Water, Water Every where,

Nor any drop to drink.

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By

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I think it safe to say that we rarely give any thought to our good fortune in being able to turn on a faucet and receive what we rightly believe is an unlimited supply of clean, fresh, potable water. It is a situation unknown today to fully one fourth of the globe's inhabitants and that portion of the world's population with limited access to water, clean or otherwise, is expanding as the population grows.

Day after day, day after day,
We stuck, nor breath nor motion;
As idle as a painted ship
Upon a painted ocean.

Water, water, every where,
And all the boards did shrink;
Water, water, every where,
Nor any drop to drink.

This excerpt from Coleridge's "The Rime of the Ancient Mariner" is an apt metaphor for current times, with the Ancient Mariner speaking as surrogate for all of us. Water is a sober subject. There is no pleasure in bringing a dire message regarding what has been done and continues being done around the world to such a vital resource, but we should be cognizant of the situation and its implications.

Flat earth advocates have been predicting exhaustion of the earth's finite storehouse of natural resources for at least fifty years that I know of, and yet today we have more oil, natural gas, iron ore and other hard assets than we

did fifty years ago and no discernable end in sight. The thesis for exhaustion of the world's natural resources has pretty much been discredited, with one exception. The availability of fresh water is the limiting factor in our ability to grow the world economy and raise living standards for the global population. Water is essential to our physical survival, but is also required for agriculture, industry, and other activities that comprise an expanding economy that provides a growing standard of living. Water is not yet a doomsday situation, although the movement is in that direction, but it is now, and will continue to be, an on going challenge to provide adequate potable water for an expanding world population. The reverse of this coin, the absence of potable water, gives beck and call to the four horsemen of the Apocalypse, visiting conquest, war, famine, and death on populations as they struggle to provide this vital resource. Water is a subject as large as human experience and as nuanced and intractable a political problem as any in existence.

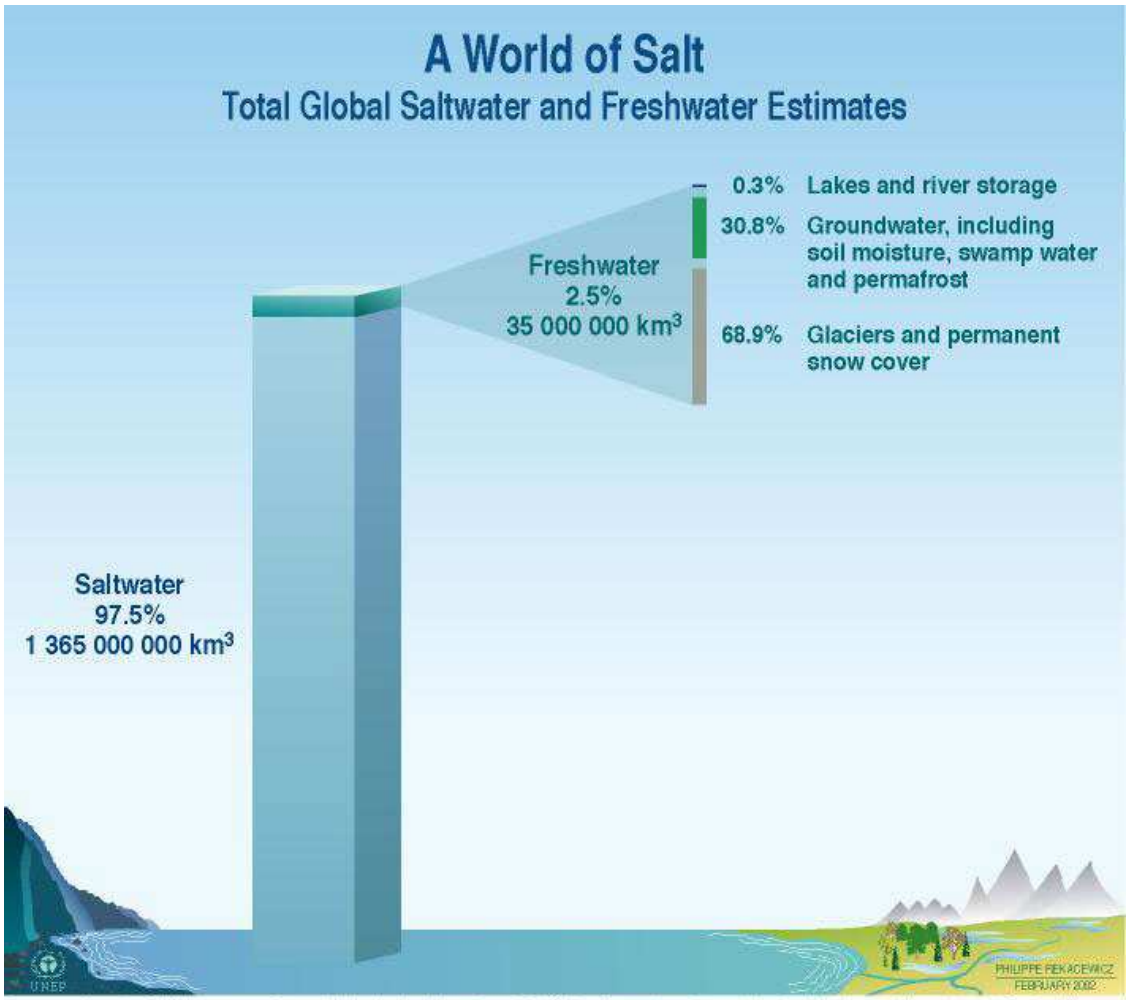
Water is essential to our bodily functions, and since we leak all the time through perspiration, exhaling water vapor, and urinating, constant water intake, or topping up, is necessary to maintain healthy bodies. One widely circulated physiological concept which speaks to the limits of our ability to cope with lack of certain essentials is called the Rule of Three, which states:

