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Climate Change-Induced Water Scarcity: A Threat to Human Health*

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ABSTRACT

Climate change might affect the development of water scarcity least in some areas of the world. Water scarcity means not only the availability but also the quality of water and sanitation. Climate change might reduce the capacity of the state to provide health care to the population. Thereby, climate change has direct and indirect impacts on human security and hence health effects may result from (climate change induced) water scarcity. Mainly developing countries will be affected by water scarcity due to their population increase. Water scarcity may lead to a reduction of institutional resources and thereby to a lack in the health care system. Therefore, climate change causes different factors which may promote local and/or transnational conflicts. This impacts the human security and health. Even though climate change is not the only reason for water scarcity, it may affect political and social conflicts and has thereby impact on populations' health.

KEY WORDS: Climate Change, Water Scarcity, Conflict, Health and Well-being.

Climate Change and Water Scarcity

Climate change poses a potential threat to the earth's biodiversity. Recent assessments have shown that climate change could undermine the living conditions of people all over the world (Scheffram & Battaglini, 2010). Anthropogenic climate changes could cause water stress, food insecurity, soil degradation, natural disasters, and environmental migration. There is a growing consensus among scientists that climate change is creating a physical shortage of

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water which is likely to be a source of regional and international conflicts (Mukheibir, 2010).

The concept of water scarcity needs to be understood in both global and regional contexts. Hydrologists typically assess scarcity by looking at the population-water equation (Mukheibir, 2010). From the water stress index, when a country falls below 1000 m^3 of fresh water per person per year, it is considered a water-scarce country; and if it is below 500 m^3, the country is considered to be in absolute water scarcity (Falkenmark, Lundquist, & Widstrand, 1989). It is reported that currently about 1.2 billion people do not have access to safe drinking water and this figure will be 2.7 to 3.5 billion people by 2025 if effective steps are not taken to mitigate the water scarcity problem (Mukheibir, 2010). The Middle East and some parts of Africa could suffer water scarcity as they are likely to run out of water (Qadir et al., 2003). Table 1 shows that some countries in Africa and the Middle East will be in the grip of serious water scarcity within the next fifteen years.

Table 1
Water Availability in 1995 and in 2025 (Source: Homer-Dixon, 1999)

	Per Capita water availability 1995 (m^3/person/year)	Per Capita water availability 2025 (m^3/person/year)
Africa		
Algeria	527	313
Burundi	594	292
Egypt	936	607
Ethiopia	1950	807
Kenya	1112	602
Libya	111	47
Malawi	1933	917
Morocco	1131	751
Rwanda	1215	485
Somalia	1422	570
South Africa	1206	698
Tunisia	434	288
Asia/Middle East		
Bahrain	162	104
Iran	1719	916
Israel	389	270
Jordan	318	144
Kuwait	95	55
Oman	874	295
Qatar	91	64
Saudi Arabia	249	107
Singapore	180	142
Yemen	346	131

The most visible effect of climate change is the change in availability and patterns of consumption of fresh water because of changes in temperature, precipitation, productive capacity of the soil, and in the patterns of human settlement (Raleigh & Urdal, 2007). Increasing climate variability is expected to

alter the present hydrological resources and increase pressure on the availability of water resources in some parts of the world (Mukherbir, 2010).

Furthermore, anthropogenically induced climate change could create a serious imbalance in the supply and demand of water world-wide. It may be noted that water availability and consumption is contingent upon the geographical and temporal availability of water. Unfortunately, water is in high demand in regions like South Asia, Southeast Asia and North Africa, places where it is not naturally abundant (Kanae, 2009). The reason for the high consumption of water in these regions is intensive agricultural activities, as 70 percent of water in these regions is used for crop production. Figure 1 shows that already water-scarce countries such as Egypt, Jordan, and Pakistan are extensively using renewable water resources for irrigation purposes, which is obviously not ecologically sustainable (Khan & Hanjra, 2009). Many crop-producing regions are located in semi-arid areas and the exploitation of water is greatest in these regions. To meet the huge demand for water, sophisticated pumping technologies are used to extract groundwater, thus making water use unsustainable and beyond the capacity of the hydrological cycle to recharge. This is why, all over the world, groundwater sources are in decline due to over-pumping and pollution (Schewartz & Ibaraki, 2011). There are persistent warnings that groundwater, especially in parts of India, northern China, and Pakistan, is being depleted at a rate higher that its replenishment (Butler, 2009).

