An Open Letter to Bill Gates

and everyone else with lots of money
and a social conscience

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WHAT'S THIS ABOUT?

Dear Bill:

This is a sneaky way to try to get in touch with you, but it's the only one I can think of. I'm sure you get more mail and emails than you can possibly look at, and there's no reason you should look at one of mine. I might try to contact your foundation but the website says it will accept ideas and suggestions only from established charities -- presumably because they have paid staff to make proposals and need your money to live on. I don't plan to live on your money but I think I see some problems coming that would be better averted than dealt with.

Besides, by putting this on the web I make it available to everyone -- including "everyone else with lots of money and a social conscience."

With all the big brains that are paid to solve the world's problems why should anyone be interested in the ideas of an outsider who doesn't even have a university degree? I suggest that one reason is that I haven't got a degree.

Most of the pundits who are paid by governments, foundations and news media have credentials to prove that they learned their trade from professors who learned from professors who learned from professors who learned from professors ad infinitum. They are as well educated as the Vatican's scholars who knew, in 1633, that Galileo had to be wrong because he did not preach the wisdom of Aristotle -- which had guided much of the western world for nearly 2,000 years and was accepted as gospel by the church.

We could think of this as an extension of the phenomenon that psychologists call the *Einstellung effect*[1] -- the common practice of trying to solve a problem in a way that has been learned, even when a simpler solution is obvious -- as demonstrated by psychologist Abraham Luchins in 1942 with his famous *water jar experiment*.

In Luchins' experiment subjects were given three water jars, each with a different capacity, and asked to measure out a specific volume of water, different from the capacity of any of the jars.

In one run, for example, the subject may have one jar that will hold 127 fluid ounces, one that will hold 21 fluid ounces and one that will hold 3 fluid ounces -- call them jars A, B and C -- and be required to measure out 100 fluid ounces.

The solution in this case is to fill A and then, from A, fill B once and C twice. 127 fluid ounces minus 21 fluid ounces minus 3 fluid ounces minus 3 fluid ounces equals 100 fluid ounces.

One group was given five 'practice' problems followed by four 'test' problems, and a second group was given only the four test problems. All five practice problems and some of the test problems had the same solution -- A minus B minus 2C -- but at least one of the test problems could be solved with a simpler procedure.

If the subjects were required to measure out 18 fluid ounces of water with jars that would hold 15, 39 and 3 fluid ounces, for example, they could fill the 15 fluid ounce and the 3 fluid ounce jar, and dump them both into the 39 fluid ounce jar -- but many of the subjects who had been given the 'practice' problems used the more complex solution 39 fluid ounces minus 15 fluid ounces minus 3 fluid ounces minus 3 fluid ounces.[2]

They used the solution they had learned, even though a better solution was available, and should have been obvious.

In many cases the Einstellung effect is more apparent at the higher levels of an organization than at the lower. This should be no surprise if

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1 also known as *path dependence*

2 https://en.wikipedia.org/wiki/Einstellung_effect

we remember that the road to the top of any organization is paved with the conventional wisdom accepted by the organization and that, once they reach the top, many people see no need to keep learning.

In fact many people stop learning long before they reach the top. Economist John Maynard Keynes wrote, “There are not many who are influenced by new ideas or theories after they are twenty five or thirty years of age, so that the ideas which civil servants and politicians and even agitators apply to current events are not likely to be the newest.”[3] I call this *Keynes’ Law* and, as a working reporter, I have seen it in action many times.

I have fond memories of the time I went, as a reporter with technical expertise, to the introduction of a new business jet. It had a conventional layout -- big wings in front and small wings at the tail -- and I asked the head of the team that designed it why he had not used a "canard" design -- with the main wings at the back and small wings at the front -- which some designers think is the better layout. The Wright brothers first plane was a canard and so are some modern fighters, home-builts and the Beechcraft ‘Starship’ of the 1980's -- a wonderful business plane that was a commercial failure.

When I asked why the new jet was not a canard, the engineer had a terse answer.

"Because,” he said, “we have to sell these things to dinosaurs."

He knew that most of the business CEOs who are in a position to authorize the purchase of new jet planes don't know much about aircraft, and they would avoid a design that looks different.

