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As Rivers Run Dry: A Study of Global Freshwater Scarcity and Its Implications for Socio-Economic Development

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And it's implications for socio-economic development

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Preface

Water scarcity is a serious problem—without adequate supplies of clean freshwater, there cannot be life. The direct and indirect costs of water scarcity are huge, including poor public health, gender inequality, and acute restrictions for economic development. Currently, around 20 percent of the global population lacks access to safe drinking water and 2.4 billion people do not have access to adequate sanitation facilities (UNEP Brief, 1). About 1.8 million people—most of them children less than five years old—die every year due to water-borne diseases from fecal pollution—the equivalent of about 15 killer tsunamis each year or 12 Boeing 747 crashes every day (1).

The problem of water scarcity—the lack of a minimum supply of clean, fresh water where it is vitally needed to support human health, sustainable food production and fundamental ecological well-being—is not an issue simply for environmental activists, for it is fundamentally an issue of economics. Human health, economic development and ecological well-being all depend on the availability of clean freshwater.

Water scarcity is caused by a variety of human and non-human factors: geography, population growth, high demand, pollution, deforestation, poor governance and climate change. Climate change, in particular, has the potential to greatly exacerbate the problems associated with water scarcity. Scarcity also threatens peaceful cooperation in regions with high levels of pre-existing tensions, and also threatens the realization of the United Nations' Millennium Development Goals. Although water scarcity threatens security under certain circumstances, full-scale "water wars" are unlikely. Strong, integrated systems of water management have the potential to prevent and mitigate situations of water scarcity. Although the problem of water scarcity is nuanced and complex, there are a number of practical solutions that can easily, effectively and inexpensively diminish the problem.

Part One: Introduction to the Importance of Water

1.1 Water is Life

> *"Water, like religion and ideology, has the power to move millions of people. Since the very birth of human civilization, people have moved to settle close to it. People move when there is too little of it. People move when there is too much of it. People journey down it. People write, sing and dance about it. People flight over it. All people, everywhere and every day, need it."* –Mikhail Gorbachev, 2000

The photograph known as "Earthrise," taken from the moon by astronaut William Anders in 1968, has been called the most influential environmental photograph of all time. This photograph, in which the earth is pictured as a tiny, blue and white, iridescent marble, reminds us that our planet—"the Blue Planet"—is not as infinite as it might seem. When seen from space, it is evident that the earth, with all of its abundance, is not merely a resource to be exploited for economic growth, but is also our home. And for now, it's the only one we've got.

Earth is often called the "Blue Planet" in acknowledgement of the fact that nearly seventy percent of its surface is covered by water: oceans, lakes, rivers, streams, pools and geysers. Water is the lifeblood of our planet. It sustains all forms of life, socio-economic systems and ecological systems, facilitating the modern economy, global agricultural production, health and development. It serves as the fundamental link between human society and the natural environment—there is no substance so vital to the perpetuation of life as water. Without food, a human can survive for up to one month, but without water, one can only survive for five to seven days (Environment Canada). Although substitutes can be found for other natural resources like oil, there exists no substitute for water.

Sheer physical importance aside, water is valued as a symbol. Throughout history, water has been respected as a symbol of purity and spiritual cleansing, and has often been hailed as the creative life force of the universe. Although the world's religions frequently disagree in regards to the nature of spirituality, the respect and valuation of water has historically been and remains today a common, underlying theme. It can thus be seen that at a very basic level, respect for and dependence upon water has the potential to unite an otherwise oft divided humanity.

As one muses over Anders' photo, a paradox may come to light: why, in a world that is nearly ¾ water, do people talk about a problem of water *scarcity*? To those in the world for whom water is a seemingly abundant resource, it is easy to overlook both its significance and the nuanced nature of its availability. The fact is, however, that nearly 97.5% of earth's water is to be found in the form of saltwater oceans and seas, a form that is of little immediate value for human purposes. Of the roughly 3% of freshwater contained on earth, an estimated 2.5% percent of it is locked in glaciers and permanent snow. Thus, both humanity and nature must rely on as little as 0.5% of the world's total water supply to meet all of their domestic, socio-economic and ecological needs (UNEP Brief, 1).

1.2 The Water Cycle

The world as we know it is characterized by the hydrological cycle. The hydrological cycle illustrates the constant movement of freshwater on, above and below the surface of the earth. The cycling of water through the oceans, atmosphere and soil serves multiple functions: it purifies water, replenishes the land, transports minerals to different parts of the earth, and distributes water across landscapes. A regularly functioning hydrological system is able to fulfill both human and ecological needs by providing an adequate supply of clean freshwater for aquatic habitats, human consumption, and ecological consumption.

Of available freshwater resources, 10,000,000 km3 are stored in underground aquifers, 119,000 km3 manifest as rainfall (after accounting for evaporation), 91,000 km3 resides in natural lakes, over 5,000 km3 exist in manmade storage, and 2,120 km3 are to be found in rivers, which are constantly replaced by both rainfall and melting ice (1). Contrary to what some may have thought, only 0.3% of total global freshwater is to be found in lakes and rivers—and this is not evenly distributed around the globe (Environment Canada). It is important to note that climate change is disrupting—and will continue to disrupt—the earth's hydrological cycle, changing the distribution of available freshwater resources in a non-linear way.

Part Two: The Challenge of Water Scarcity

2.1 Water Scarcity is a Serious Problem

> *"Water is life. It's the briny broth of our origins, the pounding circulatory system of the world. We stake our civilizations on the coasts and mighty rivers. Our deepest dread is the threat of having too little—or too much." –Barbara Kingsolver*

Water scarcity is a major problem, and threatens to become an even greater problem if not adequately addressed. The direct and indirect costs of freshwater scarcity are huge, including poor public health, gender inequality, and acute restrictions for economic development. Currently, around 20 percent of the global population lacks access to safe drinking water and 2.4 billion people do not have access to adequate sanitation facilities (UNEP Brief, 1). About 1.8 million people—most of them children less than five years old—die every year due to water-borne diseases from fecal pollution—the equivalent of about 15 killer tsunamis each year or 12 Boeing 747 crashes every day (1). On 22 September 2010, UN Secretary General Ban Ki-Moon asserted that, "in 2010, it is not an exaggeration to say that the lack of access to clean water is the greatest human rights violation in the world" (Global Crisis of Water Shortage, 5). Shortly thereafter, the United Nations finally declared water to be a basic human right.

Water scarcity is the lack of a minimum supply of clean, fresh water where it is vitally needed to support human health, sustainable food production and fundamental ecological well being. There are two types of water scarcity: physical and economic. *Physical water scarcity* occurs when there is a physical lack of water. *Economic water scarcity* describes a situation in which resources are abundant relative to use, but where insufficient infrastructure or the lack of financial capacity prevent people from accessing the water they need (Salim). The term "water scarcity" implies, perhaps counter intuitively, that situations of severe flooding are also situations of scarcity. Although floods are characterized by large quantities of displaced fresh water, the water is generally of a degraded quality and cannot be used to support health, food production or ecological well-being. Quite simply, the term "water scarcity" describes situations in which the availability of clean freshwater is not sufficient to meet basic human and ecological needs.

