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Telling you things everyone else doesn't already know.

The day they turned off the taps - Part 4

As a general rule, the most successful man in life is the man who has the best information

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Ahead of the Herd is putting together a series of articles on climate change. We plan to cover the whole range of global warming causes and effects. Each article will endeavor to explain a facet of climate science that is not only extremely interesting, but also has investment implications. Look for the articles on Fridays and in our weekly Ahead of the Herd newsletter which is sent out each Saturday morning.

fter weeks of shortage, authorities have now enforced water rationing in Shimla. Photo: AFP

Imagine a day when the water supply to your city is turned off. Water piped into your house or apartment for drinking, toilets, bathing, dishwashing, laundry, and watering your plants suddenly goes from a gush to a trickle, and then, nothing.

From now on, water for all these purposes will need to be purchased from an outside source, because the city no longer has enough to go around, states an official letter delivered to each household. The water supply has run dry, and there's chaos. People scramble to find containers large enough to fill up as much water in one go as possible.

There's a run on bottled water and within two days it's gone from grocery and big box stores. Now people are turning to water purifiers previously only used for camping. Bathing is a once-a-week luxury.

Is this a scene from an apocalyptic movie? For now the scenario is fictional, but it very nearly became reality in Cape Town, South Africa this year. A combination of population growth, over-development and climate change conspired to bring about the worst drought on record, in the country's most popular tourist city. Officials in Cape Town warned that unless drastic conservation measures were taken, by summer the city's 4 million residents would be forced to cue up for drinking water surrounded by armed guards. "Day Zero", when taps would be turned off due to perilously low reservoir levels, was originally predicted for July 2018 but has now been pushed back to 2019.

The reprieve was thanks to fruit growers making more water available to the city, along with re-routing and conservation measures, including Capetonians not being allowed to use more than 50 liters a day. That's less than a sixth the amount of water the average American uses. This meant showers restricted to two minutes, swimming pools drained, and gardens going dry.

The dire situation shocked a city that was always blessed with a lush Mediterranean climate and a steady stream of new-comers and visitors. But after its six dams filled up in 2014, three years of drought gradually depleted them; in 2018 they were at just 26% of capacity. The city plans to cut the taps when levels drop to 13.5%.

A family negotiates their way through caked mud around a dried up section of the Theewaterskloof dam near Cape Town, South Africa, on January 20, 2018. (MIKE HUTCHINGS / REUTERS)

According to National Geographic, Cape Town isn't an isolated case. Other cities at risk of water crises due to droughts caused partially by climate change include Los Angeles, Melbourne, Jakarta, Mexico City and Sao Paulo.

"There are lots of potential Cape Towns in the making. Things will only get worse globally, as water demands increase and the effects of climate change begin to be felt." Charles Iceland of the World Resources Institute (WRI)

We've talked about how global warming is changing our planet for the worse; its effects on indicator species like birds, insects and bees; and how warming oceans are depleting fish, plankton and corals to the point where more of our oceans have become dead zones devoid of all living creatures except for jellyfish. Now we turn to how climate change is impacting our most important resource: water.

326 million trillion gallons of water, less than 1% fresh

There's a lot of water on the planet we inhabit – an estimated 326 million trillion gallons or 1,260,000,000,000,000,000,000 liters.

