

Chapter 2

Current and Future Water Scarcity and Stress



Current trends show that numerous water systems which sustain ecosystems, as well as growing human populations, have become stressed. Water sources are either being degraded by various types of pollution becoming unsuitable for use or have dried up. The different water use sectors have contributed to increased water scarcity by increased water wastage through inefficiencies as well as pollution. Climate change has also attributed to water shortages and droughts in some areas and floods in others around the globe. This chapter contains various case studies which emphasise the different manners in which water scarcity or stress can occur in various regions around the world.

Current consumption rates and further expansion and growth of the human population will exacerbate water stress and scarcity within regions and increase the rate of ecosystem degradation around the world. This should be a concern for all as it further increases water as a global risk.

2.1 Current Water Scarcity and Stress

The combination of increasing population growth, demographic changes, urbanisation, climate change and increasing water scarcity is posing numerous challenges for water supply systems. Water scarcity is defined as the lack of sufficient available water resources to meet a particular region's water needs. It has been widely documented that an increased number of countries around the world is entering an era of severe water shortages and limitations in freshwater supply are already evident where large areas are facing amplified consequences of dwindling and disappearing water reserves. Previously, most attention has been placed on Middle Eastern and North African countries, however, recently other regions have started to receive attention.

It is estimated that approximately four billion people worldwide are affected by severe water scarcity for at least one month a year which is much higher than the previous estimation of between two and three billion. This estimation was calcu-

lated by looking at people's water footprint from month to month and comparing this with the monthly availability of water in largest river basins. Particular problem areas which feel the effects of water scarcity directly were identified as Mexico, Western USA, Northern and Southern Africa, Southern Europe, Middle East, India, China as well as Australia farmers, industries and households which regularly experience water shortages. Other areas' water supplies were estimated to be fine but at a long-term risk (Mekonnen and Hoekstra 2016). Most of the sub-Saharan regions is characterised by economic water scarcity while more and more regions in developed countries such as the USA and China are approaching physical water scarcity.

Recent research has highlighted these alarming figures and has placed the water scarcity increasingly higher subject on the global agenda. With the human population estimated to expand to nine billion by 2050 accompanied by increased urbanisation, the demand for freshwater resources is set to increase dramatically. We therefore need to look at water stress within regions which occurs when water demand exceeds the available amount during a certain period or when poor water quality restricts use due to it being of an unsuitable standard for use.

Numerous countries around the world are experiencing different degrees of water stress. A country is deemed as water stressed when the annual per capita renewable freshwater availability is less than 1,700 m³. Increased number of regions and countries around the world are entering a period of water stress. 60% of European cities with more than 100,000 people are using groundwater at a faster rate than it can be replenished. Other cities such as Mexico City, Bangkok, Beijing, Madras and Shanghai have experienced aquifer declines of between 10 and 50 m. The human population has succeeded in harnessing most of the world's natural waterways by building dams, water wells, irrigation systems as well as other infrastructure which have allowed the human population to expand. This expansion has, however, been accompanied with increased stress on these water systems and has led to some rivers, lakes and aquifers to run dry. The main causes or threats to increased water stress around the globe, but not limited to, include water pollution, inefficient water use especially in the agricultural sector, continued population growth as well as climate change (WWF 2017).

Water Pollution Water systems can be polluted by various point and non-point sources which can include untreated human and industrial wastewater and waste as well as pesticides and fertilisers washing into systems from farms. These effects can be immediate or take a period of time to build up in the environment and food chain before the effects are recognised. A section within this chapter will elaborate more on the main water quality challenges which exacerbate water stress or scarcity within the different regions of the world.

Inefficient Agricultural Water Use The agricultural sector is the biggest water user in the world, however, 60% of its water use is deemed as being wasteful or inefficient due to leaky irrigation systems, inefficient application methods as well as planting "thirsty" crops. This sector has led to the drying out of some rivers, lakes and aquifers and big food producing countries such as India, China, Australia, Spain and USA

are facing increased water stress by having reached their water resource limits. The combination of agriculture's high water demand, as well as extensive water pollution through fertilisers and pesticides, have placed this water use sector as one of the main threats affecting both humans and other species.