The Einstellung effect may be produced by education. If we learn to solve problems in school we learn the solutions that our teachers learned -- which are often the solutions that their teachers learned from teachers who learned from teachers who learned, and so on. Most of the important advances of the modern world were made by men with little formal education -- Henry Ford left school after grade eight, Thomas Edison had only three days of schooling before the teacher decided that he was not intelligent enough to learn, John Deere was a blacksmith, the Wright brothers were bicycle repairmen and Elisha Otis was a craftsman before he invented the safety brake that made elevators practical.

The Einstellung effect is a problem for humanity because it hinders or prevents the development of new technology and encourages the application of old solutions to new problems, but it's a benefit to the established order for exactly the same reasons.

Behavioral economist and Nobel Laureate Richard Thaler offers an example of this from his own experience.

Conventional economics predicts the behavior of idealized but non-existent 'rational' consumers under imaginary conditions. Behavioral economics studies the behavior of real people in real conditions. In a question and answer session after Thaler had outlined his recent work at a conference one well-known economist rose to speak.

"If I take what you are saying seriously," he said, "what am I supposed to do? My skill is knowing how to solve optimization problems."[4]

That well-paid professor had only one marketable skill -- his ability to apply conventional methods to solve conventional problems in conventional ways -- and if the world adopts the more-realistic science of behavioral economics he, and thousands of

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[3] This is said to be Keynes’ most famous quote, but it’s also one of the hardest to track down. It’s in chapter 24 of the 1936 and 1947 editions of the *General Theory* and on the last page of the 1939 edition but not in later editions. It’s possible that Keynes changed his mind but I think it more likely that his publisher reacted to the yowls of outraged academics, and considered the possible effect on the acceptance of Keynes’ work as course texts. If you google it, you’ll get lots of references.

[4] Thaler, Richard H., *Misbehaving*, W.W. Norton, NY, 2015, p 43.

other comfortably ensconced 'professionals' will have to be re-classified as untrained and unskilled. They will be unemployable as economists but, if they have the right paper qualifications and credentials, they might still be able to work as professors of economics.

If not they might apply for retraining, but they might be retrained by someone whose skill or knowledge is as obsolete as their own. This really does happen. An acquaintance of mine who had paper qualifications but no job as a computer programmer was re-trained, at government expense, as an instrument mechanic. After retraining neither he nor any of his classmates got jobs, because the instruments they had been trained to repair were obsolete.

I'm sure most economists think the standards of professors of economics are higher than those of instrument-repair teachers, but that's a matter of opinion. Considering the possible effects of global warning one prominent professor of economics (who shall be nameless because I'm writing this to illustrate a point; not to shame him) wrote: -- "Agriculture is practically the only sector of the economy affected by climate, and it contributes only a small percentage (three percent in the United States) of national income. If agricultural productivity were drastically reduced by climate change, the cost of living would rise by one or two percent, and at a time when per capita income will likely have doubled."[5]

No problem? In a world in which tens of millions of people are already on the edge of starvation? If "agricultural productivity were drastically reduced" millions of people might die of starvation, but there would be no serious harm to the economy. Hmmm…

I suggest that many of the professional pundits who advise governments and foundations, and pontificate on news media, are hired and listened to because they can be relied on to repeat the ideas they learned in school, which are the same ideas that government and media functionaries, and many philanthropists -- learned in school.[6]

I'm sure that a lot of people in the charity and foreign aid businesses will reject my ideas and I don't reject all of theirs, but I think there are needs that may soon become more pressing than the ones the news media publicizes and that you and other philanthropists are persuaded to invest in. I accept that there is a real need for immunization and medicines in the third world but I have read that the producers of pharmaceuticals are some of the most profitable companies in the United States and it would not surprise me if some of them help to promote 'charities' that want to distribute drugs -- at your expense -- in the third world.

If the drug producers are as profitable as they appear to be, they could distribute some drugs themselves.

But on the other hand we all need food and with climate change -- whether for hotter or colder, drier or wetter -- we may all face the global famine that Thomas Robert Malthus predicted more than 200 years ago. He got the date wrong but the idea is still valid. A global famine can be delayed, but we have no guarantee that it can or will be prevented.

Still, we might as well try. I don't see much sense in offering medicine and immunization to children who will starve to death in a few years, and the ideas I propose here are intended to prevent starvation, rather than to cure or prevent disease.

I know that even if you wanted to you could not follow up on more than one or two of my suggestions but, if I make them public enough, someone else might. I address this to you but it's aimed at everyone willing to invest in the future of humanity. Mostly, it's what I would do if I ruled the world.