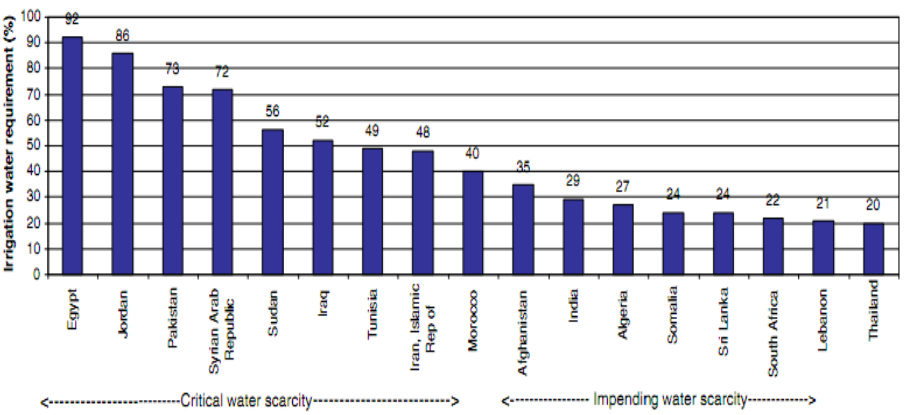

Figure 1. **Water scarcity: Irrigation water withdrawal as percentage of renewable water resources (Source: Khan & Hanjra, 2009)**

Agriculture consumes more water than any other human activity. Although the total amount of water available in this world is enough to complete the hydrological cycle, most of it is concentrated in specific regions, leaving other areas water-deficient (Qadir et al., 2003). In most developing countries, which are already water deficient, population growth is high and as a result agriculture is under pressure to produce more food. Hence, in these countries, the consumption of good-quality irrigation water will further increase municipal-industrial-agricultural competition (Qadir et al., 2003). Usually, in a situation of competition,

socially and economically powerful sectors of society are successful in capturing (through buying or bullying) major sources of water, thus depriving the marginalized population of an adequate quantity of fresh water or forcing them to use water polluted by industrial activities.

Climate change could aggravate periodic and chronic shortfalls of water, particularly in the arid and semi-arid areas of the world (Mujumdar, 2008). Recently, climate models have consistently and robustly predicted that global warming will create water scarcity in semi-arid regions (Kanae, 2009). One of the most obvious hydrological changes due to global warming is the change in natural water supplies from snow cover and glaciers, both of which are projected to decline (Kanae, 2009). The resulting low water flow, combined with higher temperatures, will not only create water shortages but will also pollute fresh water with sediments, nutrients, pesticides, pathogens, and salts (Peterson & Posner, 2010). Another connected factor could be global-warming-induced sea level rise, which will lead to saline water intrusion into groundwater and thereby reduce the availability of fresh water (Werner & Simmons, 2009).

Climate change could also contribute to decreasing the level of precipitation and increasing the frequency and average length of droughts (Peterson & Posner, 2010). Such a situation leads to a sharp increase in the demand for irrigation water as well as domestic and industrial water use (IPCC, 2001).Additionally, climate-change-induced high temperatures may degrade water quality as increasing water temperature could alter the rate of operation of bio-chemical processes and lower the dissolved oxygen concentration of water (IPCC, 2001).

Climate change is not only creating a scarcity of water but is also causing the problem of "too much water", such as flooding in some temperate and humid regions of the world (Kanae, 2009). It is projected that the minimum flood-affected population in a year is soon likely to exceed 300 million and will mostly affect populations in warm humid regions, including South Asia, Southeast Asia, and East Asia (Hirabayashi et al., 2008).

Although the damage inflicted by climate change is global in scope and is not restricted by national boundaries, poor and less developed countries are the worst victims (Nordas & Gleditsch, 2007). The negative impacts of climate-change-induced water scarcity are multiplied when they are combined with social conditions such as warfare, corruption, trade dependency, and inadequate education and health-care infrastructure (Barnett & Adger, 2007). For instance, most developing countries lack the resources and institutional capacity needed to treat poor-quality water. Therefore, people are forced to consume contaminated water, which sharply increases their health problems and economic vulnerabilities (Nordas & Gleditsch, 2007). As a result, health and economic inequalities both within and between countries are widening and the global system has not yet been able to bridge or reduce these inequalities. Cumulatively, the potential consequences of water scarcity for security, the environment, and human well-being are grave (Brown & McLeman, 2009) as they have, directly or indirectly,

contributed to increasing social chaos, economic uncertainties, and political conflicts across the globe (Barnett & Adger, 2007).

Water is essential to sustain life. Access to an adequate quantity and quality of water is a fundamental human right as denial of this right means deprivation of health rights, and the inability to live a dignified life. Millennium Development Goal Number 7 stresses the need for environmental sustainability. To realize this goal, accessibility to safe drinking water and basic sanitation is necessary (Vidyasagar, 2007). But to date, in many parts of the world, people still do not have the basic right to access water. It is unfortunate that the not very distant future (2025) is likely to pose a very daunting challenge of water scarcity in many developing countries which are not even ready to meet the water scarcity challenge today (See Figure 2).