Population Growth The doubling of the human population in the last five decades with the accompaniment of economic development and industrialisation has led to the transformation of the world's ecosystems and massive loss of biodiversity. Approximately, 41% of the world's population lives in river basins that are under water stress and the concern about water availability is increasing as freshwater use continues to be unsustainable. The continual increase of the human population requires continual increase for the demand for food, shelter and other resources which will result in additional pressure on freshwater resources. The increased demand for water will be driven primarily by the growing demand for food which is expected to increase by 70% in 2050 causing agricultural water use to increase by at least 19%. The increase of consumption will also be accompanied with increased water demand and use in manufacturing and production sectors.

The combination of the continued growth in the human population, as well as increased urbanisation, is creating further challenges and risks in terms of water scarcity and stress. The pressure that the world's human population places on available water resources varies across the globe. It is estimated that the global urban population will reach 66% by 2050 and is accompanied by major concerns of over-exploitation and pollution of water resources. Developing regions such as Africa and Asia are the two regions already suffering the most from lack of urban water supply and sanitation. An example of this is that 22 out of 32 major Indian cities deal with daily water shortages. The main driving forces, therefore, include a steady increase in water demand, inefficiencies in transfer and use as well as persistent water pollution. The lack of adequate infrastructure such as proper wastewater treatment and drainage facilities are leading to continued pollution of ground and surface water supplies.

Numerous scientists and academics have highlighted the pending predicament for all humankind that will result from high population growth rates and limited natural resources, the latter having been exploited and been depleted since the 1800s. Even though this physical end has not yet been reached, a crisis point from an international security standpoint is already evident in many regions. A large proportion of the world's population will be confronted with severe risks that will be triggered by inevitable droughts in their regions. The water shortages are expected to multiply in the future—even in the absence of the factor of global warming or climate change—as a result of mismanagement and pollution (Shen et al. 2008; Frederiksen 2009). Unless the human population learns to cope with less water, more and more communities will face water scarcity and their regions running dry.

Climate Change The continued effects of climate change on the world's resources are increasingly being recognised or noticed around the world. The continual pumping of carbon dioxide as well as other greenhouse gases into the atmosphere have

been accompanied with changes in weather and water patterns around the world and have consequently led to increased occurrences of droughts, floods and other extreme weather events. These changes can make less water available for water use sectors around the world and increase water stress. Chapter 4 investigates the possible influence of climate change on the world's freshwater resources.

It is important to note that the World Economic Forum has placed the world water crisis in the top three of global problems alongside climate change and terrorism. This threat is quite clear as numerous regions across the globe are faced with water stress. The sub-Saharan African region has the largest number of water-stressed countries of any region in the world.

More than 80 nations across the globe are characterised by water demands exceeding available supplies, more than 300 cities across China have inadequate water supplies and in some arid regions such as the Middle East and parts of North Africa, the low annual rainfall and expensive irrigation techniques have culminated in a grim scenario for agriculture in the future.

Impacts or consequences of increased water scarcity and stress can be severe and have everlasting effects on a region. Some of these impacts include the disappearing of wetlands, damaged ecosystems as well as the lack of water for billions of people around the world. Clean freshwater is essential for the functioning of ecosystems as well as for human health. When waters run dry, people are unable to access enough water to drink or feed crops and can lead to economic decline. Furthermore, inadequate sanitation may also lead to increased water-related diseases such as deadly diarrheal diseases which include cholera, typhoid fever and other waterborne illnesses.

2.2 Case Studies of Current Water Scarcity and/or Stress

2.2.1 Desiccation of the Aral Sea and Lake Chad

The cases of the disappearance of the Aral Sea located in Central Asia as well as Lake Chad in Central Africa are perfect examples of the consequences of excessive surface water withdrawal causing water stress within a region.