2.2 Peak Water

> *"In an age when man has forgotten his origins and is blind even to his most essential needs for survival, water along with other resources has become the victim of his indifference." –Rachel Carlson*

Considering the total volume of water on Earth, the concept of "running out" of water at the global scale is of little practical utility (Gleick, Peak Water, 11155). Yet, if water is not running out, then what is the nature of water scarcity? An examination of the concept of "peak oil" can provide a framework through which to evaluate the nuanced nature of freshwater scarcity, and can help to elucidate the utility of the concept of "peak water."

As the industrialized world consumes Earth's oil reserves at faster and faster rates, questions have been raised in regards to the global limits of oil availability. The phrase "peak oil" describes the hypothetical "point at which approximately half of the existing stock of petroleum has been depleted and [where] the rate of production peaks" (11156). As the issue of water scarcity has gained political importance, some academics have suggested that the use of freshwater, like the use of oil, will reach a peak level of use beyond which "natural limits will constrain growing populations and economic expansion" (11115). There are, however, significant differences between oil scarcity and water scarcity which, when taken into account, can help to guide the development of more appropriate and effective water policies.

Oil is a non-renewable resource in the sense that it will not replenish itself in a timeframe that is meaningful for humans. As we continue to use this resource, our limited oil reserves are depleted. Use of oil is almost entirely consumptive in nature, which is to say that when oil is burned for energy, it evaporates into a non-reusable gas. Thus, a hypothetical peak in oil use, a peak beyond which the production of oil would necessarily decline, is a feasible and appropriate concept. Were a peak in oil use realized, it would likely be followed by the substitution of alternative forms of energy, like solar, wind and hydropower. Solar power is an example of a renewable resource, for there is no “reserve” or “limited supply” of sunlight.

The nature of freshwater use is more nuanced, for water can be considered both a renewable and a non-renewable resource, depending on the source and quantity of extraction. Non-renewable resources, like oil, are stock limited, while renewable resources, like solar power, are flow or rate limited. Water is both stock and flow limited. When extracted from “fixed or isolated stocks of local water resources,” like aquifers, at rates faster than the natural rate of recharge, water should be considered a non-renewable resource (11157). When extracted from rivers and lakes or harvested from rainfall—sources replenished at relatively fast, constant rates—water can be considered a renewable resource. Renewable resources, however, should not be considered unlimited.

The use of freshwater is generally non-consumptive, for wastewater is eventually recycled via the hydrological system. Some uses of water—industrial and agricultural production—can, however, degrade the quality to a point that constrains the kinds of use possible, and such uses *should* be considered consumptive (11165). While the cost of transporting oil is offset by its high economic value, the cost of transporting of water is not. A “supertanker” can carry as much as $250 million dollars worth of oil, but it can only carry about $500,000 worth of water (11158). As such, the large-scale transport of water from areas of plenty to areas of scarcity is somewhat unlikely.

The Pacific Institute of California suggests that the concept of peak water be considered in three ways: peak renewable water, peak non-renewable water and peak ecological water. *Peak renewable water* describes situations where flow constraints limit total water availability over time. *Peak non-renewable water* describes groundwater systems where the production rates substantially exceed natural recharge rates and where over pumping or contamination leads to a peak of production followed by a decline, similar to a more traditional peak oil curve. *Peak ecological water* is the point beyond which the total costs of ecological disruptions and damages exceed the total value provided by human use of that water. According to the Pacific Institute, many of the world's watersheds appear to have already passed or to be near the point of passing peak water—the Colorado River, the Yellow River, the Nile and the Jordan are notable examples (11159). One problem with the concept of peak water is that its utility is dependent upon the availability of data, and "data on water use is sparse" (11160). The concept of peak water is, however, appropriate and should be used to highlight the vital need for better water management systems at local, regional, national and basin-wide levels.

2.3 Water Scarcity, Development and Security

> *"As if to dramatize Africa's water woes, thirsty monkeys and starving villagers clashed over drinking water near a trading post in northern Kenya on Monday [in 1999]. Eight monkeys were killed, and ten people injured in a fierce two-hour melee that erupted when relief workers arrived and began dispensing water in the drought-stricken village" (The Big Question, 8).*

The availability of clean freshwater is closely linked to development and security. Communities that have access to sufficient quantities of clean, fresh water are less likely to experience water-related health problems or conflicts, and are more likely to experience situations of gender equality, education, economic productivity and, as a corollary, good governance. Communities that are water secure also often have a heightened socio-economic capacity to respond to exogenous shocks like floods and droughts. Freshwater availability can reduce the likelihood of inter-national and intra-national tensions in regions prone to disagreement as well as in regions where ethnic, cultural and identity-based tensions are high. It can also promote development. The way water scarcity impacts health, development and security largely depends on their respective conditions prior to the decreased availability of water.

Water Scarcity and Development: The Millennium Development Goals

> *"If I sit and stay at home and do nothing, nobody likes me. But if I run up and down [the mountain] to get water, they say I'm a clever woman and work hard. [Women] never get five seconds to sit down and rest." –Aylito Binayo; Foro, Ethiopia*

The relationship between water scarcity and development is reciprocal: *while water scarcity affects development, development also affects water scarcity.* The development level of a community, region or nation affects its capacity to effectively manage water resources; areas with high levels of health and development—and thus stronger economic systems—have the capacity to maintain up to date water infrastructures with state of the art technology, while less developed countries—with comparatively weaker economies and levels of public health—often do not have this capacity. On the other side of the street, it is evident that water scarcity jeopardizes development by exacerbating pre-existing weaknesses: if a region is underdeveloped, water scarcity makes development more difficult; if there are weak sanitation and health systems, scarcity impacts public health; if there are pre-existing cultural or ethnic tensions in a region, scarcity can heighten them and lead to conflict. As noted by the UN, "growing scarcity and competition for water stands as a major threat to future advances in poverty alleviation, especially in rural areas" (Coping With Water Scarcity, 4). Less developed countries, regions and communities are generally more susceptible to situations of water scarcity, most notably when both physical and economic factors limit availability.

Water scarcity has jeopardized the realization of the United Nation's Millennium Development Goals (The MDG's and Water, 1). An examination of how the MDG's are linked to the availability of freshwater can elucidate the multifaceted way in which water scarcity is a development challenge.