That makes it hard to believe that there are somewhere between 780 million to

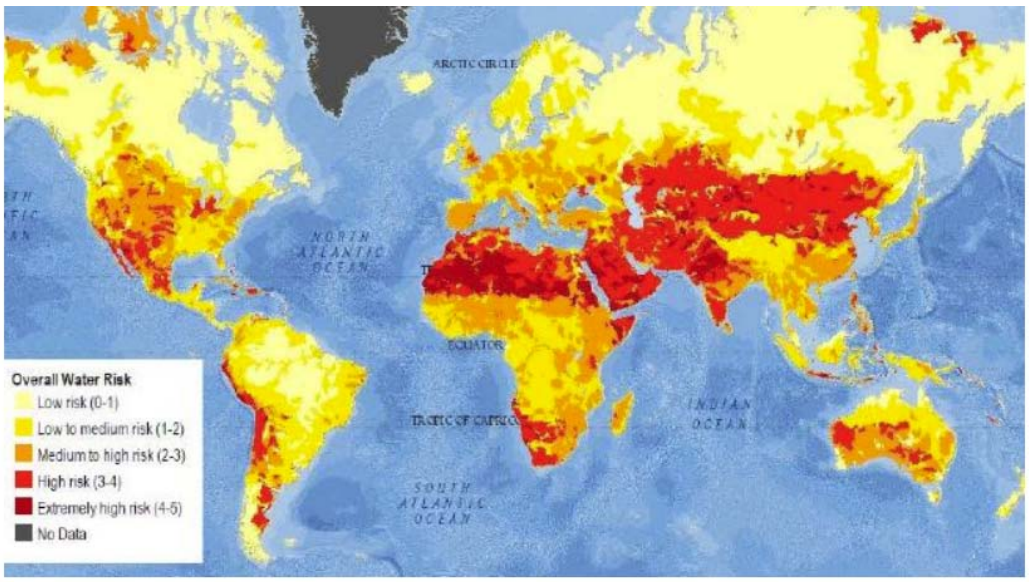
one billion people without basic and reliable water supplies and that more than 2 billion people lack the requirements for basic sanitation.

Peter Voser, chief executive of the world's second-largest energy company, Royal Dutch Shell, warned us in June 2011 that global demand for fresh water may outstrip supply by as much as 40 per cent in 20 years if current fresh-water consumption trends continue.

98% of the world's water is in the oceans – which makes it unfit for drinking or irrigation because of salt.

Just 2% of the world's water is fresh, but the vast majority of our fresh water, 1.6%, is in a frozen state, locked up in the polar ice caps and glaciers.

Our available freshwater (.396% of total supply) is found underground in aquifers and wells (0.36%) and the rest of our readily available fresh water, 0.036%, is in lakes and rivers.



A current map showing water scarcity produced by the World Resource Institute. The dark red represents extremely high risk, the orange represents medium to high risk, while the lightest yellow indicates low risk. *Source:Supplied*

A recent report predicts that this remarkably small global resource is in serious peril due to climate change, increased demand and polluted supplies. The World

Water Development Report warns over 5 billion people could see water shortages by 2050, leading to conflicts (wars) over water unless actions are taken to reduce stress on rivers, lakes, wetlands and reservoirs, states The Guardian.

Among the key findings of the report:

- Humans use about 4,600 cubic km of water every year, of which 70% goes to agriculture, 20% to industry and 10% to households.
- Global demand has increased sixfold over the past 100 years and continues to grow at the rate of 1% each year.
- The world population is forecast to reach between 9.4 billion and 10.2 billion (up from 7.7 billion today), with two in every three people living in cities.
- Drought and soil degradation are already the biggest risk of natural disaster.
- Climate change will put an added stress on supplies.

Another report, from the UN Intergovernmental Panel on Climate Change, says that global temperatures will rise from between 0.3 and 4.8 degrees Celsius by the late 21st century. The report notes developing countries like India are likely to be worst hit by climate change due to the frequency of droughts which will lead to water shortages and problems with food production. Scientific American notes that in 2013, water scarcity got so bad in New Delhi that hospitals cancelled surgeries because there was no water to sterilize instruments, clean operating theaters or for staff to wash their hands.

Women queuing to fill water in plastic pots is a common sight in India

Aquifer depletion

The world's 7 billion people are using almost 60% of all accessible freshwater contained in rivers, lakes and underground aquifers. By 2050 the United Nations estimates we will have upwards of 10 billion people on this planet.

Freshwater aquifers are one of the most important natural resources in the world, but in recent decades the rate at which we're pumping them dry has more than doubled. The amount of water pumped has gone from 126 to 283 cubic kilometers per year. If water was pumped as rapidly from the Great Lakes they would be dry in roughly 80 years.