The Aral Sea was the fourth largest saline lake in the world up to the twentieth century and is fed by two rivers namely the Amu Darya and the Syr Darya located, respectively, in the South and North. These rivers were, however, diverted by the Soviet Union in the 1960s to irrigate the desert region surrounding the sea for agricultural purposes rather than feed the Aral Sea basin. The construction of these canals was aimed at developing a massive industry on cotton farming but led to dramatic negative consequences for the basin.

The Aral Sea was deprived of its main sources of water income and it was estimated that the majority of the water that was being diverted through canals were soaked up by the desert and blatantly wasted (25–75% season dependent). The diversion of

the rivers caused an imbalance in the water system and led to the slow desiccation of the sea since the 1960s.

Lake Chad, located on the southern border of the Sahara, was an attractive oasis for four separate nations which laid claim to it as their borders intersect in the middle of the body of water. The basin supports more than 20 million people with the upper part of the catchment supporting fishing, agriculture and pastoralism. The increase in the surrounding region's population led to an increase in agricultural water demand for irrigation (Jacobs 2007). This with the accompaniment of warmer summers led to excessive water use within the region and led to Lake Chad being reduced to one-twentieth of its original size. Overgrazing, as well as unsustainable irrigation, resulted in the replacement of natural vegetation with invasive plant species, deforestation and the drying of the climate.

The consequences for the Aral Sea region has included hotter summers and colder winters, dust storms as well as "salt storms" which has swept across the region and bombards the surrounding environment with sand and toxic chemicals which have been left behind by Soviet factories built on once islands isolated from the sea's shore. Two small portions remain in the north and south. The Northern portion may survive as extensive work is being done to make sure that it does not receive the same fate as the rest of the region, however, the Southern part is drying up year after year and has no inflow from any rivers. The main environmental impact has therefore been the significant loss of water accompanied by a sharp increase of salinity exceeding the threshold of commercial fish.

Other impacts included a change in sea surface temperature (hotter in summer, colder in winter), desertification of the surrounding region, salinization of soil, and climate change. These environmental effects have caused the population growth rate in the Aral Basin to become diminished. Other regions have experienced an increase in population as well as water demand and have forced Uzbekistan to trade water for natural gas with Kyrgyzstan. The idea of the Soviet Union did, however, work in the sense that today cotton is Uzbekistan's primary export. However, the environmental price that has been paid is that the Aral Sea is now massive expanses of salt plains and a dry, barren graveyard surrounded by dozens of ghost towns which thrived on the fishing industry (Ataniyazova 2003; White 2013).

The consequences for the Lake Chad region may include future wars and civil violence as water scarcity intensifies with climate change and the lifeblood of Lake Chad's 20 million beneficiaries decreases with continued population growth, spread of disease, oppression and corruption. The fluctuations of the lake's water level have also caused considerable changes in fish fauna leading to high mortality, disappearance of some open water fish species as well as appearance of species adapted to swamp conditions which were previously unknown. The surrounding population is consequently relying less on fishing and shifting more towards the raising of cattle, sheep and camels as well as the farming of the emergent lake floor as flood waters recede. The region is also threatened by desertification due to climatic irregularity, occasional extreme droughts, unsustainable management of natural resources and population increases throughout the region. Other impacts also include the spread of invasive alien grasses and improper water management which include the building

of dykes and lack of proper irrigation systems have led to the accumulation of salt in the soil (FAO 2017).

Therefore, the disappearance of the Aral Sea and Lake Chad can be seen as prime examples of how excessive water use within a region and poor water planning and management could lead to increased water scarcity within a region and have severe consequences for the environment as well as the surrounding population. There are numerous other examples of disappearing water resources over the world which are also attributed to excessive water use. We must therefore highlight these issues and stay mindful of that excessive water use accompanied with a lack of proper water planning and management can have severe unintended consequences.