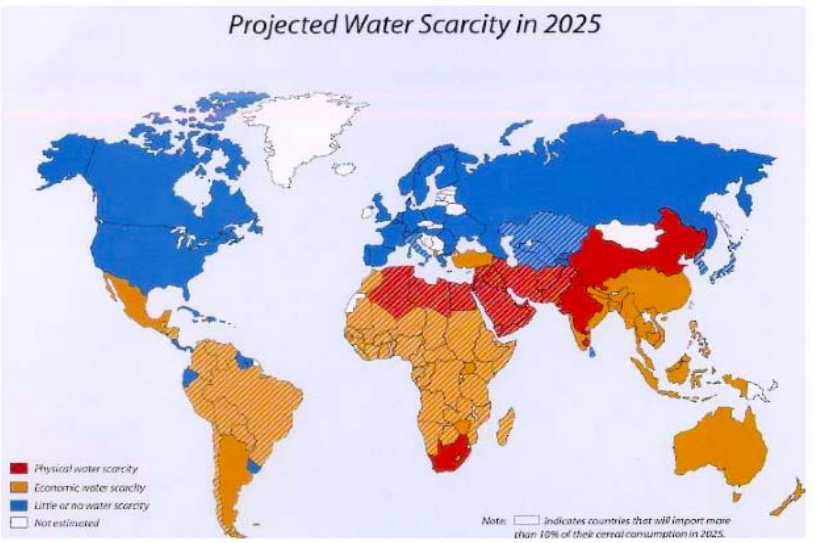

Figure 2. **Projected water scarcity in 2025 (Source: International Water Management Institute 2000)**

Currently, water is a saleable commodity; it is sold by commercial profit-making enterprises. Water prices are regulated according to market dynamics; an individual needs to buy water and those who do not have the buying capacity remain without water or rely on poor-quality water. So if an individual is deprived of access to an adequate quantity and quality of drinking water, the scarcity of water is not only physical but also social: it is a societal failure of not providing individuals with the capability to acquire a valuable commodity (water) that is essential for survival.

Although there is evidence that climate change could cause water scarcity, one should be careful about exaggerations and oversimplifications. The problem of water availability may not be exclusively due to global warming but may also depend on the patterns of change of water withdrawal (consumption), which are primarily driven by population growth, the expansion of agriculture, and ruthless competition for economic growth. Historically, resource scarcity or its threat may

not always have a destabilizing character or destructive consequences. Sometimes threats produce opportunities for beneficial change in the distribution of wealth and in processes of governance (Homer-Dixon, 1994). But this threat can only be translated into opportunity if the true nature of the threat and its causative mechanisms are understood, and there is the political will to solve the problem. In essence, the problem of water scarcity is complex and deeply embedded in collective and individual human behavior patterns; and the conservation or wastage of water depends on the ways in which societies exploit, divide, distribute, and use ecological and environmental resources. In order to ensure sustainable water consumption and to provide access to water to marginalized populations in developing countries, there is a need for a radical transformation in society's approach to the environment, population growth, the expansion of agriculture, and the distribution of rights, opportunities, and entitlements (Butler, 2009). In summary, water is essential for sustaining life and no segment of society across the globe should be deprived of its fair share of water.

Water Scarcity, Social Inequality and Conflict

Water and social inequality. The debate about water availability and scarcity is complex and somewhat uncertain. For example, despite scarcity statistics, humans currently use <10% of the maximum available renewable freshwater resources (Oki & Kanae, 2006). Nonetheless, the distribution of renewable freshwater resources between and within countries is highly unequal and 80% of humanity lives in regions where water security is threatened (Seekell, D'Odorico, & Pace, 2011). Water scarcity is not only rooted in the physical availability of water, but also in the problem of water consumption and distribution in the face of unbalanced power relations, poverty, and inequality between various sections of society (Kummu et al., 2010). Both physical and social scarcities highlight important aspects of water scarcity and thus complement each other.

Water is a precious commodity and is essential to sustain life. Like air, "safe, clean drinking water and sanitation are integral to the realization of all human rights" (United Nations General Assembly, 2010, p.1). But, unfortunately, water is seldom considered a public good or a basic human right in many parts of the world. All over the world, especially in developing countries, industrial projects and excessive use of chemicals and fertilizers pollute and contaminate water reservoirs (Clark & York, 2005). This destruction is not abstract, theoretical, or hypothetical, but real and observable at a common-sense level. People observe this destruction and understand its consequential existential threats, even though they may not be powerful enough to stop this process. This is the point where affected people realize their powerlessness and voicelessness.

Overpopulation, economic development, and changing patterns of consumerism have been sharply increasing the demand of water. Currently, more than 50% of humanity lives in cities (United Nations Center for Human

Settlement, 2001) and the process of urbanization continuously puts pressure on freshwater consumption and also produces a huge quantity of wastewater (Jenerette & Larsen, 2006). In many developing countries, untreated industrial and domestic wastewater drains into rivers and streams, which contaminates both surface and groundwater.