Millennium Development Goal One: By 2015, reduce by half the proportion of people living on less than a dollar a day: According to UNESCO, "problems of poverty are inextricably linked with those of water—it's availability, it's proximity, its quantity and its quality"(1). The lack of clean, fresh drinking water often leads people to consume contaminated water, which more often than not causes health problems. Nearly 900 million people in the world have no access to clean water, and 2.5 billion have no safe way to dispose of human waste—many defecate in open fields or near the same rivers they drink from (National Geographic, 102). Sickness, often due to water borne diseases, makes it increasingly difficult to escape from poverty—it decreases the capacity to work and earn an income. The UN notes, "improving the access of poor people to water has the potential to make a major contribution towards poverty eradication" (The MDG's and Water, 1).

Goal One, Part Two: Reduce by half the proportion of people who suffer from hunger. In many regions of the world, women—roughly 50% of the population—are too busy collecting water to spend ample time growing food or raising animals, which impacts local food security. Floods, droughts and other natural disasters also decrease food security. Both too much and too little water make the agricultural production of food very difficult, if not altogether impossible. As climate change increases the frequency and severity of droughts and floods, the number of people suffering from hunger could increase if not adequately responded to.

Millennium Development Goal Two: Achieve universal primary education. According to the World Water Development Report, the need to collect domestic water plays a large role in school attendance. Currently, approximately 113 million children of school age, 60% of which are girls, do not attend school (1).

Millennium Development Goal Three: Promote gender equality and empower women. Currently, two-thirds of the world's illiterate are female, and the rate of employment of women is only two-thirds that of men. Girls are prevented from attending school by the need to collect water, and women are prevented from joining the formal economy for the same reason. In general, "a man hauls water only during the few weeks following the birth of a baby" (National Geographic, 102). As already noted, women in Africa and Asia walk an average of 6 km per trip to fetch water (Environment Canada). In northern Kenya, the Gabra women spend up to five hours a day carrying heavy jerry cans filled with murky water. As National Geographic notes, "if the millions of women who haul water long distances had a faucet by their door, whole societies could be transformed" (96).

Millennium Development Goal Four: Reduce child mortality. Of all people in the world, children are hit hardest by water-related diseases (The MDG's and Water, 1). According to the World Water Development Report, of all the people who died of diarrheal diseases in 2001, 70% were children. In areas of the world like Konso, Ethiopia, even district hospitals lack access to clean water. This seriously weakens efforts to combat both child mortality and other diseases.

Millennium Development Goal Five: Improve Maternal Health. Access to clean, freshwater is essential to reduce the maternal mortality rate. Consuming dirty water can cause a whole host of health problems, many of which impact pregnancy. Women's health in many parts of the world is affected not only by the consumption of dirty water, but also by the process of fetching water. In Ethiopia, Aylito Binayo carries as much as one hundred pounds of water from a lowland river up to the mountain village in which she lives—a weight that, if carried everyday, takes a toll on the female body.

Millennium Development Goal Six: Combat HIV/AIDS, Malaria, etc. People weakened by HIV/AIDS are likely to suffer from the lack of safe water supplies and sanitation, especially since diarrhea and skin diseases are two of the more commonly experienced infections—access to clean water is essential for combating this disease (1).

Millennium Development Goal Seven: Ensure environmental sustainability. It will not be possible to ensure environmental sustainability without ensuring the sustainability of freshwater resources. Some 50% of the world's wetlands have been lost since 1900, with great environmental consequences (1). This MDG also aims to reduce by half the proportion of people without sustainable access to safe drinking water by 2015. If this were achieved, it would be a major step forwards in dealing with the problem of both physical and economic water scarcity.

Millennium Development Goal Eight: Develop a global partnership for development. According to the World Water Development Report, achieving the MDG on drinking water supply will by itself represent a major expenditure in all countries, requiring between US$10 billion and US$30 billion a year, on top of the amount already being spent (1).

Overall, water scarcity can affect the potential for development—most notably in less developed countries—by impacting health, gender equality, economic productivity and the health of the natural environment. It is clear that when clean water becomes more plentiful, "all the hours previously spent hauling water can be used to grow food, raise more animals, or even start income-producing businesses" (National Geographic, 106). In order to prevent water scarcity from inhibiting the eventual realization of the MDG's, measures must be taken to prevent, mitigate and adapt to situations of scarcity. As will be discussed subsequently, these measures must be taken at the local, national and international levels to be truly effective. Should water scarcity lead to conflict, the potential for development would most certainly be affected—as Alec Crawford has said, "conflict is development backwards" (Alec Crawford).

Water Scarcity and Security

> *"'We wake up every morning fighting over water,' says Kamal Bhate of Nehru Camp in Delhi. The brawls can be deadly. In a nearby slum a teenage boy was recently beaten to death for cutting in line" (National Geographic, 79).*

The "big question," as some have put it, is whether or not water scarcity will give rise to conflict. The UN estimates that 300 potential conflicts over water exist in the world today (The Big Question, 1). Water scarcity has the potential to negatively effect security if not properly managed, although it is and will likely remain first and foremost a development challenge. Non-water based factors will determine both whether and how water scarcity manifests as a cause for conflict, for "water is rarely an isolated problem" (Brown and Crawford, Africa, 15). Some have argued that "just as oil conflicts were central to the 20^{th} century history, the struggle over freshwater is set to shape a new turning point in the world order and the destiny of civilization" (The Global Crisis of Water Shortage, 3). In contrast to such Malthusian assertions, this paper argues that *water scarcity is unlikely to be the sole determinant of conflict in most situations.* The assumption that "water wars" are inevitable is deterministic and assumes the worst of humanity. It is important to remember that the potential to peacefully overcome water scarcity does exist; it depends on political will, trust between nations and real manifestations of cooperation (Salim).

The potential for water scarcity to generate conflict is context-specific. Conflict is most likely to occur in regions where there is *both physical and economic water scarcity*; it is more likely to arise in less developed nations with poor water management systems and underlying cultural tensions—like Sudan—than in highly developed nations with strong water management systems and low levels of internal tension, as in western Europe. In situations where the circumstances *are* unfavorable, conflict is most likely to occur at the local level, where water management systems are less developed. Many factors must be considered when evaluating the likelihood of scarcity driven violent conflict: poverty levels, natural freshwater endowments, population characteristics, ethnic and religious fractionalization, education levels, geography, as well as previous conflicts. In this discussion, the words “security” and “conflict” will be used in alignment with the definitions provided by the International Institute for Sustainable Development. “Security” is understood as “a condition where the changes and internal pressures that all countries experience can be managed in a non-violent way,” and “conflict” describes a “dispute or incompatibility between two opposing sides,” and implies “violent conflict” (Brown and Crawford, Africa, 6).