These fast-shrinking underground reservoirs are essential to life on the planet. They sustain streams, wetlands, and ecosystems, and they resist land subsidence and saltwater intrusion into our freshwater supplies.

Some of the largest cities in the developing world - Jakarta, Dhaka, Lima and Mexico City - depend on aquifers for almost all their water.

Most rural areas pump groundwater from wells drilled into an aquifer.

The highest rates of groundwater depletion are in some of the world's major

agricultural centers:

- Northwest India
- Northeastern China
- Northeast Pakistan
- California's central valley
- Midwestern United States

China’s wheat crop is mostly grown in the semi-arid northern part of the country and is particularly vulnerable to water shortages. Irrigated land accounts for four-fifths of the grain harvest in China.

In India the water situation is even more serious - the 21 million wells drilled are lowering water tables in most of the country. In North Gujarat, the water table is falling by 6 meters per year. In the state of Tamil Nadu falling water tables have dried up 95% of the wells owned by small farmers.

Irrigated land accounts for close to three-fifths of the grain harvest in India. Indian water well drillers are now using modified oil drilling technology and going as deep as 1,000 meters.

India is the largest user of groundwater resources in the world, using an estimated 230 cubic kilometers per year. That figure is more than a quarter of the total world consumption.

In the Pakistani part of the fertile Punjab plain, the drop in water tables appears to be similar to that in India.

In Yemen the water table under most of the country is falling by roughly 2 meters a year.

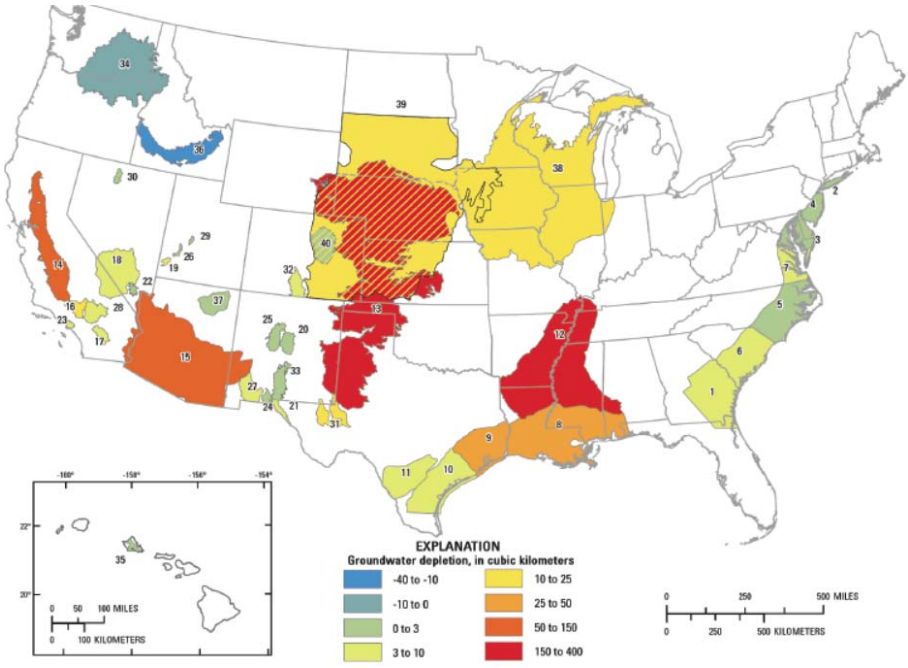
In Mexico the demand for water is outstripping supply. In the agricultural state of Guanajuato, the water table is falling by 2 meters or more a year.

In North America the major concern is over water levels in the Ogallala aquifer under the US Great Plains - the world's bread basket. The Ogallala is the world's largest known aquifer. With an approximate area of 450,600 square kilometers, it stretches from southern South Dakota through parts of Nebraska, Wyoming, Colorado, Kansas, Oklahoma, New Mexico and northern Texas.