2.2.2 China: Plentiful but Unusable

The dominant view or image associated with water scarcity is primarily the excessive overuse of water resources leading to dry riverbeds and lakes, however, this is not the only factor which plays a role as the case of China will illustrate. Until recently, most focus has been placed on the country's immense air pollution, however, it is now stated that water pollution is as serious an issue.

China contains approximately 20% of the world's population, however, only 7% of the world's available water resources. The country has enjoyed double-digit economic growth over the past three decades making it one of the world's largest economies but not without a price. The region has been facing increased water scarcity, particularly within the northern part of the country which has recently started to spread to the south. The increased water scarcity and stress is mainly attributed to insufficient local water resources as well as improper water quality due to continued increased pollution. The uneven spatial distribution of water resources within the country, the continued rapid economic growth and urbanisation of a large and growing population with poor resource management have caused China to be very vulnerable in terms of its water resources (Jiang 2009; Tiezzi 2014; Jing 2016).

Water scarcity has become more prominent within the region as it has spread from the north and west to the south and east with major lakes along the Yangtze River drying up. This situation is further exacerbated with intense pollution causing water to be unusable. Parts of the Poyang Lake, the largest freshwater lake in the country, have been drying up and become grassland within the winter months due to overexploitation of water resources upstream. A similar situation is present at the Dongting Lake, located in Hunan, where inflows from the Yangtze River have decreased by 40%. Rivers in the northern regions of the country have also been overexploited beyond international safety limits. Sustainable groundwater extraction limits have also been surpassed by extracting 6 billion m³ for industrial and agricultural growth and has consequently led to villagers in Wei county having to dig 360 instead of 120 m deep to reach groundwater resources (Economy 2013; Shemie and Vigerstol 2016).

The country's water resources are further plagued by excessive industrial wastewaters and pollution as well as fertilisers and pesticides from the growing agricultural sector which has made many resources unusable. Excessive pollution is causing the more plentiful water resources located in the south and east of the country to become scarcer and have consequently expanded the country's water crisis. Water pollution and shortages is a major problem in Northern China with 45% estimated to be unfit for consumption compared to 10% in the south. The northern province of Shanxi has been affected the worst with 80% of rivers being rated unfit for human contact. The situation will become even more severe as the country's economy continues to grow.

The country is, therefore, experiencing a severe water pollution crisis with nearly 80% of the groundwater being polluted and is unsafe for drinking, up to 40% of rivers are seriously polluted and 20% are polluted to such an extent that their water quality is rated as being too toxic to come into contact with. Main causes for water pollution include wastewater from factories such as the 10,000 photochemical plants located along the Yangtze and 4,000 along the Yellow Rivers as well as sewerage pollution from more than 80% of treatment facilities not meeting government standards. China has focussed predominantly on industrialisation and economic growth which has been accompanied with widespread destruction of the natural environment and ecosystems through smog, sewage and industrial wastewaters and litter (Economy 2013; Jing 2016; Shemie and Vigerstol 2016).

Approximately one third of industrial wastewater and more than 90% of household sewage is estimated to be released untreated into rivers and lakes around the country. This is mainly attributed to almost 80% of cities not having proper or any sewage treatment facilities. Half of the country's population lacks safe drinking water and an estimated more than 500 million people in rural areas use water contaminated by human and industrial waste. Lakes are often affected by pollution-induced algal blooms and multiple rivers are unsuitable for human contact. The pollution and waste associated with the agricultural sector did not receive enough attention and led to pollution being double the predicted estimate set by the government in 2010 and a pollution census revealed that fertiliser is a bigger source of water contamination than factory effluent.

