of the dry season when irrigation farming is at its most prolific—pointing to excessive water usage (Kibona et al. 2009).

Many water usage sectors are facing increased competition in respect of water withdrawals. In order to mitigate the business risk for industries and to ensure that the needs of future generations can be met, trade-offs need to be made and water management strategies and technologies should be developed or improved upon within the global, national and regional contexts. These sectors therefore have an influence on water availability through physical water abstraction as well as through water degradation. We therefore need to look at water quality as well before we determine the degree of water scarcity or water stress within a region or area.

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