1) Humans cannot survive more than three hours exposed to extremely low temperatures.
2) Humans cannot survive more than three days without water.
3) Humans cannot survive more than three weeks without food.

W. C. Fields, who you may remember was quite a sodden character, once remarked, “I never drink water because of the disgusting things that fish do in it”. The remark is good for a chuckle, but following his advice would be bad for your health. The relentless, unremitting requirement for water embodied in rule 2 drives humans to do whatever is necessary to acquire it, and once acquired, to consume it whether the water is safe, polluted, or somewhere in between. This necessity for constant topping up makes the absence of clean water the largest public health hazard in the world today. According to the UN, polluted water is estimated to affect the health of 1.2 billion people, approximately 20% of the world’s population, and water born diseases contribute to the death of 15 million children annually. In the United States this largely rings hollow because we have no experience, or even any concept, of what the lack of clean water would be like. Karl Bandemer provided figures in his paper two years ago regarding water in the western United States that water use in the western US is 75% agricultural, 20% industrial, and 5% personal. The UN confirms that this division of water use is true world wide. Karl’s paper presented a disquieting look at water supply in the western United States, with an expanding population running head on into what life is like in the desert, with depletion of underground aquifers and inadequate supplies of surface water.

This graphic, taken from a UN paper dated 2002, presents an overview of the worldwide water supply and points out that only 0.75% of the total water on the planet is both available and suitable for human consumption. The balance is sea water and ice caps. It further shows that 99% of the water

suitable for human consumption is ground water in swamps, permafrost, and underground aquifers, with the remaining 1% in lakes and rivers.



Source: Igor A. Shiklomanov, State Hydrological Institute (SHI, St. Petersburg) and United Nations Educational, Scientific and Cultural Organisation (UNESCO, Paris), 1999.

Accepting these figures as reasonably accurate, the drawdown of underground aquifers, whether in the western US or elsewhere, is unsettling

on several levels because they are a stalwart of our human supply. We have limited knowledge about the actual remaining quantity of water an aquifer contains, we don't know whether the water will be potable until exhaustion of the aquifer, and we don't have any idea the length of time required for the aquifer to replenish. The concern about current and future supply of fresh water is real, is worldwide, and spares no one.