The effects of this widespread pollution have been detrimental towards the environment and human health. Some effects include mass mortality of fish as rivers are covered with layers of floating litter and contaminated by agricultural, industrial and human waste. Deformities in fish have also been recorded and been blamed on a paint chemical widely used in the industry. The pollution is also spreading and China is now described as the largest polluter of the Pacific Ocean with the development of offshore dead zones and red tides. Pollution has also affected the Chinese economy by causing economic losses of approximately US\$69 billion per year. Human health has also been seriously affected with gastrointestinal cancer now being the number one killer in the rural areas due to two-thirds of the rural population having to use water contaminated by human and industrial waste. Some village residents within the Guangxi Province in Southern China were poisoned by arsenic-contaminated water which has been attributed to the waste from a metallurgy factory located nearby. Some villages are now being described as "Cancer Villages" where cancer rates

have risen dramatically due to pollution. There are said to be around 100 cancer villages along the Huai River and its tributaries in Henan Province, especially on the Shaying River. Death rates on Huai River are 30% higher than the national average. Other health effects include diarrhoea, bladder and stomach cancer, other diseases caused by waterborne pollution, miscarriages and birth defects as well as death (Jing 2016; Shemie and Vigerstol 2016).

The country has acknowledged the urgency to address the water crisis and have provided funding to local governments to address water issues from water conservation and water diversion projects primarily aimed at “stabilising economic growth” by raising employment and investment levels. Focus has also been placed on increasing water efficiency and decreasing water use and has worked on the US\$60 billion South–North Water Diversion Project which will bring water from the moisture-rich south to the dry north. The acknowledgement of the water crisis, as well as the development of various pollution prevention work, are encouraging however it was found in 2016 that US\$2.56 billion was not effectively used and seems like corruption may hinder the needed progress (Jing 2016; Shemie and Vigerstol 2016).

Therefore, the degradation of water resources is as big as a threat to increase water scarcity within a region as excessive water use. The combination of these two factors can be detrimental to both the environment as well as the region’s population as shown in this case study. Countries, therefore, need to take note of this and highlight the importance of proper water treatment infrastructure or technologies as well as enforcement of regulations to ensure that wastewater is treated properly to decrease the further degradation of water within regions. The combination of excessive water use as well as the continued degradation of water quality can be detrimental to a region and lead to increased water scarcity if proper steps and measures are not taken to address the various identified issues.

2.2.3 Sri Lanka: Water Scarcity Due to Drought or a Lack of Planning

Sri Lanka, a developing country, has been described as a country with untapped surface and groundwater resources with water resource potential, estimation of some major competition for water resources between sectors, an unlikelihood of severe water shortages with water quality as well as excessive extraction of groundwater becoming an issue of concern. The country has an average rainfall of 2,200 mm per annum with drier regions having 900 mm per annum. The agricultural sector accounts for 85% of the water demand through irrigation. The country is heavily dependent on both rain-fed and irrigated agriculture and the sector forms the pillar of rural livelihoods (IWMI 2007).

It has been estimated that the country is not likely to face a water crisis situation by the year 2025 but will have some areas of concerns in terms of quality and groundwater extraction which needs to be monitored and properly managed. Some

research has suggested that the overall rainfall of the country has decreased in some areas, that rainfall patterns have changed and that the distribution of rainfall in certain parts of the country have also been undergoing changes. Other research also indicates that aggregated national level statistics on water scarcity has been misleading as recent statistics indicate that water availability will be a significant constraint in certain districts and will indeed be a significant constraint on social and economic development (IWMI 2007; Rodrigo and Senaratne 2013).

The country has also experienced an increase in water demand by sectors such as hydropower, domestic and industry along with the population growth. Increased water demand within the various sectors will and may lead to conflict between water use sectors. Water quality within the country has also steadily decreased due to increased urban pollution, agrochemical pollution which will exacerbate water scarcity by leaving water resources unusable. As most other developing countries, Sri Lanka also has a high water inefficiency in many irrigation schemes which also needs to be taken into account. Water scarcity will therefore indeed be an issue in the country and requires proper planning and management to ensure that the country does not experience a water crisis in the near future (Rodrigo and Senaratne 2013; Fernandez 2017).