Intra-National Conflict

Although water scarcity is generally not the sole cause of conflict, it has certainly played a role in catalyzing conflicts in the past—though this is not always recognized. The violence in Darfur is a notable example. Due to its geographical location, recent and drastic decrease in annual rainfall, weak infrastructure and poor water management system, Sudan experienced severe ecological degradation and water scarcity. These factors heightened, at least in part, pre-existing ethnic tensions. In 2007, Ban Ki-Moon argued that:

> “Almost invariably, we discuss Darfur in a convenient military and political short-hand—an ethnic conflict pitting Arab militias against black rebels and farmers. Look to its roots, though, and you discover a more complex dynamic. Amid the diverse social and political causes, the Darfur conflict began as an ecological crisis, arising at least in part from climate change” (Brown and Crawford, Africa, 5).

The conflict in Sudan has been considered a tragic example of the social breakdown that can result from ecological collapse. The potential for intra-national water-driven conflict is most likely to manifest in regions like Sudan where there is both physical and economic water scarcity, poverty, ethnic and religious fractionalization, low levels of human capital and a propensity for violence.

Transboundary Water Basins

> *“The word ‘rival,’ from the Latin* rivalis*, originally described competitors for a river or stream.” (National Geographic, 159).*

In certain zones and regions of the world, the potential for international water-driven conflict appears to be higher than in others; transboundary water basins are one such zone. The world's lakes, rivers and aquifers exist as constituent parts of the earth's circulatory system, providing water where it is vitally needed to support life. This extensive network of water basins does not respect international political boundaries—it is estimated that approximately sixty percent of the world's freshwater lies in transboundary basins, areas in which at least one of the tributaries crosses a political boundary (Environment Canada). There are 256 transboundary water basins in the world today (Salim). Approximately forty percent of the world's population lives in river and lake basins that comprise two or more countries, and perhaps even more significantly, over 90 percent lives in countries that share basins (Transboundary Waters, 1). It is clear that "all transboundary water bodies create hydrological, social and economic interdependencies between societies" (1). In river basins, the way water is used and managed upstream has direct consequences for the availability of usable water downstream. When managed effectively, transboundary zones can promote international peace and cooperation. When managed ineffectively, these zones can become potential sites for conflict. As freshwater is not evenly distributed around the globe, certain transboundary basins—the Nile River and the Levant Basin, for example—play more vital roles than others in regards to supporting regional water needs.

Transboundary water can serve as a medium for international cooperation. "Since 1948, history shows only 37 incidents of acute conflict over water, while during the same period, approximately 295 international water agreements were negotiated and signed" (3). It is again important to point out that people will not inevitably resort to violence to attain resource security in the face of scarcity. As a UN briefing on transboundary water management notes, "…averting disputes is often a strong political driver for initiating cooperation on transboundary waters, as riparian States recognize that they must safeguard their greater common interests" (3). Transboundary water basins are often recognized as common public goods.

At the national level, effective transboundary water management requires political will, cooperation and trust between states, a sound legal framework, commitment to policy implementation and "the formation of joint bodies with strong enforcement capacity, such as river, lake and aquifer commissions" (7). At the local level, it is necessary to involve the public in water management so as to "maximize agreement, enhance transparency and decision making, create ownership and facilitate the acceptance and enforcement of decisions and policies" (9). The countries of Western Europe have effectively managed the Danube River by integrating these principles; it is clear that strong institutional and human capacities are necessary to accomplish such tasks. Often, effective management of transboundary basins involves a good deal of financing, for there are costs associated with "developing a legal framework, establishing institutions, developing capacity, creating monitoring, data-sharing and assessment systems" and—most costly of all—of developing sustainable "long term investment programs that optimize equitable use and protection" of water resources (10). For these reasons, transboundary water basins shared by less developed countries can be more difficult to manage and are more likely to become potential sites for conflict. Two regions in which transboundary management is especially difficult are the Levant in the Middle East and the Nile Basin in Africa.

The Levant: Without a drought, the world's most water-scarce region

The Levant—composed of Syria, Lebanon, Israel, Jordan and the occupied Palestinian territory (oPt)—is the region "considered the world's most [physically] water scarce, where demand for water already outstrips supply in many places, [and where] climate models are broadly predicting a hotter, drier and less predictable climate" (Brown and Crawford, Middle East, 6). While the accepted threshold for water scarcity is 1,000 cubic meters per person per year, Israel has available water resources of only 265 m^3, while Jordan has 169 m^3 and the Occupied Palestinian Territories a meager 90 m^3 (11). Population is predicted to grow rapidly in the coming years—Syria's population is predicted to increase by nearly 70 percent over the next four decades, and it is estimated that the population of the oPt will more than double over the same period—increasing from a total of 42 million in 2008 to 71 million in 2050 (10). The Jordan River, a major source of water for the Levant, has lost more than 90 percent of its flow in the last five decades. Today the lower Jordan has been described as a "toxic brew of saline water and liquid waste that ranges from raw sewage to agricultural runoff" (National Geographic, 159). Needless to say, both population growth and pollution will add immense strain to a region that already experiences extreme water scarcity. The Middle East "as a whole withdraws the world's highest proportion of its total renewable water resources (75 percent)" (Brown and Crawford, Middle East, 11). Without large-scale desalinization, improved water efficiency or possibly international transfers of water, it is predicted that the region's renewable water resources will soon be unable to provide for everyone's needs, let alone their aspirations.

Most sources of water in the region are transboundary in nature; "the Jordan River, which is a crucial water source for Israel, the oPt and Jordan, is supplied by tributaries in Lebanon and Syria. More than four-fifths of the renewable water resources in Syria originate from outside of its borders" (12). Jordan shares an aquifer, the Azraq, with Syria and another, the Disi, with Saudi Arabia. Israel and the West Bank of the oPt share the three basins of the Mountain Aquifer. This has complicated Israeli-Palestinian water management, for "eighty percent of the natural replenishment of the [Mountain] aquifer takes place within the West Bank, but as the natural flow of the groundwater is from the West Bank towards Israel, the majority of the water withdrawal takes place in Israeli territory" (12). Another aquifer, the Coastal Aquifer, lies beneath Israel and Gaza, is extremely degraded in quality and is the only source of drinking water for the 1.5 million people of Gaza.

When talking about water, “Israel and its neighbors face a similar situation: Their survival is at stake—which makes the line between war and peace very fine indeed” (National geographic, 167). Strong tensions between Israel and Palestine have not been eased by water scarcity—water has been used by Israel as a political tool (Salim). In a 2009 World Bank report, it was noted that Israelis use four times as much water per capita as Palestinians (National Geographic, 166). While Palestinians struggle to secure enough water to hydrate their families and animals, Israelis, just next door, are able to enjoy the luxury of water parks. In the summer, when water is even scarcer, Palestinians often have no choice but to purchase water from Israel for about a dollar a cubic yard—effectively buying back water that was pumped out from under the oPt in the first place.