The Ogallala aquifer was formed roughly 10 million years ago when water flowed onto the plains from retreating glaciers and streams of the Rocky Mountains. The Ogallala is no longer being recharged by the Rockies and precipitation in the region is only 30-60 cm per year.

In three leading grain-producing states - Texas, Oklahoma and Kansas - the underground water table has dropped by more than 30 meters.

A 2013 study of 40 aquifers across the United States by the U.S. Geological Survey reported that the rate of groundwater depletion has increased dramatically since 2000, with almost 25 cubic kilometers (six cubic miles) of water per year being pumped from the ground. This compares to about 9.2 cubic kilometers (1.48 cubic miles) average withdrawal per year from 1900 to 2008.



Groundwater depletion in the United States

Much of the reason for declining groundwater is due to over-use. For example the Ogallala aquifer is being sucked dry at an annual volume equivalent to 18 Colorado Rivers. A World Bank study indicates that China is over-pumping three river basins in the north: the Hai, the Yellow and the Huai. A 2017 study in *Nature Journal* found that in 10 years, China doubled its use of irreplaceable groundwater from underground reservoirs, and that they are draining faster than they are being replenished. From 2000 to 2010, the study found that globally, the amount of water drawn from aquifers for the purpose of irrigation increased by a quarter.

1/3rd of Earth's largest groundwater basins are being rapidly depleted says new study: http://go.nasa.gov/1G3fLIV

Iran is over-pumping its aquifers by an average of 5 billion tons of water per year. Saudi Arabia, relying heavily on subsidies, developed an extensive irrigated agriculture based on its deep fossil aquifer, and they sucked it dry. Some Saudi farmers are now pumping water from wells that are 4,000 feet deep. In 2015, the country announced that the 2016 wheat harvest would be its last.

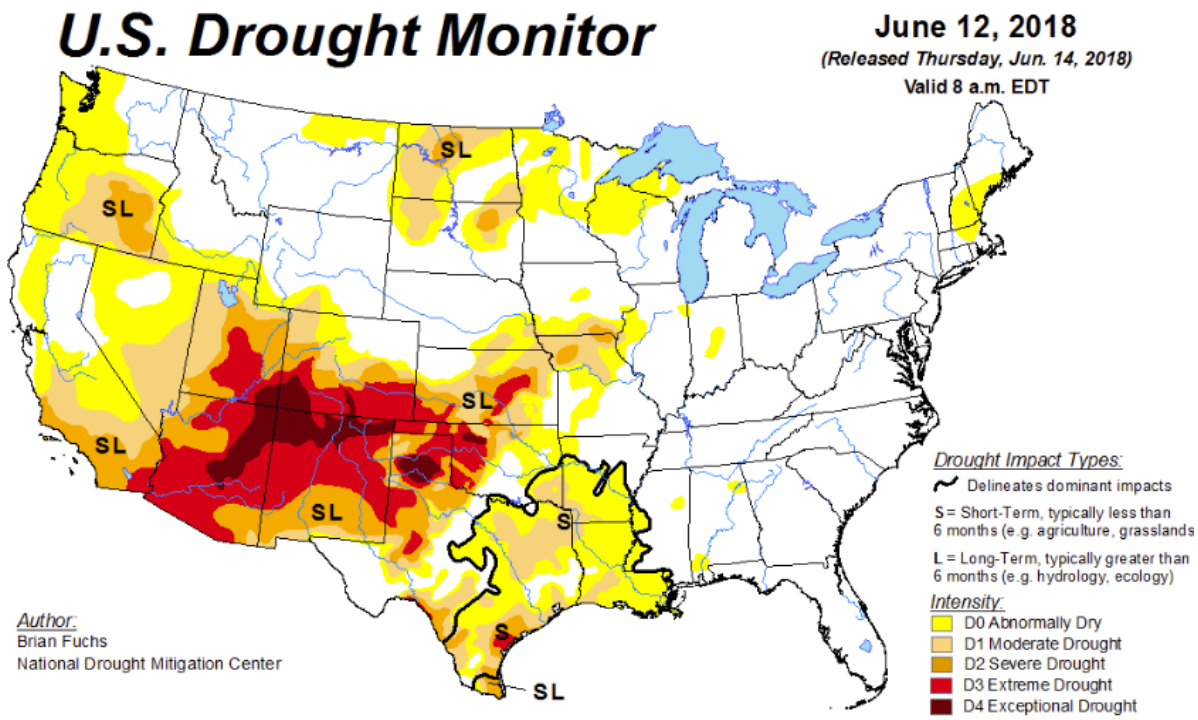
The research in *Nature Journal* found that depleted water reserves will limit the availability of food and raise food prices. Pakistan uses the most irreplaceable groundwater to grow and export its food, closely followed by the US, then India. The crops that contribute most to trade in food grown using groundwater are rice, wheat, cotton, maize and soybeans.