The country has recently been experiencing the worst drought in four decades and has fallen into a water crisis with more than a million people experiencing acute water shortages and with more shortages expected in the near future. The lack of rain associated with the drought has caused water resources to become saline and not suitable for drinking. Rain is not expected, water levels of reservoirs are declining to a fifth of their capacity and the agricultural and hydropower generation sectors have also been affected. The drought has caused a delay in the planting seasons and has been responsible for crop damages. Farmers have only managed to plant a third of the usual paddy fields, predictions show that half of the crops may fail and the next planting season is at risk. Several districts in the country have been affected by water shortages (Fernandez 2017).

Efforts have been made by the government to address some water-related issues by establishing new infrastructure, rehabilitating or renovating dams, reservoirs, canals as well as promoting agro-wells and micro-irrigation technologies to address the rising agricultural water demand. Despite these efforts, water scarcity problems have continued to rise.

The lack of policies, improper planning as well as the lack of public awareness related to the extent of the country's water problems has been identified to be the biggest culprit for the country's water shortage problem. The country has been experiencing more extreme weather conditions and has been alternating between drought and floods, both which have led to shortages of clean water. This pattern has been identified by experts and policymakers and effective national interventions have not been put in place to address the identified issues. An example of this is the reluctance of officials to release water in storage of the largest reservoir in the Polonnaruwa District that is currently at 50% capacity as they fear that there will not be enough water for irrigation for farmers to plant in the next growing season which starts in November. The water demand, as well as competition for water, is growing within the

country and better cooperation is required between the various government sectors as currently very little coordination exists. The lack of public awareness related to the extent of the country's water problems has also contributed to the country's water supply problems. Residents within the Poddibanda village is a good example of this as they are at the mercy of changing rainfall patterns and have had little assistance in learning to manage their water resources better. The improvement of water management within villages are important for their economic well-being as most farmers who are water short are preparing for cultivation as they expect the government to provide free irrigation water, regardless of rain or reservoir levels. Public awareness campaigns are therefore needed to build knowledge within these communities about water management practices and national water management policies are required to coordinate water planning between water sectors (Rodrigo and Senaratne 2013; Perera 2016).

The country will experience aggravated water scarcity as increasing evidence suggest that climate change will exacerbate water availability and quality issues. New innovative approaches are required in the agricultural sector to meet its future demands. Water balances also need to be achieved between the demands of the agricultural sector and the municipal and industrial water use sectors. The achievement of water balance between these major water use sectors will enable the country to carefully assess their set public health, environmental protection, economic viability as well as their food security goals. Other steps which can be taken are the development of crop varieties which have a lower water demand. It is therefore of prime importance that different government agencies such as the Department of Agriculture, Department of Irrigation as well as the Department of Meteorology recognise that they have an important role to play and that they have to work closely and share knowledge and information to improve water management strategies within the country (Rodrigo and Senaratne 2013; Perera 2016).

2.2.4 The Horn of Africa—Persistent Cyclical Drought

The Horn of Africa, which includes Kenya, Ethiopia, Somalia, Uganda and Djibouti, experienced the worst drought in 60 years in 2011 which threw millions of people across the region into one of the worst crises. Somalia which has been ravaged by conflict experienced the most disastrous consequences and hundreds of thousands of people, many of them children, have starved to death.

The United Nations Food and Agriculture Organisation has once again declared that the region is facing food shortages owing to the persistent lack of rainfall between October and December and as many as 12 million people, are in need of food assistance. This is, however, not a new occurrence within the Horn of Africa as the region has experienced persistent drought since 2014. The region has been caught up in this cycle which is likely to repeat itself despite countries attempting to prevent drought and other climate-related disasters. With little rain and none expected for the next

couple of months, it has been warned that 17 million people are facing hunger in the region (FAO 2016).