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5 "The cost of combating global warming: Facing the tradeoffs" *Foreign Affairs,* 76.6 (Nov/Dec 1997): pp 8-14.

6 While I often write dismissively of school, I still respect it's value. School teaches us to think alike and hold common values, both of which are required in a cohesive society. The problem is that when we all think alike, there is little room for independent thought.

Many of these ideas may not look like conventional 'philanthropy' but sometimes, I suspect, conventional philanthropy may be over-valued. Dr. Albert Schweitzer was a great humanitarian but, while he saved a lot of lives, the people whose lives he saved had children who had children who had children and, in the long run, many of the children born of parents he saved from disease eventually starved to death and many more are liable to starve in the future.

Writing in 1968 biologist Paul Ehrlich said the global famine that Malthus predicted would come in the 1970s but it was delayed because Norman Borlaug's new variety of wheat tripled Mexico's crop in a few years and, in 34 years from 1965 to 1999, multiplied India's crop nearly six times. Following Borlaug's lead other researchers developed high-yield rice varieties that are now growing about the world.

Promoters of industrial farming like to cite Danish economist Ester Boserup's contention that farming becomes more productive as the population increases.[7] Unfortunately we have evidence that Boserup's idea is not always valid. While the population of New York state increased, wheat yields declined from 25-35 bu/acre in 1780 to 6-9 bu/acre in 1849.[8] American farmers solved that problem by moving west and opening new land, but today's farmers don't have that option.

And while Boserup's idea is open to question the corollary -- that population increases when farming becomes more productive -- is not. For a few years after Borlaug's *green revolution* the world's food supply increased faster than the population but population growth continues and per-capita production of grain peaked in 1984 and has declined ever since.[9]

One problem is that green revolution grains need lots of water -- about 500,000 gallons to grow an acre of modern corn -- and irrigation pumps can drain underground aquifers faster than rainfall can replenish them. More than half of the water in the Ogallala aquifer, which supplies much of the American prairies, has already been withdrawn and current use is 130% to 160% above replacement.[10] If this continues, the aquifer will be drained by 2030.[11] Even now, much of the American southwest has problems and California is near disaster.

Lake Chad -- once the biggest lake in Africa and one of the biggest in the world -- is drying

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7 https://en.wikipedia.org/wiki/EsterBoserup

8 Montgomery, David R., *Dirt; The Erosion of Civilizations*, University of California Press, Berkley & Los Angeles, 2007, p. 133.

9 FAO. 1961-1999. *Quarterly Bulletin of Statistics*, Food and Agriculture Organization of the United Nations. Cited by David and Marcia Pimentel in *World Population, Food, Natural Resources, and Survival*, College of Agriculture and Life Sciences, Cornell University, Ithaca, NY, February 28, 2002.
see also http://www.fao.org/faostat/en/#home

10 P. Beaumont 1985. "Irrigated agriculture and groundwater mining on the high plains of Texas," *Environmental Conservation* 12: 11pp, cited by Pimentel, 2002.

11 *Britannica* CD98
see also Soule, Judy, David Piper and Wes Jackson, *Farming in Nature's Image: An Ecological Approach to Agriculture* Island Press, Washington, DC, 1992.

up and much of Africa is in drought that may last for decades.[12]

In Asia the Aral Sea -- once the fourth largest lake in the world, with a surface area of nearly 26,000 square miles, is now mostly desert.[13] The Gobi desert has more than doubled in size since the 1950's and is growing by an estimated 950 square miles a year. China's *Institute of Desert Research* says the cause is increased water use by humans. The demand for water exceeds supply in nearly 80 nations

A study by British, Indian and Nepalese researchers at Calicut University in India suggest that both India and Pakistan will have more water than usual for about 40 years as the glaciers of the Himalayas melt, flooding the Indus and Ganges rivers, but when the glaciers are gone both rivers will drop to less than half their present flow. The Indus irrigates about half the crops in Pakistan, and the Indian government plans to take water from the Ganges to water the arid southern section of the country. When the rivers fail, crops will fail.[14]

The growth of cities takes more than 25 million acres of land a year. About half of this was cropland and around the world we now have only about 0.6 acres of cropland per capita, or about half the amount needed to feed the world to North American standards.[15] The United States now has only 1.25 acres of cropland per capita, which is about the minimum required.[16]

History shows that conventional farming methods destroy the topsoil and that most farming areas revert to desert. The first grain farms of history are now the deserts of modern Iraq, Iran and Syria. North Africa was the granary of the Roman empire, but it's now mostly desert. The Chaco Canyon area of New Mexico is a desert now, but it was forested before the Pueblo people farmed it. The Amazon basin is still forested but, as farmers move in and cut the trees, ecologists predict that it will soon be a desert.