We visited our children in Wisconsin over the holidays last year end and I cut an op-ed out of the December 30, 2009, Milwaukee newspaper titled "The Chicago water heist that just keeps on taking". The gist of the article is that around 1900 Chicago stole Lake Michigan from all the other states that border on the lake when they dug a 28 mile canal connecting the Chicago River to the Des Plaines river. This canal reversed the flow of the Chicago River and connected Chicago, and Lake Michigan, to the Mississippi, allowing the city's fetid discharges, cargo in barges, and water from Lake Michigan to move south and west, all the way to the Gulf of Mexico. In the bargain this reversal of flow made the Chicago River a drain on Lake Michigan rather than a supplier to it, hence the words "Chicago water heist". In the 1980's Illinois governor Jim Thompson supported the heist of additional billions of gallons of water from Lake Michigan to increase the level of water in the Mississippi during a drought. Supposedly this raising of the level of water in the Mississippi would have prevented difficulty with barge navigation. The governor's of the other states bordering Lake Michigan made some rather unseemly personal remarks regarding the governor's suggestion, as well as threatening lawsuits, and the additional "heist" was never implemented. The connection of the Mississippi to Lake Michigan through this canal has been much in the news lately because of the

threat of Asian carp entering the Great Lakes and destroying all native marine life. The article illustrates that in this country we have strongly held differences of opinion regarding the management of water, in the face of what we perceive as adequate supply. You can imagine what rancor comes out in the face of shortage.

The supply of water around the world is unevenly distributed, with much of the water located far from human populations. Uneven distribution results in uneven availability so communities and countries often ration water for certain uses to insure an adequate supply for other uses deemed to have higher priority. This reminded me of a tour my wife took to the low countries of Europe some years ago as a singer with a chorus. The chorus performed gratis in churches on the tour route and in exchange were provided room and board in the homes of parishioners. In turn, the chorus members helped with household chores like dishwashing. One evening after supper my wife and the lady of the house were doing the dishes with the lady of the house washing and my wife drying. At the outset my wife attempted to rinse the dishes to remove any soap, as is customary in our experience, and was promptly told not to rinse, just dry them. The explanation was that water was much too precious and scarce to waste in rinsing dishes. From a selfish standpoint, this perception in the low countries that rinsing dishes is a waste of water is to be encouraged, because adequate water will then remain for the production of Heineken.

Nature not only distributes the supply of water unevenly, but in most cases the supply of water is also distant from population centers where it is needed. Being distant from the water supply opens the possibility that

intervening geography between the water supply and water consumer belongs to an outside party. This leaves the water consumer in a tenuous position because control over supply of one of life's necessities belongs to someone else. Examples of this situation abound. Roughly 85 percent of the Nile River's flow originates from Ethiopia, from whence it flows through six intervening countries before coming to Sudan and finally to Egypt. The nine countries on the river comprise the Nile Basin Initiative, which is a forum for discussing sharing of the water in the Nile. Egypt considers the fresh water it receives from the Nile River to be a matter of national security, and steadfastly resists any agreement within the Nile Basin Initiative which diminishes its share. Sudan assumes the same posture. The headwaters of the Jordan River, which is a major source of fresh water to both Israel and Jordan, are controlled by Syria, and in Iraq both the Tigris and Euphrates rivers originate in Turkey. A substantial portion of Pakistan's water supply comes from glacial melt originating in Indian Kashmir and from snow melt in Afghanistan. The potential for outside control of a population's water supply is a situation ripe for mischief and misunderstanding.

Water is a root cause of squabbles between India and Pakistan, with disagreements between these two nuclear armed neighbors over water originating in Kashmir having the potential to escalate into the unthinkable. The two powers finally agreed in 1960 to share some control over tributaries of Kashmiri rivers, but Pakistan insists to this day that India tampers with its

portion of the supply. They have continued to squabble over water through the intervening years, and climate change and expanding populations will only exacerbate the ire on both sides. The name of the Pakistani province of Punjab, which contains the capital Islamabad, means "the land of five rivers," and three of these five rivers originate in, or pass through, the Indian sector of Kashmir. The portion of Pakistan's water supply contained in these three rivers is a large factor contributing to the ongoing dissension between the two countries over the status of Kashmir. Indian control of all of Kashmir would give India control over the major portion of Pakistan's water supply, and Pakistan's past actions indicate it will never let that happen. As the glaciers feeding the Kashmiri rivers which flow to Pakistan continue to recede due to climate change, the country's economic development, agriculture and the well being of it's population will become more problematic due to reduced and uncertain water supply. An expanding population in Indian Kashmir, sustained on the land freed by the receding glaciers, will consume a larger portion of the available water in Kashmir, which will almost certainly reduce the supply available to Pakistan, adding further to the water argument.