The region is likely to see a rise in hunger as well as the future decline of local livelihoods as the population is struggling with the knock-on effects of the consequent droughts that it has been experiencing. The situation is further intensified by the rise in refugees in East Africa, placing additional pressure on the already strained food and nutrition security of the region. The Horn of Africa is experiencing severe water shortages and some families within Kenya have resorted to eating only one meal a day in an attempt to conserve fading food supplies. The region's environment has also been affected (Ngumbi 2017; ActionAid 2011).

Climate change has been identified by scientists as being the main factor which has been exacerbating the continued droughts within the region and it has been estimated that the situation will worsen as the increase of global temperatures have resulted in droughts becoming more frequent and severe and heavy rains causing more flooding. Climate experts assumed there would be an increase in rainfall in rainy seasons due to the rise in the Indian Ocean water temperature, however, recent trends indicate that the region is drying faster than anytime in the past 2,000 years.

Not only the human population have been affected by the prolonged droughts, ecosystems such as the Serengeti, have also been adversely affected. The prolonged droughts have impacted upon the grassland and its ability to sustain large herds of herbivores as well as the level of the Mara River and Lake Victoria which is the lifeblood of the Serengeti migration as well as a source of water and livelihood for large populations of Tanzania and one-third of the East Africa population. The flow of the Mara River has already been reduced by 25% and is increasingly being polluted by pesticides, sewage and phosphates. Flash floods which have followed periodic droughts have also eaten away vegetation on the river banks increasing soil erosion and sedimentation. The declining level of Lake Victoria is a critical issue. Tanzania uses the largest share of the lake, however, Uganda controls the outflow. Uganda has constructed two dams and has increased the discharge of the White Nile River by 30–50% which has led to the reduction of the lake's water level by two metres. Another dam is being constructed which has destroyed large areas of papyrus swamps and have placed the fishing industry under immense risk through the reduction of fish populations and breeding areas (ActionAid 2011; FAO 2016).

Rapid intervention is therefore required in terms of the affected populations as well as areas constantly affected by natural hazards to assist in their ability to withstand or adapt to the impacts accompanied by these persistent droughts. Predictions indicate that some regions such as Southern Kenya will be less affected by the drought mid-2017; however, regions in the north may worsen. As indicated previously, some strategies have been implemented in the region. Short-term strategies include the distribution of food and long-term strategies include the planting of drought-tolerant crops or diversifying crop and income base of communities. Kenya has also started to invest in community water sources in an attempt to decrease the dependence on rain-fed agriculture and have established a national drought management authority (ActionAid 2011; FAO 2016; Ngumbi 2017).

The Horn of Africa is gripped in persistent droughts and water scarcity which is a great threat to various countries, millions of people as well as the environment which contributes to the region's economy through ecotourism. Climate change will exacerbate the current situation through prolonging droughts as well as increasing extreme weather events which will increase hazardous areas in the region. The Horn of Africa region is, therefore, a prime example of how climate change can exacerbate water scarcity within a region through prolonging droughts and increasing hazardous events such as flash floods.

2.3 Conclusions

In conclusion, as indicated by previous sections and the included case studies, numerous water systems which sustain ecosystems, as well as growing human populations, have become stressed around the world. Rivers, lakes and aquifers are either being degraded by pollution to such an extent that it is unsuitable for use or are drying up. More than half of the world's wetlands have been destroyed, agriculture has the highest water use and contributes to increased water scarcity by increased water wastage through inefficiencies as well as pollution and lastly, climate change have caused water shortages and droughts in some areas and floods in others.

The current consumption rate as well as the human population estimated to be 9.6 billion in 2025, will increase water stress and scarcity within regions even more and increase the rate of ecosystem degradation around the world more. With climate change estimated to exacerbate water stress and scarcity around the world, it therefore needs to be acknowledged as a serious threat to the sustainability of the environment and human livelihoods as well as increasing competition between water use sectors, promote further water-related risks and possibly conflict. The following two chapters will, therefore, focus on the multiple facets of climate change and its predicted consequences to establish which regions will be more at risk of increased water stress, scarcity and other water-related risks.

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