We are also running out of the fossil fuels we need to make chemical fertilizers and pesticides and to pump water for irrigation and, believe it or not, we are even running out of sunlight! Astronomers tell us the sun gets hotter every year but, because of air pollution and the contrails left by high-flying jets, less sunlight reaches the Earth every year. Parts of the former Soviet Union lost almost 20% of their sunlight between 1960 and 1987.

Sunlight is reduced in densely populated areas by industrial smog and airliners reduce sunlight everywhere they travel. The contrails they make are just clouds but there are so many of them that they increase cloud cover to unnatural levels. The three-day suspension of air traffic after 9/11 produced a measurable change in sunlight, and in the difference between day and night temperatures, across the United States.[17] Some pundits suggest that we could limit 'global warming' by releasing millions of tons of sulphur dioxide in the upper atmosphere. If they could do that they would reduce sunlight even further, and produce probably-disastrous acid rain.

This while dreamers are predicting that in future we will generate more and more of our electricity from sunlight!

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12 P.H. Gleick, *Water in Crisis*, Oxford University Press, New York, 1993, cited by Pimentel, 2002.

13 https://www.thoughtco.com/abu-hureyra-syria-170017
see also Peter Goodspeed, "Kazakh dam spells doom for grossly polluted Aral Sea." *National Post*, Oct 3/03.

14 "Glacier meltdown," *New Scientist*, May 8, 2004, pg 7.

15 Doeoes, B.R. "Environmental degradation, global food production, and risk for larger-scale migrations," *Ambio*, 23 (2), 1994, pp 124-130, cited by Pimentel et al, 2002.

16 USBC. 2000. *Statistical Abstract of the United States, 200th ed.,* U.S. Bureau of the Census, U.S. Government Printing Office, Washington, DC, cited by Pimentel et al, 2002.

17 Adam, David, "Goodbye Sunshine," *The Guardian*, Dec 18/03.
See also Travis, David J., Andrew M. Carlton, and G. Laurentsen Ryan, "Contrails reduce daily temperature range," *Nature*, Aug 8/02, p 601.

Air pollution is yet another danger, according to a study by researchers from MIT, the University of Hong Kong and Colorado State University. The study estimates that yields of rice, wheat, corn, and soy; which together provide more than half the calories consumed by the global population; will drop by about 10 percent by the year 2050.

The drop will be due to a combination of air pollution and global warming which together will cause an increase in atmospheric ozone, which is damaging to both plant and animals. The study estimates that nearly half the damage to soy crops previously believed to have been caused by global warming was probably due to air pollution. While both factors are important to all crops, some suffer from one more than the other. Corn, for example, is easily damaged by heat while wheat is more easily damaged by air pollution.

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FINDING MORE WATER

Perhaps our most urgent need is to find more water, and to make better use of the water we have. Some of the problems are obvious, and should be easy to solve if someone is willing to throw money at them.

For a start, the Aswan Dam on the Nile River seems to have been a mistake because huge volumes of fresh water evaporate from Lake Nasser and the silt that used to be left on farm fields by the annual floods and eventually deposited in the Nile delta now precipitates in the lake, making it shallower. Because any given volume of water in a shallow lake has more surface area than it would in a deep lake, this increases the percentage of loss by evaporation.

According to geomorphologist Prof David Montgomery of the University of Washington about 14 cubic kilometers of water evaporate from the surface of the lake and 130 million tons of silt settle behind the dam every year. The Nile delta is shrinking for lack of silt coming down the river and, while power from the dam sustains production of artificial fertilizers, small farmers can't afford them. Once the bread basket of the Roman empire, Egypt now has to import food.[18]

It would not be practical to remove the dam because it produces a lot of hydro-electric power; but we could clean up the bottom of the lake. In most dams the over-flow comes from the top of the impounded water but suppose someone were to build a big siphon to suck silt and water from the bottom of Lake Nasser and take them over the dam? I don't have numbers to justify this suggestion but we do know that the Nile floods and I assume that some of the flood must be released over spillways.