The water problem is also embedded in growing consumerism and the emerging "middle class" in booming economies like China. Within these economies, wealthier and richer populations demand a higher consumption of meat, and the production of meat requires several times more water than grain production (Khan & Hanjora, 2008). For instance, to produce 1 tonne of fresh bovine meat requires 20 000 m3 of fresh water (Qadir et al., 2003) and the production of one tonne of rice needs 7 000 m3 of water (Rosengrant et al., 2002). To overcome such problems, it is proposed that water-scarce countries can balance their water needs by importing agricultural products that consume huge quantities of water. In other words, through an international trade in agricultural and industrial products, they actually import virtual water (Allan, 1998; Chapagain & Hoekstra, 2004; Seekell, D'Odorico, & Pace, 2011).

Virtual water transfer is thought to "save" water because crops can be grown in water-use-efficient environments and exported to other countries with greater water-use requirements for the same crop (Seekell et al., 2011). But, in reality, water-scarce countries may be exporting virtual water by exporting agricultural products to water-rich countries (Wichelns, 2010). For instance, Pakistan, a critical water-scarce country, has been exporting cotton and rice to some European countries that are not yet water scarce. Such an international trade could be detrimental to global water security.

There is another dimension to water inequality in terms of its access by gender and social class. Of late, more international attention is being paid to the intimate relationship of women in developing countries to water (Seyfried, 2011). At the domestic level, women are the managers and controllers of water and are also recognized as water collectors in many parts of the world. Nonetheless, women's role in the decision-making process of water management is limited, mainly because of discriminatory gender roles (Seyfried, 2011). As in other domains of life, in patriarchal societies men dominate in the public and policy-making spheres while women are relegated to private space and are excluded from the decision-making process.

Water governance. Recently, the water crisis has been recognized as one of the major environmental and social problems facing the world and regional societies (Kanae, 2009). Since water is consumed and distributed by society, society needs to govern and streamline water consumption behavior. This may be the reason why the term "water governance" has been officially used in the documents of international institutions (World Bank, 2009). Water governance means the range of political, social, economic, and administrative systems that are in place to regulate the development and management of water resources and the

provision of water services at different levels of society (Rogers & Hall, 2003). Understandably, water governance is linked to the overall system of governance. If a society lacks peaceful conflict resolution mechanisms, then effective water governance is difficult; that is why sharing water is difficult and an immense responsibility. Arguably, the future of water rests not only on technological progress, but also, and most heavily, on strong, concrete, and sustainable political commitment (Fauchon, 2009).

Water scarcity and conflicts. Does water scarcity produce or promote violence? This question is difficult to answer. There is an increasing incidence of conflict and violence in water-scarce areas, but it is not clear whether the violence is a direct product of water scarcity or whether water scarcity promotes conditions that result in violent conflicts. Water scarcity not only undermines individuals' health and well-being but also weakens the state's capacity to provide services to the affected population. Scarcity often has its harshest social impact when these factors interact with other factors (Homer-Dixon, 1994).

Water scarcity becomes more severe when it undermines the societal capacity to adapt. Because scarcity decreases the state's capacity to create markets and other institutions that promote adaptation (Homer-Dixon, 1994), it has an impact on societal resilience against various threats. For instance, in water-scarce regions many peasants try to supplement their falling income by cutting and selling wood, which contributes to further deforestation (Homer-Dixon, 1994). In such situations, if the state is weak, corrupt, or inefficient, water scarcity will damage other systems as the state fails to promote the adaptive capacity of the people by giving them alternative sources of income. Secondly, an unjust distribution of water may weaken the relationship between the individual and the community by disrupting relationship networks and social support systems. Thirdly, water scarcity may intensify competition over resources, which places an additional burden on the available water resources (Homer-Dixon, 1994).

Water scarcity is in fact a social construction stemming from unequal water allocation based on existing asymmetrical power relations and the struggle to control water resources. Water scarcity could also be a result of war, the huge consumption of water by industry and agriculture, industrial pollution, or the blockage of water by the construction of upstream hydropower dams. Even in the democratic dispensations, especially in developing countries, decisions are made by minority ruling elites and the weaker sections of society are deprived of their basic rights like water and sanitation (Weszhalnys, 2009). While explaining the negative consequences of the decision-making monopoly of powerful classes in modern societies, Luhmann (1990, p.226) warned:

… decisions are always the decisions of somebody, not the decisions of everybody. Therefore, the real dangers in modern society are the decisions of others. Almost all other dangers, including natural disasters, can be avoided, for instance by moving out of a region threatened by storms or earthquakes or settling

elsewhere. But the danger that results from the decisions of others cannot be avoided because others are everywhere.