Climate change is exacerbating over-use of groundwater stored in aquifers. As the Earth warms, precipitation is shifting from the mid-latitudes to the low and high latitudes - wet areas are becoming wetter and dry areas drier. Less rainfall in the mid-latitudes means less new water to refill the aquifers that are being depleted the fastest.

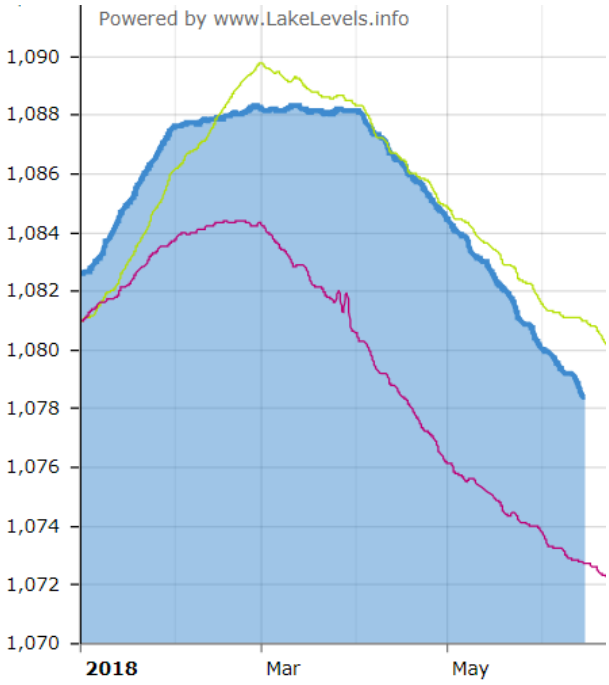
In 2014, California had its warmest year on record, and its warmest winter as

well - the high in the Sierra Nevada's California's snowpack was at a 25-year low. Last year the drought in California caused the worst forest fire season in the state's history, with over 9,000 fires costing $13 billion in damage.

According to US Drought Monitor, in February 2018, 38.4% of the US was in a drought situation, the highest percentage since 2014 when it was 40%. The unusually warm winter weather caused rain to fall instead of snow, leading to record-low snowpacks. In the Colorado Basin, a 17-year run of dry years has left reservoirs at alarmingly low levels, USA Today reported.



The Colorado River Basin lost 65 cubic kilometers (15.6 cubic miles) of water from 2004 to 2013. That is twice the amount stored in Lake Mead, the largest reservoir in the US, which can hold two years' worth of Colorado River runoff.



Lake Mead water level

A Stanford University report says that nearly 60 percent of California's water needs are now met by groundwater. That's up from 40% in years when normal amounts of rain and snow fell.

A study by the University of Arizona predicts that climate change will pull groundwater out of four economically important aquifers at a higher level than they can be recharged. They include the aquifers of California's Central Valley, and the central and southern portions of the High Plains and Arizona's San Pedro aquifers.