It might be necessary to move the intake of the siphon occasionally but, considering that it will create a current of water into the intake, it may not.

I don't see how a commercial company could profit from this but Egypt might and, if someone were to pay a grad student to develop the idea, the Egyptian government might implement it. If there is no other benefit this would support a student for a while and maybe get him or her started on a career of public service.

The student who works on this project might also think about an alternative to hydro dams. The up-stream end of the reservoir formed by a dam must be at least level with the water in the dam and, if the river runs year-round, it might be cheaper -- or at least practical -- to dig a tunnel or lay a large-diameter pipe from up-stream to a hydro station than to build a dam. This would have the added benefit that it would not displace villages or flood farmlands. In some cases, a pipe might be laid in the river. This assumes a year-round flow in the river, of course, but I don't think the Nile dries up very often.

There are a couple of drawbacks to the idea, but I don't think they are fatal. One is that friction would slow the flow of water in a long pipe or tunnel, but I don't see that as a problem

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18 Montgomery, David R., *Dirt -- The Erosion of Civilizations*, University of California Press, Berkley & Los Angeles, 2007, p 42-3.

if the pipe or tunnel were much larger in diameter than the penstock that feeds water to a turbine. Besides, because the pipe or tunnel would not flood villages or farmland it could start quite a bit farther upstream than the head of the reservoir.

It might be impractical to replace the Aswan dam with a tunnel but, if it could be done, the cropland that it drowned would be recovered and, with a thick layer of the silt precipitated by the dam, it would probably be more productive than before.

More serious is the argument that while a dam creates a store of water that can be tapped if necessary, a pipe or tunnel would not. This sounds like a good argument for the people who build and own the dam, but it overlooks the fact that the water stored by a dam is denied to downstream users.

Ethiopia's Grand Ethiopian Renaissance Dam on the Blue Nile will reduce the flow of the Nile for years and both Sudan and Egypt will be deprived of water they now have. A tunnel instead of a dam might prevent bad feelings, and perhaps a war, between Ethiopia and Egypt.

Men have been building dams for thousands of years and the people who build and/or benefit from them don't worry if they flood farmland, block spawning fish or have other environmental costs, but maybe we should. I realize that ten or twenty -- or 100 or more -- miles of pipe or tunnel would be expensive, but so are dams and I think it's a safe bet that in some cases, at least, the pipe or tunnel would be the better choice. If you count the loss to the people displaced, a tunnel might be much cheaper than a dam.

Back to the Nile. We can assume that with a population of nearly eight million people the city of Cairo must produce tens of millions of gallons of sewage and grey water a day and that, when this is dumped back into the river, it pollutes the downstream area and the once-invaluable Nile delta. We also know that Wadi El Natrun -- a 25-mile-long below-sea-level depression where ancient Egyptians mined the natron salt they used to mummify the pharaohs -- is about 60 miles northwest of Cairo. The wadi is not empty -- the road to Alexandria runs through it and at least three of the ancient monasteries where early Christians sought shelter from the Romans are still in use -- but it would have plenty of room to absorb and evaporate huge quantities of water and, with water, it could support farming.

I have no idea what it would cost or what engineering problems would be involved in piping Cairo's waste water to the wadi, but it would not be hard to find out. I'm sure there are lots of post-grad students at universities in Egypt who are looking for things to study, and who would be glad to accept grants. When and if the idea proves to be practical, it might be worth while to back the development of a chlorella farm in the wadi. More about chlorella later.

Another possibility. About 200 miles west of Cairo the Qattara Depression is more than 7,500 square miles of land (about equal to the area of Lake Ontario) that is on average about 200 feet below sea level. For nearly 150 years dreamers have been looking at this as a possible gold mine of opportunity.

In 1912 German geographer Albrecht Penck suggested a canal from the Mediterranean coast to an area of the depression that lies about 230 feet below sea level, as a hydro-electric project. Because water would evaporate quickly in the desert, Penck said, the depression would never fill up.[19]

This project would create a huge salt pan near the bottom of the depression, but that could be another economic benefit. Chemical companies ‘mine’ the waters of the Dead Sea for minerals, and they could also use super-salinated water from the bottom of the depression.[20]

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19 http://en.wikipedia.org/wiki/Qattara_Depression_Project

20 ibid

In 1927 Dr. John Ball, director of the English government's *Survey of Egypt*, mapped the depression and made the first preliminary calculations on filling rate, electricity production and salinity.