The suffering of poor sections of society may not produce immediate conflict but it definitely increases a sense of relative deprivation and sharpens social grievances; the development of such feelings may have potential for conflict and, if not redressed, may lead to violence. In terms of the availability of fresh water, intra-country variations are large. For instance, the northern part of China is facing severe water shortages while the south still has abundant water reservoirs (Khan & Hanjra, 2008). Inter-state water rivalry, such as those between India and Pakistan and India and Bangladesh, could be intensified as water shortages increase. For instance, Pakistan has been regularly accusing India of violating the Indus Water Treaty by constructing dams on the Indus and Chenab rivers, thus depriving millions of hectares of land downstream in Pakistan. Despite treaties and accords on water-sharing, there is no clear-cut policy on how Himalayan water is to be shared and conserved (Ali, 2008; Chandran, 2009). Intense water-sharing issues could be in the making as trans-boundary water conflicts spread to lower levels across India (Kahn & Hanjora, 2009). In the face of growing destabilization factors (climate change, population growth, failed states, and financial instability), the demand, supply, and control of water will increasingly become a volatile and hotly contested issue in many parts of the world.

Conflict over water usually occurs when differences exist in the perception of the main causes of decline in water levels. The causes vary from an increase in demand and use of water to the greed of upstream users who deny water to downstream users. The existence of unregulated competition or change in the use of a water source may trigger conflict between various water users (Madulu, 2003). Hence, conflict could exist between upstream and downstream riparian irrigators (Homer-Dixon, 1994), or domestic water users and others (e.g. agriculture and industry).

Historically, water has been used as an object or weapon of conflict: for instance, the destruction of water infrastructure during war is a common way of penalizing the enemy.Sometimes, the supply or stoppage of water is used as a bargaining chip or a tool to negotiate with downstream riparian states (Dukhovny & Ziganshina, 2011). Since water scarcity is expected to increase in the coming years, the risk of conflict between states and within states will also increase (Gleick, 2009; Levy, 2011). Sarageladin (1999) warns that many of the wars in the 20th century were about oil, but those of the 21st century will be over water. It is predicted that about 50 countries across the world could find themselves fighting over water unless they move quickly to establish agreements on how to share reservoirs, rivers, and groundwater (Vidyasagar, 2007). Table 2 presents the global water conflicts from 1900 to 2007, showing the increasing number of conflicts with the passage of time (Levy, 2011).

Table 2
Global Water Conflicts, 1900-2007 (Source: Levy, 2011)

Time period in which conflict began	Number of conflicts	Average number/year	Number of violent conflicts and conflicts in the context of violence
1900-1959	22	0.37	At least 19
1960-1989	38	1.27	At least 23
1990-2007	83	4.61	At least 61

The underlying reasons behind these conflicts are similar to the reasons behind water scarcity, including: 1) low rainfall, inadequate water supply, and dependency on one major water source; 2) high population growth and rapid urbanization; 3) modernization and industrialization; and 4) a history of armed combat and poor relations between countries and among different groups within countries (Levy, 2011).

Given the weakness of nation states and the declining effectiveness of the international rule of law, there could be a risk of severe and intense local and sub-national conflicts. This is not only due to scarcity, but to people's perceptions of economic and political injustice. When people think that governing elites lack moral authority or legitimacy, they may revolt and resort to violence. The legitimacy of the system is a critical intervening variable between scarcity and civil conflicts (Homer-Dixon, 1994).

Despite the findings of some previous studies, which have shown a robust relationship between shared rivers and interstate conflict (Gleditsch et al., 2006), some scholars present the opposite argument that water-stressed conditions may not necessarily lead to conflict and war (Wolf, 1998; Yoffe, Wolf, & Giordano, 2003). Nonetheless, the potential for political instability over domestic water distribution and development issues is real (Mustafa, 2007). Given the complexity and multidimensionality of the issue of scarcity, the debate over its relationship with conflict and war is still in a nascent phase and is not yet a settled issue.

The time has come when the world needs to take the water and climate issue seriously. Climate change, combined with demographic, energy, and economic pressures, could increase tensions; trans-boundary water agreements are needed now more than ever, but new forms and arrangements for such agreements may be necessary in connection with climate change (Gleick, 2009). Instead of dealing with the water issue in a piecemeal and segmented way, there is a need for holistic, integrated water resource management (Anokye & Gupta 2011). For this, it is imperative to include the principle of public participation, including the active involvement of women, ethnic minorities, and indigenous populations (Anokye & Gupta, 2011).

At the heart of the scarcity issue is the problem of social exclusion and asymmetries in participatory decision-making about access to and distribution of water. Lofty goals like environmental justice, water rights, or water democracy

(Shiva, 2002) cannot be realized if the powerless and marginalized are excluded from the decisions that affect their access to water. They must be empowered to judiciously manage and conserve water for their own benefit. No decision imposed from the top can change behavior and make people environmentally responsible unless they are kept on board and get a fair share of water. If they are deprived of their water rights, they will never share "water responsibility".