As is widely known, there is a legacy of conflict in the Levant—for the last sixty years bloodshed has been, unfortunately, the norm. Large sums of money “have been spent on weapons and armies that might otherwise have been spent on clinics or schools”—or water infrastructure (Brown and Crawford, Middle East, 10). Small scale armed conflicts over water in the Levant are nothing new—confrontations over the Jordan have occurred since the founding of Israel in 1948. In the 1960’s Israel led air strikes after Syria attempted to divert the Baniyas River, which is one of the Jordan’s headwaters in the Golan Heights; In 2002, Israel threatened to shell agricultural pumping stations on the Hasbani, another of the headwaters in southern Lebanon (National geographic, 159). Violence and threats of violence have decreased the region’s capacity to effectively manage its water resources.

Although the propensity for cultural clashes and interstate violence complicates water management, the fundamental necessity of water has also occasionally led these generally nontrusting, non-cooperative states to cooperate—albeit minimally—to manage their joint freshwater resources. In the 1970's, while Jordan and Israel were officially at war, the countries were able to agree to a divvying up of water resources (160). Although countries in the Levant have led brief military stints against one another in attempts to guarantee water security, it is notable that scarcity—and one of the most severe situations of scarcity in the world—has not led to outright war. "It seems counterintuitive, but water is just too important to go to war over," says Chuck Lawson, who was a U.S. official working on Israeli-Palestinian water issues in the 1990's (160). He notes, "regardless of the political situation, people need water, and that's a huge incentive to work things out."

Although there may not be outright war over water resources in the Levant, the lack of political will, cooperation, trust, financing, legal frameworks and basin level water management systems make efficient management of water resources impossible. This makes it more difficult to cope with scarcity, and affects the potential for sustainable development. Lack of an effective water management system will also decrease the capacity of states in the Levant to cope with extreme weather events—like flooding and drought—caused by climate change. It is possible that in the future, if these states remain uncooperative, water scarcity could lead to a situation of full-scale international conflict. In the case of the Levant, it seems that, as of today, there is a greater propensity for conflict than cooperation.

The Nile Basin

Africa is another notably water scarce region—one third of all its inhabitants live in drought-prone areas, while one-quarter currently experience significant water stress (Brown and Crawford, Africa, 13). At 6,700 kilometers, the Nile is the world's longest river. It serves as a lifeline for ten countries of Northeastern Africa—Rwanda, Burundi, Zaire/Congo, Tanzania, Kenya, Uganda, Eretria, Ethiopia, Sudan and Egypt—flowing North from its headwaters in

Rwanda and Ethiopia up to the Mediterranean. Economic progress in this region, which is tied to water availability, is intimately linked to international water management. As is evident in the case study of the Levant, this knowledge can serve as a rationale for regional cooperation but can also serve as a cause for heightened tension and conflict. A question that is often raised when discussing transboundary basins is how to effectively and equitably manage a water resource that is perceived as a common good, that originates in one country, affects ten countries and changes in quality as it flows downstream.

The UN has identified nine river basins in Africa that are at risk for the onset of tensions or conflict, one of which is the Nile; "serious inter-state conflict over water in the Nile Basin… has long been predicted" (15). In the 1950's, hostilities broke out between Egypt and Sudan over Egypt's plan for the Aswan High Dam (Mohammed). This hostility was settled with a treaty in 1959 that some, like Sudanese diplomat Ali Mohammed, consider to have been successful. It is notable, however, that no such agreement exists with Ethiopia, where most of the Nile's flow is sourced (Brown and Crawford, Africa, 16). Many countries in the Nile Basin are already water stressed and are predicted to become even more so as population grows, demand rises and the climate changes. Egypt, the riparian country farthest downstream, is entirely dependent on the Nile for its water resources. The population of Ethiopia—which is but one of nine riparian countries upstream of Egypt—is projected to grow from 85 million to 183 million by 2050. As upstream water usage grows, Egypt is and will continue to be directly effected.

Since the early 1990's, the Nile Basin Initiative has coordinated management between the ten riparian countries in the region. The conditions in Northeastern Africa have, however, changed since this time and will continue to change as a result of population growth, pollution and climate change; a new initiative is needed. When Sudan recently asserted that it hopes to irrigate portions of the Sahel, Ethiopia responded with a threat of military response (16). Climate change is adding another dimension to the game—it has been predicted that sea-level rise could inundate the heavily populated Nile Delta, which plays a vital role in the Egyptian economy in both agricultural and industrial terms (16). If the annual water flow were to decrease by twenty percent due to increased temperatures or abnormal rainfall, normal irrigation patterns would be affected, again placing the heaviest burden on Egypt. As noted by Andrew Sims, "such a situation could cause conflict because the current allocation of water, negotiated during periods of higher flow, would become untenable" (16). Egypt has quite openly declared that it would, if necessary, go to war to secure freshwater resources (Csurgai).

The situation of scarcity in the Nile Basin is aggravated by poverty, underlying cultural tensions, predispositions for violence, lack of institutional capacity, lack of financing and lack of ability to accurately predict the potentially dramatic effects of climate change. Although cooperation is possible in the Nile Basin—and perhaps more conceivable than in the Levant—it would involve a full commitment by each of the ten riparian countries to cooperate, trust each other, develop a basin-wide initiative more comprehensive than the one currently in place and to actually implement the new policies. There would need to be a basin-wide mechanism of enforcement, which would be costly. Thus, international funding would be necessary. As international funding often involves considerations about the appropriate allocation of funds, there would need to be an international mechanism for monitoring and preventing corruption. All things considered, cooperative water management in the Nile Basin is conceivable, but would be costly.

Water Scarcity and Food Security

Agriculture is the largest consumer of water by humans worldwide; 85% of total human consumptive use of water is used to irrigate agriculture (Gleick, 280). In 2000, around 270 million hectares of land were irrigated worldwide, which is 18% of total cropland; around 40%

of all agricultural production comes from these areas (280). As declared by the United Nations, *everyone has the right to food.* Food, however, cannot exist without water. Water scarcity has the potential to threaten food security.

The potential of water scarcity to threaten food security is context-specific; it depends on both physical and economic levels of scarcity and is influenced by geography, development of agricultural infrastructure, and capacity for trade. As with water scarcity in general, food insecurity is most likely to affect the rural poor. In most countries of the world, the agricultural sector is the primary consumer of water. The UN notes:

> *"Irrigated agriculture, which represents the bulk of demand for water [in countries like Mexico, Pakistan, South Africa, China and India], is also usually the first sector affected by water shortage and increased scarcity, resulting in a decreased capacity to maintain per capita food production while meeting water needs for domestic, industrial and environmental purposes" (Coping with water scarcity, 2).*

Food insecurity has the potential to degrade the quality of life for millions of people. It would also make economic development increasingly difficult.