In 1957 the American Central Intelligence Agency suggested that peace in the Middle East might be achieved by flooding the depression to change the climate, with the side effects that it would provide work for displaced Palestinians and, as an American project, counter the influence Russia had gained with the Aswan dam.

From 1964 onward Prof. Friedrich Bassler, working for Germany's Federal Ministry of Economics led an international Board of Advisers that tried to plan and finance a hydro-power station in the depression. The Bassler study of 1973 laid the basis for the Egyptian government to commission a study of its own and, in 1975, it commissioned Bassler and a group of companies known as *Joint Venture Qattara* to conduct a feasibility study of the project.

The project proposed a cut 60 meters deep to connect the depression to the Mediterranean. The project would provide hydro power, fill the depression to about 60 meters below sea level and provide a shipping route to an inland harbor and fishing grounds. Engineers said it would take about 10 years to fill the lake to the predicted level, after which it would have enough surface area that evaporation would balance the inflow. About 25,000 people would have to be relocated to make way for the canal and the lake.

The plan stalled over the cost of the canal and the proposal that that it should be blasted open with nuclear explosives. The Egyptian government of the the day didn't want to use nuclear explosives because there were concerns that shock waves from nuclear blasting might de-stabilize the Red Sea Rift, about 450 miles away, and that salt water might contaminate the oases of Bahariya and Siwa.

The concerns were valid, but that was then and this is now. Canals can be built without nuclear explosives and, in a world where drought threatens famines that may kill tens of millions of people, the project deserves a second look and so do several other suggestions to create the body of water that some call the 'Sahara Sea.' Digging and tunneling machines have been improved in the past 40 years, and the project is probably more practical now -- and the need more urgent -- than in 1975.

I don't know where the people who would be displaced would be displaced from but if they live along the line of the canal they would not be displaced by a tunnel, and if they live near the bottom of the depression they might appreciate the conversion of their home desert to a seashore.

This idea needs some study, of course, but that's what grad students are for. I don't know enough about winds in the area to predict the effect of several dozen cubic miles of water evaporated in the depression every year, but it has to come down somewhere.

If there were no other benefits, the coastal areas of a flooded depression could grow mangrove forests, which would have considerable economic value. It has been estimated that 75% of the game fish and 90% of the commercial species in south Florida rely on mangroves[21] and a study of Mesoamerican reefs found that there are as many as 25 times more fish of some species on reefs close to mangrove areas than in areas where mangroves have been cut down.[22]

There is also a small tract of below-sea-level land quite close to the sea in Djibouti and a larger one, farther from the sea, in Eritrea. The depression in Djibouti might be flooded anyway, if the climate warms and the sea level rises, and I don't know whether it would be worth while to drill a tunnel or cut a canal to fill the one in Eritrea.

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21 http://mangrove.org/video/mangroves.html

22 http://wwf.panda.org/about_our_earth/blue_planet/coasts/mangroves/mangrove_importance/

Several sources have suggested a canal from the Gulf of Aqaba (an arm of the Red Sea) to the Dead Sea, as a hydro-electric project and to restore the water level in the Dead Sea; which is now falling because so much water is taken from the Jordan River. Last I heard the project was stalled by a diplomatic hassle between Israel and Jordan, but increased water in the Dead Sea would lead to increased evaporation and if that would increase rainfall in desert areas, it should be considered.

And we might consider something different from the current plan, which seems to depend on pumping water up about 230 meters over a height of land before it runs down to the Dead Sea. The downhill run would be used to generate more than enough power to drive the pumps for the lift but, considering that the benefits of the project can be expected to last hundreds or even thousands of years, I suggest that in the long run it makes sense to consider a tunnel rather than pumps and generators which would have to be maintained and replaced.[23]

Power from the Red Sea - Dead Sea project could also be used to desalinate seawater and Saudi Arabia plans nuclear-powered desalination plants to produce fresh water from the Red Sea but, given the solar power available, mechanical or nuclear power for this use sounds like overkill to me. Years ago professor emeritus Richard Hummel of the University of Toronto imagined a solar-powered still that could be built almost any size.