Water and Health Nexuses

A safe, reliable, affordable, and easily accessible water supply is essential for healthy and prosperous survival (Hunter, MacDonald, & Carter, 2010). Conversely, poor or insufficient water quality and supply can cause various infectious and non-infectious diseases (Motoshita, Itsubo, & Inaba, 2011). Despite the fact that water is a basic human need and human right, "access to water is understood and seen as organized through market mechanisms and the power of money, irrespective of social, human or ecological needs" (Swyngedouw, 2009, p.58). As a result, politically and economically powerful sections of society can "buy" high quality and sufficient quantities of water, while the poor and marginalized are forced to consume contaminated or insufficient quantities of water (Krishnaraj, 2011).

Despite water's existential importance, in 2006 nearly 13% of the world's population lacked access to improved water sources and 38% did not have access to improved sanitation (Mor & Griffiths 2011). It is reported that poor-quality water, sanitation, and hygiene account for 4% of all deaths and 5.7% of the total disease burden occurring world-wide (Prüss et al., 2002). The importance of water in the maintenance of human survival may be measured by the fact that 1.4 million children die each year as a result of diarrhea and one in five children born in developing countries will not reach their fifth birthday due to contaminated water (Elliott, 2011). It is estimated that around 10% of the global burden of disease could be prevented by improvements related to drinking water, sanitation, hygiene, and water resource management (Prüss-Üstün et al., 2008).

Water Scarcity and Water-related Infectious Diseases

A recent study in India has shown that domestic water scarcity is strongly associated with various kinds of health damage caused by infectious diseases (Motoshita, Itsubo, & Inaba 2011). Unclean water may cause water-borne diseases (bacterial, feco-oral contamination), water-based diseases (toxic material), water-related vectors, and water-scarce diseases (Vidyasagar, 2007). In many parts of the world, water scarcity results in inadequate access to safe drinking water and this can lead to the spread of infectious diseases via fecal contamination of drinking

water (water-borne diseases), such as typhoid and salmonellosis (Motoshita et al., 2011; Howard & Bartram, 2003, p. 67).

The poor quality of drinking water coupled with a lack of basic sanitation is an important factor in the spread of diarrhea, which is the second most common contributor to the disease burden in developing countries (Mor & Griffiths, 2011). In many countries, water scarcity compels the local population to use wastewater for irrigation purposes, but this serves to disperse microbes into the environment. Since untreated wastewater contains human and animal feces and other dangerous chemicals, the crops produced using this water may be contaminated with various pathogens and dangerous substances (Ensink & Hoek, 2009). Understandably, unwashed and uncooked agricultural products (e.g. vegetables, fruit, etc.) produced using wastewater could cause various ailments and infections (Ensink & Hoek, 2009; Hunter, MacDonald, & Carter, 2010).

Additionally, through the use of untreated wastewater for agricultural purposes, fecal pathogens enter surface water (e.g. lakes and rivers) and groundwater (accessed through wells and bore-holes) and may be ingested by unsuspecting hosts when they drink the contaminated water or eat food that is either washed with contaminated water or directly contaminated by feces, especially when untreated sewage is used as a fertilizer (Mor & Griffiths, 2011).

Water scarcity is also a barrier to basic sanitation and hygiene and can lead to the spread of infections such as trachoma, scabies, etc. that can otherwise be prevented by promoting washing and improving hygiene (water-washed diseases). Stagnant water also provides an essential habitat for the intermediate hosts of important parasites. Human infection can result following exposure to water in which these hosts and parasites live (water-based diseases) or through the bite of insects that live or breed in water (water-related diseases) (Mor & Griffiths, 2011). The classification of water-related microbial infections may be seen in Table 3.

Table 3

Classification of Water-related Microbial Infections (Source: Mor & Griffiths, 2011)

Category	Transmission	Description	Examples
Water-borne	Fecal-oral	Enteric infections spread through fecal contamination of drinking water	Typhoid, Giardiasis, Campylobacter, Cholera, E. Coli, etc.
Water-washed	Direct contact	Infections that spread in communities having insufficient water for personal hygiene	Trachoma, Scabies, Shigella
Water-based	Various	Diseases where the causative organism requires part of its lifecycle to be spent in water	Schistosomiasis, Dracunculiasis
Water-related	Vector-borne	Diseases where the insect vector requires access to water	Malaria, Onchocerciasis, Trypanosomiasis

The water-health nexus is complex and multifaceted: if water is scarce or of poor quality, it will not only damage the health of individuals, but it also retards individual and community resilience and reduces their capacity to build effective resistance against various health hazards (Bunch et al., 2011). Water scarcity also

has a negative influence on educational, economic, and developmental activities (Krishnaraj, 2011). The poor quality of human resources and the increasing burden of disease reduce the revenue and administrative prowess of the state and weaken its capacity to provide health care and other vital social services (Krishnaraj, 2011; Checkley et al., 2004). The negative developmental consequences of poor-quality water and inappropriate sanitation services are cyclical and self-perpetuating.