In Afghanistan both India and Pakistan vie for influence, with Pakistan becoming alarmed lately by the growing influence of India. One reason for this alarm is that Indian investment in Afghanistan has doubled since 2006 to $1.2 billion dollars, with up to 35% of the Indian investment going into canals for local irrigation and hydroelectric dams that will supply electricity for sale by Afghanistan to Iran and Turkmenistan. These water projects would reduce flow from Afghanistan into the volatile border regions of northwest Pakistan and water shortages in these regions would impact crop

irrigation and reduce the amount of electricity Pakistan could generate from its own dams. Water shortages would inflame local residents and add to local insurgencies. Add water as one more stumbling block to peace in Afghanistan.

The current issue of Newsweek magazine, dated February 15, 2010, contains an article “Kashmir is the key to peace in Afghanistan”, and as we see here water is a major point of contention in any agreement between India and Pakistan regarding Kashmir.

We could go on for quite a long time with examples from around the world of similar conflicts about water, but let’s look at a more positive response to water needs between neighboring states that aren’t often thought of as cooperative.

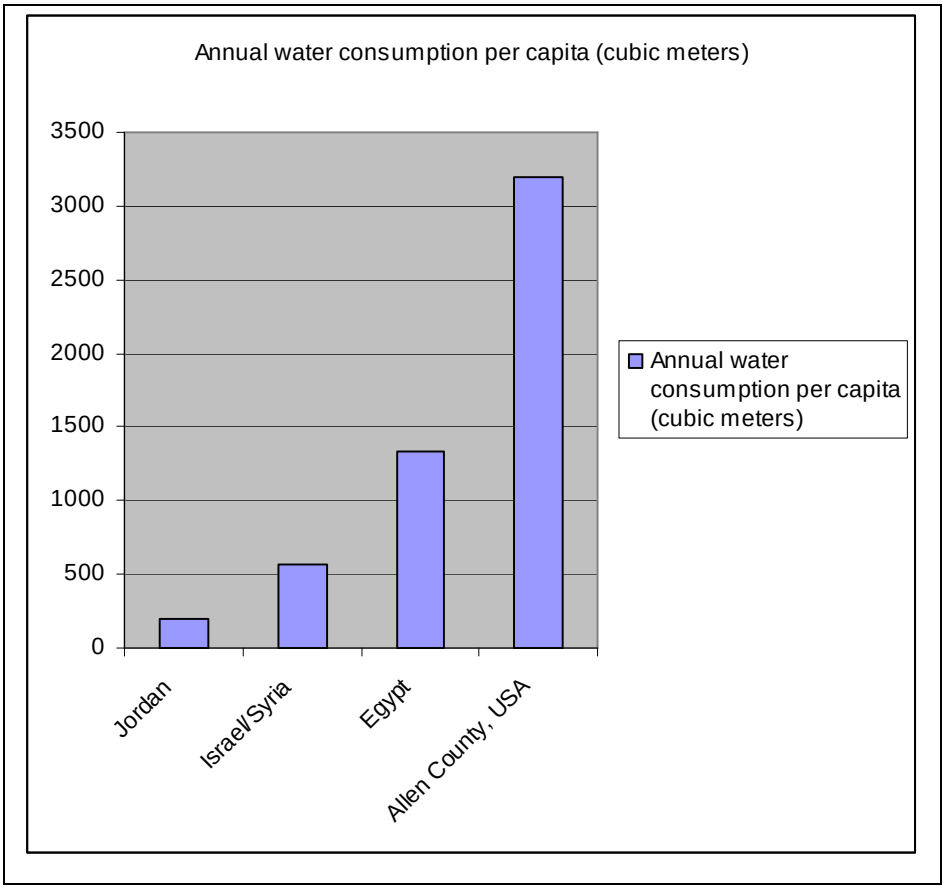
Israel and Jordan share a common border, and along with the Palestinian territories, have common water problems. They share the Jordan river, which originates in Syria, and after Syria removes some of the flow for its use the remaining water in the river is inadequate to satisfy downstream needs. The Jordan river flows into the Sea of Galilee and the Sea of Galilee overflows into the lower Jordan which ends in the Dead Sea. So much water is removed from the Jordan river north of the Sea of Galilee that the flow in the lower Jordan is inadequate to maintain levels in the Dead Sea. The level of water in the Dead Sea has been falling about three feet a year for more than twenty years and is now about 90 feet below where it was in the 1970's. The water crisis among these three riparian neighbors retards economic development, impairs the people's well being and increases friction. To help alleviate this water crisis a grand project has been envisaged to move water from the Red Sea to the Dead Sea through a 120 mile canal connecting the two bodies of water. The proposal is referred to appropriately as the Red-Dead project and is a huge undertaking that would require years to complete and cost between 5 and 10 billion dollars. The Red Sea is approximately 400 meters higher than the Dead Sea, which is the lowest inland point on the globe, so water pumped over the Red Sea coastal cliffs would run down hill all the way to the Dead Sea. The project would also include generating stations and desalination plants to provide about 850 million cubic meters of potable water annually, which would greatly aid in alleviating the area's chronic water shortages. All three states are cooperating in pushing Red-Dead, with a major sales point being the purported political benefits that would accrue by relieving the chronic water shortage in the area. The political argument is that fresh water from Red-Dead would enable