A brief examination of Chinese agriculture can demonstrate the potential magnitude of this problem. Chinese farmers currently depend on irrigated land to produce roughly 70 percent of the grain for their huge population of 1.2 billion people (Brown and Halweil, 10). As the nations' water resources run low due to overuse—certain rivers, like the Fen, no longer exist—China's demand for grain imports is rising. As the Chinese population is so massive, the rise in demand for grain imports is "pushing the world's total import needs beyond exportable supplies" (10). A Harvard University study recently concluded that China will continue to need massive grain imports in the decades ahead (Brown and Halweil, 11).

Rise in demand for agricultural products due to water scarcity should be considered a rise in demand for water itself. In the language of international economics, trade in agricultural products is also considered as trade in “virtual water.” Virtual water refers to *the amount of water used to create a product*; it represents freshwater consumption that is not immediately apparent. Today, *“trillions of gallons of virtual water are transferred in the global trade of agricultural products—comparable to the volume of water that yearly flows down the Congo River… To feed a growing population, experts say that water-use efficiency will need to double in the next 20 years”* (National Geographic, Map).

As global demand for virtual water rises, it is logical to assume that the price for such goods will rise as well. While China will likely have the economic capacity to afford food imports at higher prices, the 1.3 billion people who live on $1 a day or less will not (10). For these people, lower levels of agricultural production coupled with higher prices on the international market “could quickly become life-threatening” (10). Although some suggest that genetically modified organisms (GMO’s) could increase crop resilience in situations of scarcity, the large sums of money needed for GMO research and development would be better spent improving agricultural water-use efficiency by updating management and infrastructure systems. Effective international, national and local water management systems could help to mitigate food insecurity.

2.4 The Multifaceted Problem of Water Scarcity: Contributing Factors, Mitigation and How to Cope

There are a variety of factors that cause and exacerbate situations of water scarcity, some of which are natural and many of which are man made. It is important to note that discussion of water scarcity refers to much more than just climate change. The assumption that resource scarcity is primarily due to climate change is inappropriate, misleading, and could limit the adaptive capacity of populations to deal with resource-based problems by failing to recognize other contributing factors. Although water scarcity is and will continue to be greatly effected by climate change, it is also caused and exacerbated by a host of non-climate factors.

Natural Causes: Geography and Natural Disasters

Geography and natural disasters are two non-human driven factors of water scarcity that contribute significantly to the problem. While some areas of the world are naturally water-plentiful, like the Pacific Northwest of the United States, other regions, like the Middle East, have naturally lower levels of physical water availability. A variety of extreme water-related events in 2009 affected both the availability and quality of freshwater resources around the world: prolonged rains which caused flooding and mudslides in Tajikistan caused water shortages which affected 15,000; drought in Northern China affected 43% of wheat production; drought in the Horn of Africa caused 23 million people to need humanitarian assistance due to lack of water; typhoon Kujira in the Philippines killed 25, displaced 237,000 and destroyed around 40,000 tons of paddy rice; while monsoon related floods in Bangladesh displaced 200,000 and destroyed 30,000 hectares of crops, putting immense strain on already degraded fresh water resources (UNEP Yearbook, 46-47).

The challenge posed by geography and natural disasters can be difficult to overcome, as they are natural challenges. As they cannot be prevented, they must be adapted to. In regions where water scarcity is affected by geography, adaptation could include diversification of the economy away from reliance on agriculture, the use of virtual water (i.e. food imports), increasing the efficiency of water infrastructure, building desalinization plants (if finances allow) and improving water management systems. In these situations, the goal is to free up water resources by increasing efficiency. Mitigation of natural disasters could include community response plans for situations of both flooding and drought; there should be an emphasis on developing infrastructure capable of increasing efficiency in times of drought and of storing and filtering water in times of flooding. Adaptation to natural causes of water scarcity can be expensive, and is thus more difficult for less developed countries. International financing will often be necessary if less developed countries hope to adapt to these challenges.

Human Driven Causes of Water Scarcity

In addition to natural causes, there are a variety of human-driven factors that cause and aggravate situations of water scarcity. Such factors include: population growth, unsustainable demand, pollution, deforestation, poor management and climate change.

Population Growth

As the global population rapidly expands—most notably in developing and less developed countries—the demand for water is expanding as well. It has been estimated that "by 2050, after we add another 3 billion to the population, humans will need an 80% increase in water supplies just to feed ourselves" (The Global Crisis of Water Shortage, 2). Between 1989 and 1999, 95% of population growth occurred in developing countries.

The challenge posed by population growth is difficult to manage. Attempts to limit population growth in China (i.e. the One Child Policy) have been controversial. The idea of regulating population growth invokes questions of ethics. Many believe that the state should not play a role in determining how many children a woman is or is not allowed to have, while some argue that regulation is necessary to prevent ecological collapse. "Adapting" to population growth would require drastic increases in the efficiency of water-use.

Pollution

Just one drop of oil is enough to render twenty-fiver liters of water unfit for drinking (Environment Canada). Pollution contributes majorly to the problem of water scarcity. Polluted water, of which there is quite a bit, is unavailable for immediate human use. When it *is* used, it often causes major health problems. Things like industrial waste, agricultural runoff, unsanitary human waste systems, leaky motor vehicles, and improper disposal of hazardous materials cause pollution. It affects 63% of the world's assessed fisheries stocks, threatening world food security (UNEP Yearbook, 14).

The challenge posed by pollution can be overcome via good governance. It is easier to address than the challenges of geography, natural disasters and population growth. Polluters should be held responsible for their actions with policies like "polluter pays;" the private sector should be held accountable for the negative externalities of industrial production. Pollution contributes to the fact that "five million people die from water-borne diseases annually," with a child dying "every eight seconds" (The Global Crisis of Water Shortage, 2).

Deforestation

Water supply is affected by the loss of watersheds due to deforestation and soil erosion in hills and mountains (The Global Crisis of Water Shortage, 2). Cutting down trees directly affects the water cycle. Trees, as part of the ecological system, draw water up through their roots and release it into the atmosphere via transpiration. The Amazon is a notable example of an ecosystem dependent on trees for water availability—over half of all the water circulating through the Amazon's ecosystem remains within the plans in the rainforest (Less Smoke, Less Ire). As trees are removed, the region just simply cannot hold as much water. As it is cut and burned the smoke, at times, stops rainclouds from forming (Less Smoke, Less Ire).

> "That forests regulate water run-off, mitigating the risks of flooding and drought, has been recognized since ancient times. The ancients also understood that trees can increase rainfall and deforestation can reduce it" (Astill).

Cutting down trees disrupts the biological process of evapotranspiration. The Economist has reported that, "between a quarter and half of the water molecules that fall in the Western Amazon have previously fallen on the rainforest. In its absence," the report notes, "it would be reasonable to expect a corresponding decrease in regional precipitation" (Seeing the Wood). Trees increase cloud cover, which means increased precipitation.