As water scarcity is increasing worldwide, water-related diseases are also on the rise, especially in developing countries (Hunter, MacDonald, & Carter, 2010). As shown in Table 4, there was a noticeable increase in total deaths due to diarrheal diseases in African countries in just a two-year time period (from 2002 to 2004). The major reason for this increased burden of disease could be that these societies lack the economic resources and administrative capacity to provide safe water and appropriate sanitation services to a majority of their population, while the vulnerability of the population is further increased by the absence of a well-functioning health-care infrastructure. Data for 2002 and 2004 from the World Health Organization (WHO) indicate that the highest levels of diarrheal disease occur in Africa and the Eastern Mediterranean regions (Table 4).

Table 4

Disease Burden from Diarrhoeal Disease: Total Deaths and DALYs for 2002 and 2004 (Source: Bloomfield et al., 2009)

		Global	**Africa**	**America**	**South East Asia**	**Europe**	**Eastern Mediterr-anean**	**West Pacific**
% of total deaths due to diarrhoeal diseases	2002	3.2%	6.6%	0.9%	4.1%	0.2%	6.2%	1.2%
	2004	3.7%	8.9%	1.1%	4.4%	0.4%	5.9%	0.8%
% of total DALYs lost due to diarrhoeal diseases	2002	4.2%	6.4%	1.6%	4.8%	0.5%	6.2%	2.5%
	2004	4.8%	8.5%	1.8%	5.2%	0.9%	5.8%	1.9%

Water scarcity and water-related non-infectious diseases

Inadequate access to safe drinking water is also associated with several non-diarrheal and non-infectious diseases (Hunter, MacDonald, and Carter 2010). Due to extensive and unchecked industrial and agricultural activities, many organic and inorganic pollutants, especially copper, fluoride, lead, nitrate, and other similar elements, become mixed into drinking water and this poses many dangers to human health and normal bodily functioning (Hunter et al. 2010). Another problem is arsenic in drinking water reported in Bangladesh, which has substantial adverse effects on health (Brinkel, Khan, & Kraemer 2009; Smith, Lingas, & Rehman, 2000). More recently, pharmaceuticals have been traced in water through sewage that carries the excreta of individuals and patients who have used these chemicals and from agricultural runoff. Such discharges potentially reach drinking water reservoirs (WHO: Water Sanitation and Health 2011; Ternes, 2006). It has

also been reported that some traces of chemicals/substances related to contraceptives, hormones, shampoos, fragrances, detergents, etc., are present in drinking water even in the developed countries (Ternes 2006), but the full health impact of such chemicals in drinking water on human health are yet to be investigated (Hunter, MacDonald, & Carter, 2010; Ternes, 2006; Hunter et al., 2010).

Water and Sanitation Converge

Drinking water and sanitation have an interactive effect on the maintenance of human health and the spread of disease (VanDerslice, Popkin, & Briscoe, 1994). Population pressure, the concentration of population in urban slums, and poor rural localities where sanitation facilities are not adequate, all lead to infections being transmitted through fecal-oral pathways and also the mixing of wastewater and drinking water. When water is scarce for agriculture, domestic wastewater is used for irrigation. Theoretically, there is no harm in using this water, but when the wastewater is used untreated or unregulated it certainly carries a risk of pollution of soil and contamination of surface water and groundwater (Huibers & Raschid-Sally, 2005). Concomitantly, the use of untreated wastewater for irrigation increases the risk of contracting infectious diseases for the product consumers, farmers and their families, and produce vendors (Carr, 2005).

The negative social and developmental consequences of inadequate water and sanitation services are grave and go well beyond the spread of infectious diseases. For example, when women have no toilet facilities, they may go into dark and remote areas in search of privacy, leaving themselves open to violent sexual attacks and the risk of snake bites. In developing countries, many schools lack sanitation and toilet facilities and, during menstruation, adolescent girls feel embarrassment and ultimately drop out of school (Ali & Rizvi, 2006). Furthermore, girls are usually kept at home to care for sick family members inflicted with water-related diseases (Peterson & Posner 2010). These girls also spend a lot of time collecting water for daily use and have little time or energy left for their education and capacity-building activities (Khawar, 2012). Hence, the absence of proper sanitation facilities is not only detrimental to human health, but also hurts human dignity and well-being and reduces the chances of upward social mobility through education, personality development, and capacity building. This situation ultimately leads to women's social exclusion and economic non-participation.