In a feature article, National Geographic writes that aquifer depletion will be exacerbated by climate change, which will make farming days hotter and longer, and cause more frequent droughts. Already, warmer-than-average evening temperatures in feedlots in southwest Kansas mean that beef cattle drink more water than they did in cooler years.

The combination of depleted aquifers and lower snowpacks due to warmer winters and hotter summers is causing some of the world's major lakes and rivers to dry up. Among the most extreme are Lake Poopo in Bolivia, the Colorado River, the

Aral Sea, Lake Badwater, Lake Chad, Owens Lake, Lake Powell and Lake Mead.

Photo: Jesse Allen/NASA Earth Observatory

Saltwater intrusion

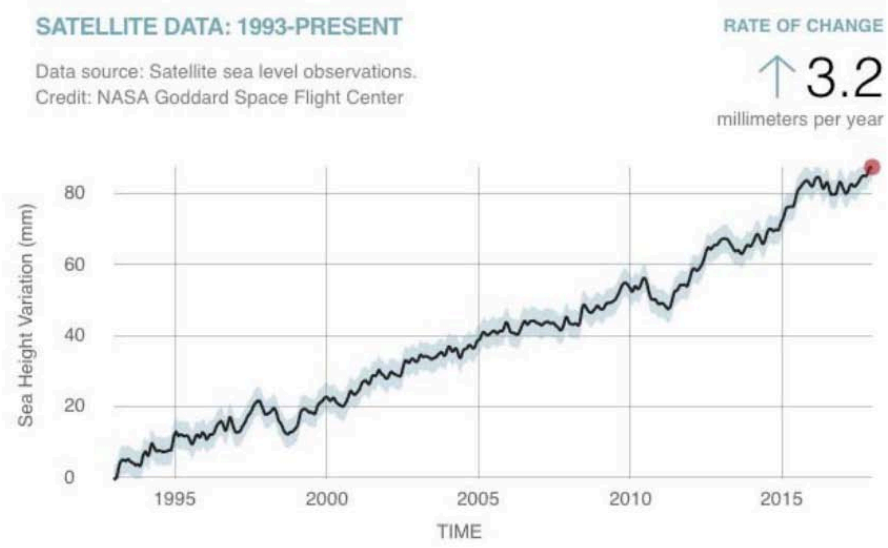
Another effect of over-pumping is saltwater intrusion. If too much groundwater is pumped out from coastal aquifers saltwater may flow into them, causing contamination of the aquifer. Many coastal aquifers - the Biscayne Aquifer near Miami and the New Jersey Coastal Plain aquifer for example - have problems with saltwater intrusion.

Streams, rivers and lakes are almost always closely connected with an aquifer. The depletion of aquifers doesn't allow these surface waters to be recharged. Lower water levels in aquifers is being reflected in reduced amounts of water flowing at the surface.

This is happening along the Atlantic Coastal Plain. Groundwater depletion is also responsible for the Yellow River in China not reaching the ocean for months at a time, the failure of the Colorado River in the US and the Indus River in Pakistan failing to reach the ocean every day.

Saltwater intrusion is also caused by rising sea levels caused by melting glaciers and sea ice.

The warming of the Earth's surface has caused a widespread retreat of the glaciers at both poles. According to NASA between 2002 and 2006 Greenland lost 60 cubic miles of ice; in Antarctica it was 36 cubic miles from 2002-05. All of this melting ice has caused sea levels to rise, from between seven and eight inches over the last 117 years, NASA states, with the most rise occurring since 1993. The expansion of ocean water as it warms also causes higher sea levels.



The latest International Panel on Climate Change report predicts sea levels rising between 52 and 98 centimeters by 2100 if nothing is done to stop rising temperatures. An increase of 65 centimeters, or roughly two feet, is expected to cause significant flooding in coastal cities. Satellite images show sea levels rising 3.2 millimeters a year, with the last measurement, taken in December 2017, recording a rise of 88mm.