For the challenge posed by deforestation to be overcome, trees must be cut in sustainable ways. Instead of clear cutting, forests should be thinned. This could actually *increase* economic productivity, for selective harvesting can improve the health of forest ecosystems by improving soil fertility (Pilarski). After logging, land should be reforested. This is not expensive and could make a world of difference for the global environment. In a reforestation effort on Madagascar, the cost per tree was five cents—much, much less than the revenue from one tree's worth of timber (Keijzer). Although it is widely recognized that deforestation is a problem, the international community must move from theoretical discussion about the issue to practice. Instead of spending thousands of dollars on conferences, such money could, and perhaps should, be used to fund actual reforestation projects.

Climate Change

Climate change is not something that is going to happen in 20 years—it is happening now. As Mr. Yu of the Geneva based group South Centre has said, "water scarcity will be a major effect of climate change" (Yu). Climate change has already contributed to the problem of global water scarcity. The extensive flooding that the world witnessed this year in Pakistan has been attributed, quite concretely, to climate change. Although factors such as deforestation and mismanagement of land and water resources played a role, scientists at the World Meteorological Organization say there is no doubt that higher Atlantic Ocean temperatures—due to climate change—contributed to the floods (The Global Crisis of Water Shortage, 7). At the most intense period of rainfall, approximately a foot of rain fell over one 36-hour timeframe; some areas received 180% of the precipitation expected in a normal monsoon cycle. Ghassem Asrar, director of the WMO, explained this abnormally extreme rainfall:

> *The record high surface temperatures in the Atlantic Ocean resulted in a huge volume of evaporated moisture entering the atmosphere and drifting over the affected area. At the same time, an abnormal airflow pattern prevented the saturated clouds from spreading over a larger area, concentrating the rains in Pakistan's watershed. (7).*

It has also been said that this abnormal weather was responsible for preventing rain from reaching Western Russia, which suffered from severe drought and wildfires this year. While UN Secretary General Ban Ki-Moon has called it the "worst natural disaster the UN has dealt with," Mr. Asrar of the WMO said, "Pakistan's misery is just a sign of more to come" (7).

In the future, climate change will affect water scarcity by increasing the frequency of extreme weather events, causing unpredictable rainfall, desertification, changing soil temperature and evapotranspiration patterns, destroying rainforests and wetlands and raising ocean levels. It will exacerbate the effects of water scarcity on development and security by making the problem exponentially more severe, for climate change will affect water availability in an extreme, non-linear and unpredictable way.

The challenge of climate change induced water scarcity must be met with a reduction in carbon emissions worldwide if we hope to mitigate the problem. If mitigation is not an option, we must learn how to adapt. This will be difficult, for it will involve adapting to situations of uncertainty—climate monitoring technology is sophisticated enough to know that climate change will cause unpredictable climate events, but not sophisticated enough to know where, when or how often. In any case, it is safe to say that climate change related disasters will be exponentially more powerful than the natural disasters of times past. To adapt, nations and communities should imagine the most severe floods and droughts that they have experienced in the past and plan for floods and droughts exponentially more severe (Salim). Again, adaptation of this kind will be more difficult for less developed countries. International aid will be necessary to assist such countries with the development of infrastructure capable of withstanding floods and droughts caused indirectly by more industrialized countries. Although climate change driven water scarcity is more difficult to control than, say, pollution, good water, land and forest management can help to mitigate—to an extent—potentially catastrophic climate events. These challenges could largely be overcome if there existed a will to adapt, international generosity, solidarity and good governance at all levels.

Part Three: Mitigating and Coping with Water Scarcity

"It is not predicting the future that matters, but being prepared for it." –Pericles

3.1 Good Governance is Key

Good governance at international, national and local levels is necessary to avoid, mitigate and adapt to situations of water scarcity. Although "the global population tripled in the 20th century…water consumption went up sevenfold" (The Global Crisis of Water Shortage, 2). Good governance has the potential to control unsustainably high levels of demand and to improve cross-sectoral efficiency and cooperation at all levels on sustainable water resources development and management (UN-Water Road Mapping, 1). Governments can raise awareness about the importance of water conservation by initiating outreach and education projects, which can increase consumer consciousness and discourage wasteful practices. By involving all stakeholders in the water management decision-making processes, governments can promote feelings of individual ownership over water resources, which is important due to the localized nature of water scarcity. Good governance can combat human driven factors of scarcity like inefficient use, pollution, deforestation and climate change, by implementing policies that discourage or penalize actions contributing to these problems. Management systems in which universal water metering has been implemented have proven to reduce overall residential and industrial-commercial-institutional water consumption by 15 to 30 percent (Environment Canada).

The framework for action known as Integrated Water Resources Management (IWRM), which integrates the principles listed below, has the potential to reduce stress on freshwater resources by promoting coordinated, holistic water management at all levels. Many IWRM experts agree that good water management practices should seek to: increase the productivity of water used in all sectors, most notably the agricultural sector, and give priority to the fulfillment of basic human needs; monitor and fine polluters by implementing "polluter pays" policies; promote efforts to collect data on water usage so as to address the issue of demand; restrict the use of water for superficial purposes (i.e. sprinklers) in situations of scarcity; enhance the productivity of water used in natural ecosystems so as to protect and restore such areas; endorse and engage in integrated water management across transboundary basins to promote international cooperation and trust; monitor and maintain high levels of water quality, to benefit health; promote systems of water recycling (i.e. filtration and re-use of greywater and rainwater); continue to fight against climate change; implement programs to mitigate the effects of extreme weather events; promote regulated foreign direct investment in water resources, when appropriate; and promote education and outreach programs. Although the IWRM framework—which is encouraged by international organizations like the United Nations—can be generalizing at the international scale, it does have the potential to "identify realistic ways for solving water scarcity problems" at the national and local levels when complemented by "a profound knowledge of domestic politics within affected states" (Kipping, 317). Although the international community can help to develop a framework within which to manage water scarcity, the most effective management policies will come from national and local governments that have context-specific understandings of regional water needs.

It has been suggested that the privatization of freshwater resources in countries experiencing economic water scarcity could be beneficial, though this is a contentious subject.

Some argue that freshwater, being a human right, has no business being treated like an economic commodity (Yu). Others argue that foreign direct investment (FDI) *does* have the potential—if highly regulated—to benefit local communities by providing the economic means to access clean water (Salim). When highly regulated, FDI could be a potential solution to water scarcity in regions experiencing economic scarcity. Agreements requiring that privatized water remain within host countries or communities would be necessary for FDI to truly alleviate situations of scarcity, for if investors exported their privatized share of freshwater, situations of water scarcity could become even more severe.

Good governance of freshwater resources is made difficult by lack of financial capacity and corruption. The maintenance of up to date, efficient water infrastructure systems can be quite expensive. In less developed countries, financial weakness can be a huge roadblock to the effective management of water resources, while corruption often serves as a disincentive for international aid. Technology also affects the quality and capacity of water management. While state-of-the-art technology—like desalinization plants—exists, it is often too expensive for poor countries and communities to afford. Due to international patent laws, less developed countries are generally required to pay market price if they wish to acquire high-technology water systems, prices that are simply too high to be affordable (Salim).