economic growth and more trade among the three states and this increase in economic activity would increase the standard of living in all three states, reducing friction and promoting peace. Critics charge that the political benefits of the project are oversold, environmental impact is largely unknown and could be devastating at both ends of the canal, the project is too expensive, and the same effect could be achieved with better cooperative management of the Jordan River. An additional risk factor is that the proposed alignment for the project parallels a major geologic fault zone.

Source: Harza JRV group

Desalination, as envisioned in Red-Dead, offers hope to arid areas for a steady supply of potable water, but is expensive and has environmental impact that is not well understood. Sea water can be desalinated in two ways, either by distillation, which is very energy intensive, or by reverse osmosis, which is the preferred technology in wide use around the world. Reverse osmosis works by using high pressure to force water through a semi-permeable membrane that allows water to pass, but blocks the passage of other materials either suspended or dissolved in the feed water. Imagine a box with a partition that divides the box into two equal volumes, with each half of the box having a pipe in one wall. The partition is the semi-permeable membrane, one pipe brings sea water into the box at high pressure and the other pipe conveys fresh water which has passed through the membrane out the other side of the box. Very simple. The system requires considerable energy to run the high pressure pumps which pressurize the inlet, or sea water, side of the box. Thirty (30) gallons of sea water must be pumped into the high pressure side of the box to yield nine (9) gallons of fresh water out the other side, and the twenty one (21) gallons of brine which did not pass through the membrane has a salinity that is 50% higher than the original sea water. Discharging the brine back into the sea results in a local area where the salinity of the water has increased by 50%, and how marine organisms fare in such a climate is not well understood. Additionally, if the intake and discharge from the desalination plant are not widely separated, the plant ingests sea water mixed with higher salinity brine for treatment, which reduces the yield of fresh water per unit of input and raises the energy needed per unit of fresh water produced. In the case of Red-Dead, the proposal is to discharge the brine into the Dead Sea, which over time would restore the level of water in the Dead Sea. The effect of