Between 1992 and 2017, Antarctica has lost close to 3 trillion tonnes of ice. The massive thaw has raised sea levels by 0.76 of a centimeter since 1992, scientists said this week. The frozen continent has enough ice to raise ocean levels by 58 meters, or 190 feet if it all melted, according to data quoted by Reuters, more than ice locked in Greenland and the Himalayas.

In Florida the ocean is already starting to seep into swamp land, which weakens the plants from their peat bedding. “When we start to lose the structure of the plants, essentially this peat, which is otherwise held together by roots, becomes a soupy pond,” explains a University of Florida researcher in an NPR article. Millions of people in South Florida get their fresh water from the Biscayne aquifer in the Everglades. The problem is also reportedly occurring in China, the Philippines and

Australia. Salt water from the Bay of Bangladesh has penetrated over 100 kilometers inland, due to sea levels rising higher than than elsewhere, thereby increasing the risk of water contamination and hypertension caused by drinking high-salinity water. High river and soil salinity in Bangladesh is also predicted to reduce rice crop yields, affect the productivity of fisheries, crack road surfaces, and increase poverty.

Desertification

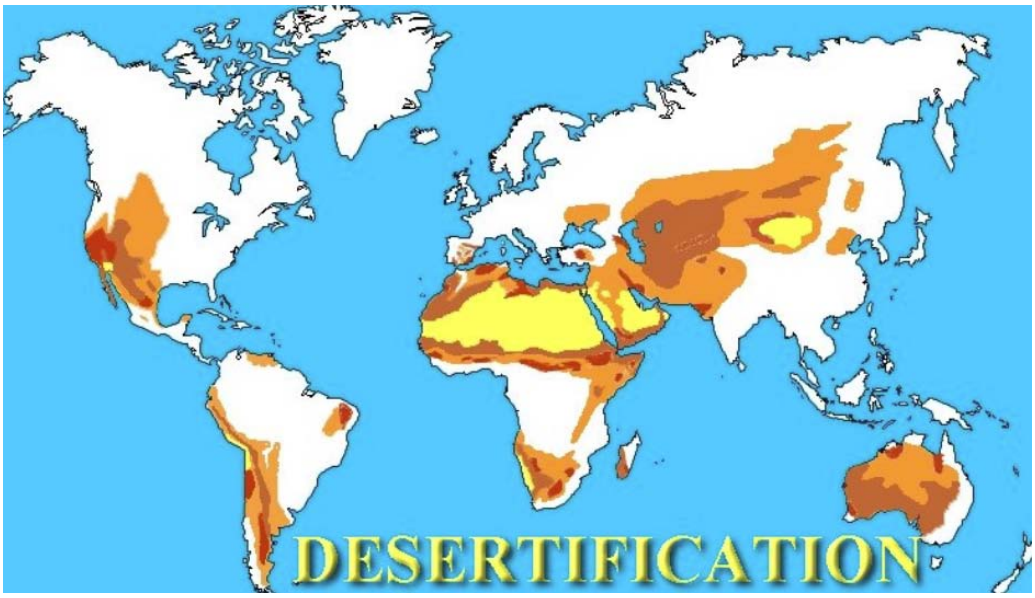
Our warming planet has not only caused droughts and exacerbated groundwater depletion, which leads to land subsidence, and saltwater intrusion in aquifers near coastal areas. Droughts are also responsible for denuding the landscape of vegetation, which has dire implications for crops and food supply.

Desertification is what happens when fertile land is degraded, due to it becoming too arid, or as a result of deforestation or improper agriculture. The process usually results in a loss of vegetation, water bodies and wildlife.

The issue of desertification is not new, it has constantly played a significant role in human history, even contributing to the collapse of the world's earliest known empire, the Akkadians of Mesopotamia.

One of the most fundamental problems we've created for ourselves is the impact of human activities on the land we need to cultivate for our very survival. Like aquifer depletion, desertification has been made worse by climate change.

According to Climatica.org, in the last few decades precipitation has declined in the Sahel, the Mediterranean, southern African and parts of southern Asia. From 1950 to 1980, 10 to 14% of the world's land mass was considered dry, but between 2000 and 2010, this figure had risen to 25-30%.