It is in the interest of more developed countries to aid less developed countries to develop efficient water systems. By developing their economies, less developed countries could experience an increased ability to trade with the industrialized world, which would provide more economic opportunities for everyone. If developed countries *do not* help less developed countries to manage their water resources, the world could experience large-scale water-related migration—especially as climate change becomes more of a tangible problem. The lack of clean freshwater can be a strong incentive to leave one's home and move elsewhere. Good governance is also made difficult by the fact that there exists no global initiative for freshwater (Yu). Such an initiative is desirable, for it could create a forum for IWRM discussion while bringing international attention to the water needs of less developed countries.

When managed effectively, the problem of water scarcity can be greatly diminished. Good governance of water resources is desirable, for nations and communities that have the capacity to prevent or adapt to situations of water scarcity are likely to have a heightened capacity for development, to avoid conflicts and to successfully manage the water-related effects of climate change.

3.2 Practical Solutions

As acknowledged by Peter Gleick, "traditional approaches to meeting water needs have focused on how to design, fund and build water-supply systems…[often at] great costs, which include ecological and environmental degradation, social disruption associated with infrastructure construction, and economic problems" (Gleick, Water Use, 277). Alternative approaches to meeting water needs are focusing on how to improve the efficiency of *existing* water infrastructure, so as to lessen the need to constantly find new water sources. There are a number of practical solutions to situations of water scarcity, many of which involve the application of indigenous technologies. Such techniques could be of use to less developed countries.

Plant Trees. As noted earlier, reforestation helps to accumulate water in individual ecosystems. The presence of trees affects the cycle of bioprecipitation, for 10-20% of rain is held in a forests' canopy (Pilarski). It essentially comes down to this: more trees mean more water. With permacultural techniques, it is possible to reforest a desert, turning an arid wasteland into a lush ecosystem (Keijzer). Planting trees could not only improve water availability, but could combat climate change. As Marie Noel Keijzer CEO of the international organization WeForest noted, "if we planted two trillion trees—that's 308 trees per person in the world—we could stop or perhaps even reverse the process of global warming." Scientists estimate that this number of trees would be enough to increase global cloud cover by 2%, the amount needed to stop the warming of earth's atmosphere (Keijzer). Trees also create wind barriers, which can prevent the drying of crops and thus promote water-use efficiency in agricultural production.

Utilize Rainwater and Greywater. Re-using freshwater can decrease the stress on resources like aquifers while simultaneously freeing up water for domestic, industrial and agricultural use. There are both high and low-tech ways to utilize greywater. The high tech filtering system of Anaheim California uses an array of micro-filters, membranes and UV lights to recycle 70 million gallons of Orange County sewage into crystal clear drinking water every day (National Geographic, 141). In terms of low-tech solutions, it is possible to safely re-use domestic greywater for home gardens with nothing but PVC piping and five-gallon buckets. This water can be used for home-scale agricultural purposes. Rainwater harvesting is another effective way to combat water scarcity. In a region that receives 12" of water per year, it is possible to harvest approximately 7.48 gallons of water per square foot of roof space. Simple, low-cost rainwater catchment systems can be set up using painted metal roofs, PVC piping and metal tanks; this should be considered a viable water-saving option for less developed countries.

Increase water-use efficiency in low-tech ways. There are a variety of low-tech ways in which to increase water-use efficiency. In arid Iran, people traditionally used a system known as "check dams" to increase efficiency. "Check dams" are small-scale dams built in streams and small rivers, which resemble the blockades built by beavers. These blockades cause little pools of water to be formed, spilling over the edges of the streambed and causing the movement of water downstream to slow, allowing more time for water to sink into the soil. Increased moisture in the otherwise arid soil promotes plant growth and, in turn, increases food yields.

Secondly, instead of using water for human waste disposal—which typically encompasses thirty percent of domestic water use—it is possible to increase water-use efficiency by using composting toilets. Although the technology exists for low-cost, sanitary, waterless human waste systems, many are hesitant to leave behind the flush toilets they are familiar with. In the United Kingdom alone, flush toilets use an estimated two billion liters of fresh water every day—that is 321,409 Olympic size swimming pools each year (Reducing Water Wastage in the UK). There exist, however, high-tech, sanitary composting systems that could and should be utilized in industrialized countries. In less developed countries, it is possible to build low-tech composting toilets by constructing elevated, ventilated outhouses over large trashcans. With a little bit of sawdust, the trashcans can be used to hold human waste. By the time the second or third trashcan is needed in the outhouse, it is likely that enough time will have passed for the first to be effectively composted. Not only is fecal pollution of water resources avoided with this system, but effective, non-toxic compost is created as well, which can safely be used to fertilize crops like fruit trees and berries.

Crops can be planted in water-efficient ways by using the traditional techniques of indigenous people in arid lands. One such technique is to plant crops in the middle of small circular rings of dirt and watering within the circle—this ring help to prevent moisture from being lost to evaporation. With slightly more technology, drip irrigation systems can effectively conserve water.

3.3 Conclusion

Water is a basic human right. Accessible, clean freshwater is necessary to sustain health, economic development, ecosystem health and, at a fundamental level, all forms of life. Water scarcity is a major problem, which threatens health, development and peaceful cooperation in less developed countries. It has the potential to catalyze conflict in regions with physical scarcity, economic scarcity and pre-existing political or cultural tension. It is caused by a variety of both non-human and human factors like geography, population growth, high demand, pollution, deforestation, poor governance and climate change. Climate change, in particular, has the potential to exacerbate situations of water scarcity in the future, in non-linear ways. Strong water management systems following the framework established by IWRM have the potential to ease the problem of water scarcity and by extension promote economic development. Water scarcity is most likely to affect those who live in less developed countries, which makes good water management more difficult—international aid will be necessary to improve the capacity of such countries to mitigate and adapt to situations of scarcity. Although the problem of water scarcity is nuanced and complex, there exist a variety of practical solutions that can easily and effectively help to mitigate the problem in low-cost ways.

We need to fundamentally change the way we think about our freshwater resources. Instead of viewing water as an economic tool, it should be viewed as a human right—as the resource most necessary for life and development. Today, it is not enough to focus on "sustainability"—if we sustained the world exactly as it is today, many regions would experience ecological collapse in the not too distant future. Instead, we should focus on regeneration. It would be in everyone's best interest—and ultimately in the interests of our wallets—to plant a few trees, here and there. Water scarcity is not an issue simply for environmental activists, for it is not simply an environmental issue; it is fundamentally an issue of economics. For the sake of future generations, our goal should not be to keep the planet blue—this will happen anyways as sea levels rise—but to keep it lush, green and fit for thriving human civilizations.

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