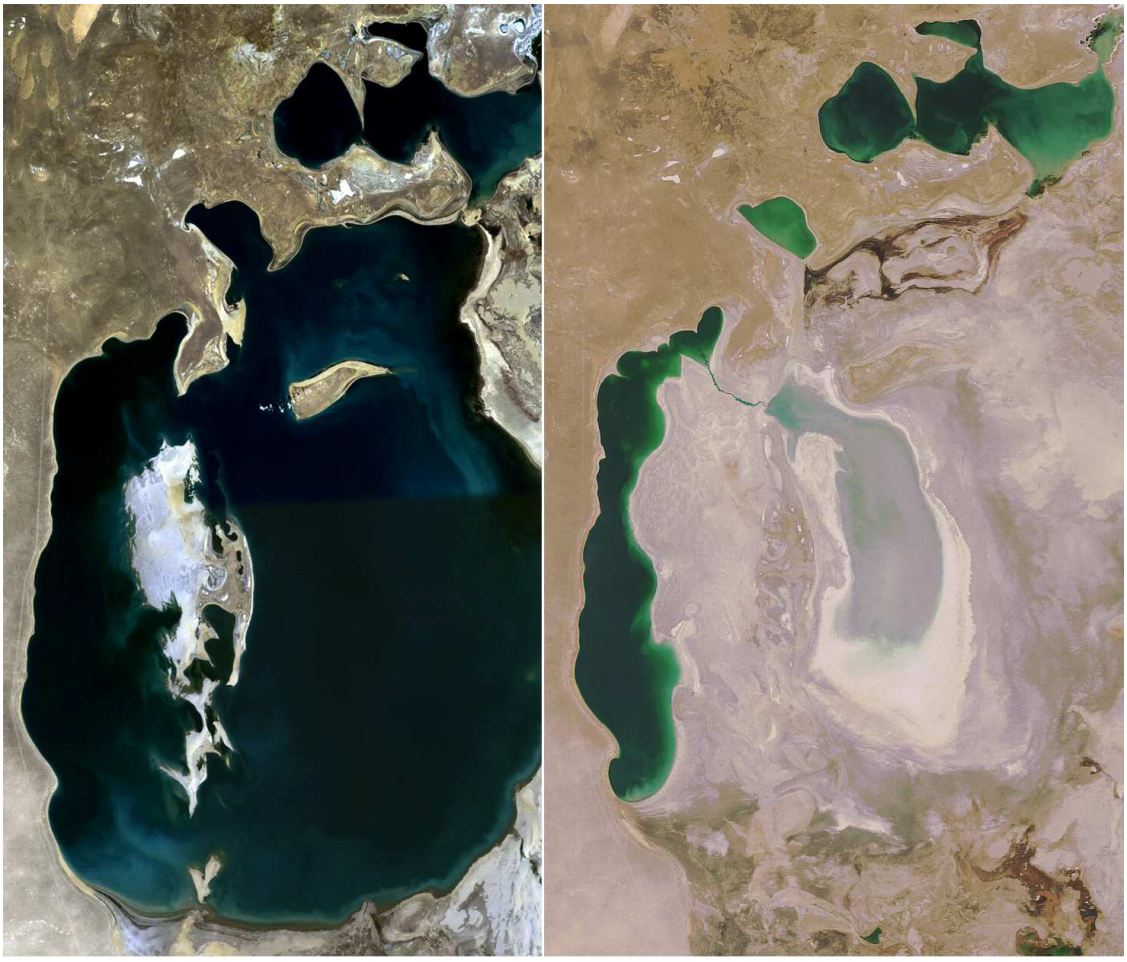
introducing Red Sea water into the Dead Sea is largely unknown, but studies that the World Bank has underway at the moment will provide information for an informed decision on the project later this year. Red-Dead is a poster child for large water projects of all kinds, whether they be desalination plants or dams or irrigation projects, with tangible benefits on one hand and unknown costs on the other.



The table above illustrates the disparity in water available to people in various places, with water consumption for other areas of the world falling somewhere between the highest and lowest numbers shown. Water