River run-off and water availability is expected to decrease in dry regions as global temperatures increase and rainfall is reduced - further adding to desertification. According to the United Nations Convention to Combat Desertification (UNCDD), by 2020, 60 million people could be forced from desertified areas of sub-saharan Africa towards North Africa and Europe. These "climate" refugees would add to the political refugees already pouring into Europe. By 2050, some 2.4 billion may be living in areas subject to periods of intense water scarcity, with up to 700 million being forced to move elsewhere.

20cm of soil between us and extinction

Desertification strips away fertile soil and leads to crop failure. It takes 100 years to generate a single millimeter of topsoil - 24 billion tons of fertile soil disappear annually.

"*The top 20cm of soil is all that stands between us and extinction."* Luc Gnacadja, executive secretary of the UNCDD

We reached "peak soil" a long time ago; soil can be considered a non-renewable and rapidly depleting resource.

Given fears over the world's present ability to feed our current population, it's surprising that desertification is so absent on most people's radar screens.

According to the UN, global demand for food is projected to increase by 50% by 2030. It is predicted there will be 9 billion people to feed by 2050. That's an increase of one billion tonnes of cereal and 200 million tonnes of meat.

It's obvious the world needs a new farm – one the size of South Africa. Unfortunately the UN also says that by 2030 an area twice the size of South Africa will become unproductive due to desertification, land degradation and drought.

Adding to our troubles - production gains from the Green Revolution are diminishing. High yield growth is tapering off and in some cases declining. This is mostly because of an increase in the price of fertilizers, other chemicals and fossil fuels, but also because the over-use of chemicals has exhausted the soil and irrigation has depleted aquifers.

The study *Climate Trends and Global Crop Production Since 1980* compared yield figures from the Food and Agriculture Organization (FAO) with average temperatures and precipitation in major growing regions.

Results indicated average global yields for several of the crops studied responded negatively to warmer temperatures. From 1981 to 2002, warming reduced the combined production of wheat, corn, and barley - cereal grains that form the foundation of much of the world's diet - by 40 million tonnes per year.

The authors said the main value of their study was that it demonstrated a clear and simple correlation between temperature increases and crop yields at the global scale.

"*Though the impacts are relatively small compared to the technological yield gains over the same period, the results demonstrate that negative impacts are already occurring*." David Lobell, lead researcher

Other researchers who focused on wheat, rice, corn, soybeans, barley and sorghum (these crops account for 55% of non-meat calories consumed by humans and contribute more than 70% of the world's animal feed) reported that each had a critical temperature threshold above which yields started plummeting, for example: 29°C for corn and 30°C for soybeans.

If average global temperatures rise just over one-half degree Centigrade the frost-free growing season in the corn belt would be lengthened by two weeks. But, as the previously mentioned study showed, if temperatures increase beyond a specific threshold, fertilization is affected, thus reducing the plants' growing season and reducing yield.

Conclusion

Our world's most precious resource, water, is in danger from rising temperatures due to human-caused or natural global warming. The changes are so gradual that most of us don't even notice they're happening. What does it matter if the sea rises a few centimeters a year, or if the aquifers are losing groundwater? It matters because we interfere with nature at our peril.

As we stated at the top, of all the water on Earth, less than 1% is fresh - found in underground aquifers, lakes and rivers. It's actually very little, and it doesn't take much to throw the entire system into chaos. We rely on aquifers not only for drinking water, but to irrigate land and grow crops. Saudi Arabia is a good example of a country that over-pumped its water supplies so much that it can no longer produce its own food. Droughts caused by a warming planet are getting more frequent and lasting longer. Combine depleting aquifers and saltwater intrusion with desertification, and you have a recipe for crop failure, leading to food insecurity, higher food prices, starvation, mass dislocations of populations and possibly even wars. The next time you fill a glass of water from your tap at home, think of where it came from, and how much is left.

Richard (Rick) Mills

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