Social inequalities, political economy and hydro-social cycle

Processes of socioeconomic development and change are never socially or ecologically neutral; they always have consequences for certain sections of society. For instance, the mobilization of water, its transportation and different uses in different places is a conflict-ridden process (Swyngedou, 1999). Each techno-social system for organizing the flow of water shows how social power is

distributed in a given society (Swyngedou, 1999) and how access to water is contingent upon these power differentials. Arguably, the problem of water scarcity is socially constructed and is rooted in environmental injustice, which is the product of social and economic injustice within societies and between societies (Klein & Schopp 2005). If the more powerful sections of society are not willing to reduce their luxurious and unaccountable consumption of water, then the weaker will continue to suffer because of the massive overuse of water resources.

To enable the effective management of water resources, the task for scientists, politicians, and policy analysts alike is to understand the socio-hydrological cycle and flow of water in a given society. Water will become scarcer and scarcer as populations grow and as the developing world seeks new levels of economic growth (Jury & Vaux, 2005). In the passion for growth and modernization, more and more people are becoming dislocated from their roots and climate change has the potential to push nomadic, pastoral, and other communities to urban centers. This process creates social and political inequalities; the provision, access, and distribution of water is defined and determined along the lines of inequalities and social hierarchies.

It is not possible to address the issue of water scarcity independently, or in isolation from other sociopolitical and ecological processes. Water scarcity is linked with the ruthless consumption of fossil fuels and other unsustainable patterns of energy consumption. There is, therefore, a need to expand existing clean energy technology (Butler, 2009) because the burning of fossil fuels is the major source of climate change which, in turn, creates water scarcity. In essence, there is an intricate and multidimensional relationship between the sociotechnical organization of the hydro-social cycle, the associated power geometries that disqualify and debar some people's access to safe water, and appropriate sanitation services (Swyngedouw, 2009).

Water Scarcity and Human Health: A Transdisciplinary Challenge

The issue of water scarcity may not be properly understood from a reductionist, technical perspective; rather, it needs a holistic, comprehensive and multipronged approach to address and solve the problem within broad institutional and structural contexts. Given the complexity and multidimensionality of the problem, the issue must be addressed at academic/scientific, political, and implementation levels.

At the academic level, there is a need to improve interdisciplinary and multi-disciplinary understanding of the social, ecological, and biological systems and processes that influence the access, distribution, and quality of water. The peculiar feature of water is that it cannot be "produced" like food: it can only be stored, transported or recycled (Krishnagar, 2011). It is, therefore, important to investigate the interactive and synergistic effects of various sociotechnical systems responsible for "water handling" in a given society. For this, a new scientific perspective needs to be developed so that innovative techniques can be used for water governance, conservation, and efficient usage (Kanae, 2009). Such a

comprehensive approach should not only identify the gaps in knowledge but also correct misunderstandings about the patterns and behaviors that affect water quality and accessibility (Jury & Vaux, 2005; Kanae, 2009).

At the political level, many unanticipated developments such as climate change, global warming, unchecked urbanization, overpopulation, and overexploitation of natural resources have been infusing multiple uncertainties, and political leadership in many countries has yet to understand the full implications of these changes on the health and well-being of their populations. Though, of late, some climatologists have advanced sophisticated models to predict the consequences of climate change on water resources, uncertainty and unpredictability still prevail, among both political and scientific communities. Given such a scenario, it would be wise not to postpone action until the ending of uncertainty: political leaders must proactively devise a system for the judicious use and equitable distribution of water. The situation also warrants a new approach to grant water rights and water entitlements to marginalized populations and, at the same time, draft new laws and regulatory mechanisms to conserve and protect scarce water resources.

At the implementation level, water needs to be treated like a living organism that "lives" and interacts within the "totality of the social system". In almost all societies, water is handled by various subsectors such as supply, sanitation, irrigation, drainage, resource management, and so on. These subsectors usually operate in a compartmentalized and segregated fashion and are often run by uncoordinated government departments and agencies. Such a compartmentalized system creates many barriers to implementing water reforms. It is extremely important to devise a mechanism that will enable appropriate intergovernmental coordination to provide safe water and adequate sanitation services by recognizing their interdependence and ecologically cyclic interactivity.

In essence, access to clean water for all human beings cannot be left to market forces: society must ensure the equitable and just distribution of water to all. Otherwise, disease, poverty, and human misery cannot be controlled or minimized. The provision of water and sanitation to disadvantaged sections of society may well be one of the most reliable policies to reduce the burden of disease and improve human health. Put simply, millennium development goals (MGDs) cannot be achieved without the provision of safe drinking water and appropriate sanitation services to all.

Notes

- The Indus Water Treaty was signed by Pakistan and India in 1960. According to this treaty, India would have unrestricted use of the three eastern rivers (The Ravi, Sutlej and Bias), while Pakistan would completely control the three western rivers.

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