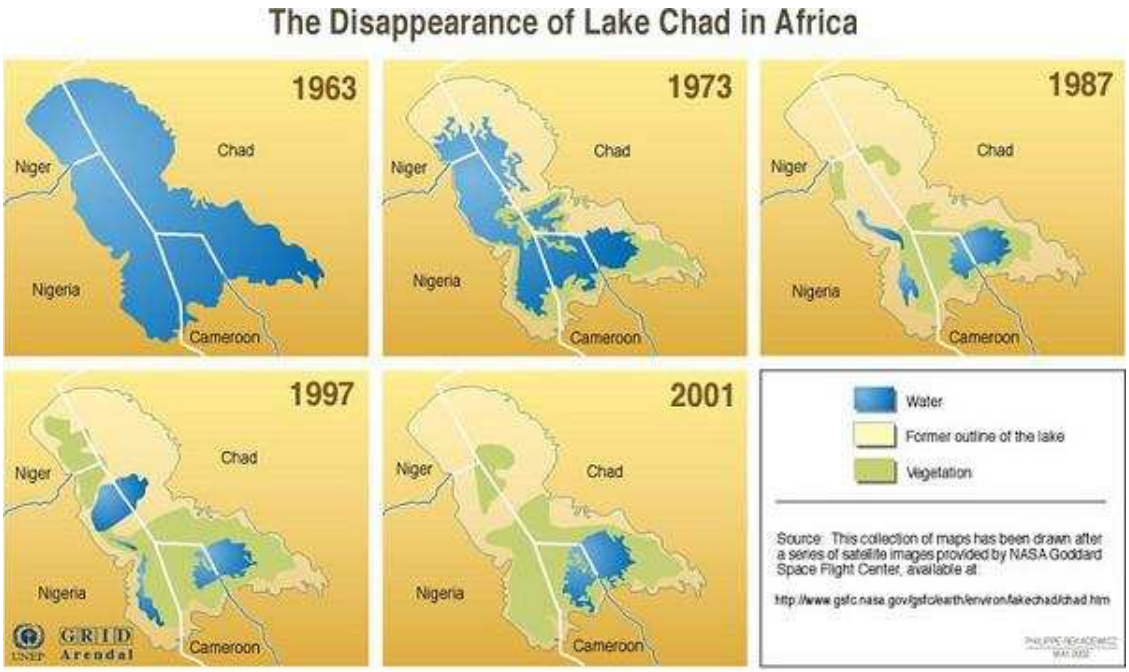
availability is a necessary driver for economic development and Jordan and countries with similar availability have no prospects for economic growth without more water per capita. The shortage of water is a situation that blunts any prospect of economic development, reduces standards of living, destroys hope, and increases mischief.

In closing, I would like to share with you two other images that are indicative of what is happening to water resources around the world. These images are of lakes and were chosen because they were readily at hand from the internet, but other similar examples of lakes and rivers exist all over the world, as for example the Dead Sea that was discussed earlier, or the Rio Grande in the United States.



July - September, 1989 October 5, 2008

The Aral Sea, in central Asia, was the fourth largest lake in the world, with a surface area in 1960 of 26,000 sq mi, placing its surface area between that of Lake Michigan and Lake Superior. Located in central Asia, the Soviet Union dammed the two principal rivers feeding the lake as a water development project to provide irrigation to the surrounding desert and generate electricity. The irrigation provided by these two dams allowed them to grow cotton for export. The Soviets became a major player in the world cotton market and the lake died.



The story concerning Lake Chad, in west Africa, is similar to that of the Aral Sea. All the water flowing to Lake Chad has been diverted for agriculture and the lake has virtually disappeared. In this case there are four countries bordering the lake, and they now have disagreements over how the water previously flowing into the lake should be divided among them.

Is there a solution to the world wide shortage of potable water? Construction of desalination plants is a world wide growth industry at the moment with plants in operation or being built in Israel, Dubai, Australia, California, South America, the Caribbean Islands, and a host of other places. Do these plants offer anything more than a stop gap solution, with the increase in water supply that they provide being overpowered eventually by increases in population? The increased supply they provide is expensive and

comes with an environmental cost that is unknown. Is there a sustainable solution for providing an adequate supply of fresh water? Certainly I do not have answers to these questions. An obvious conclusion is that smaller demand for water would relieve or reduce myriad problems, but looking for a long term solution that reduces demand for water means addressing the elephant in the room: how to stabilize and then reduce world population. One widely reported observation that holds true in all developed countries of the world is that the education level of women correlates negatively with family size. Women with more education have fewer children, and fewer children would reduce population, which in turn would reduce the demand for water. Is educating women the end run around the population issue which provides a sustainable long term solution to the shortage of potable water?

Nebuchadnezzer's Defense of Babylon
http://www1.american.edu/ted/ice/assyria.htm

Kashmir: Melting Glaciers, Boiling Conflicts by Samantha Hulkower
http://www1.american.edu/ted/ice/kashmir-glacier.htm

Central Intelligence Agency, The World Fact Book
https://www.cia.gov/library/publications/the-world-factbook/geos/af.html

Cadillac desert : the American West and its disappearing water by Reisner, Marc. (ISBN 0140178244)

Litani River and Israel-Lebanon by Angela Joy Moss
http://www1.american.edu/ted/ice/litani.htm

Nile River Dispute, ICE Case Studies
http://gurukul.ucc.american.edu/ted/ice/nile.htm