One interesting innovation Hummel suggests could be applied in quite a few places at relatively low cost. He notes that sunlight penetrates hundreds of feet into seawater and, where the ocean is deep, the heating effect is diffused. But imagine a network of black panels, each perhaps one meter square, suspended a couple of feet below the surface to form a net that would trap solar energy in the top few feet of water. Given that water temperature in the Red Sea normally ranges from 79 degrees F (26C) in the north to 86 degrees F (30C) in the south, water above the heat trap would evaporate very quickly. Water below the heat trap would be cooler than normal but, given that the trap could cover only a small area of the sea, I would not expect to see much ecological impact on the sea.

Hummel's design also includes a system to condense and collect the evaporated water, but I find the heat trap itself most interesting. Without the condenser it would be very cheap, and such heat traps could be used in many areas where more evaporation from the sea would result in more rain on the land. We might also consider the possibility that a Stirling engine; which could be powered by the heat differential between the water above and below the heat trap; could drive coolers to condense fresh water from the vapor produced by the heat traps.

In some cases, Hummel suggests, it might be practical to fly huge horizontal sails over the array, with the down-wind edge of each sail held down to a few feet above water level and the up-wind edge allowed to fly as high as conditions and the size of the sail permit. The effect would be a huge air scoop that would produce a strong airflow over the water at the low end of the sail, and increase evaporation. This would be practical, of course, only in areas with a constant wind.

But even without accessories, Hummel's heat trap would produce a lot of evaporation. That might not be enough because in the Red Sea and some other areas very warm water that produces a lot of evaporation is surrounded by deserts. Hummel says this is because evaporation cools the air immediately above water level, so it does not develop thermal updrafts to lift moist air to higher altitudes where it would cool and rain drops would form. He suggests that an island of floating black panels in the middle of the network would heat the air above it enough to create thermals.

New materials might make this idea work even better. In the summer of 2014 a team at MIT announced the development of a sponge-like

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23 https://en.wikipedia.org/wiki/Red_Sea–Dead_Sea_Water_Conveyance

mix of graphite flakes and carbon foam that floats on water and can generate steam with much less sunlight than conventional steam-producing solar generators. This material is still in development but it might be ideal for use in Hummel's idea.

Hummel is retired now and may not be interested in serious work but, again, universities have lots of grad students looking for projects and grants. Sun traps would not be very expensive and I suggest that the idea could be developed and presented to governments of countries that would benefit.

We might also consider the possibility of greening some of Australia. Much of the continent has been desert for thousands of years, and even some of the fertile areas have been in drought for the past few years with more drought predicted for the future.

Lake Eyre, about 200 miles north of the south coast town of Port Augusta, is 49 feet below sea level at it's lowest point and covers about 3,500 square miles when it is full; which happens about once every ten years. What if we dug a canal or ran a big pipe from Port Augusta to Lake Eyre? A mangrove forest on the edge of the flooded area could speed evaporation and perhaps provide economic benefits and, again, I leave it to ecologists and climatologists to calculate the effect of several dozen cubic miles of water evaporated in that area every year. The opal mining town of Coober Pedy is also below sea level, and it might have to be protected by a dyke.

All of these projects would support ecosystems with some commercial value and, more important, they would evaporate huge quantities of water in desert areas. I assume that this would produce rain somewhere, but I leave it to others to predict the final result. For someone with money to invest, it should not be hard to find a few graduate students to study the idea and the problems that might be involved.

The United States has a water problem too, because the Ogallala aquifer -- which is the main source of water for about 225,000 square miles of Texas, New Mexico, Oklahoma, Kansas, Colorado, and Nebraska -- is running dry and, with or without the aquifer, much of the area is in drought. If it's fully depleted, Wikipedia says, the Ogallala will take over 6,000 years to replenish naturally through rainfall.

But several big rivers pass near or cross over the northern end of the aquifer. They don't replenish it because the aquifer is covered by a layer of waterproof clay but Prof Hummel suggests that reservoirs on the rivers could hold spring flood waters and 'reverse wells' drilled from the surface could cut through the clay and feed water from the reservoirs down to the porous rock of the aquifer. He notes that such a scheme should include sand filters, to filter the flood water so it won't plug up the aquifer.

Floods on the Mississippi could also be stored in reservoirs and channelled from there into the aquifer. It would not be practical to pump surface water from the Mississippi to the high plains, but the aquifer is lower than the Mississippi and farmers on the high plains are pumping from it anyway.

Hummel also suggests that floodwater from the Himalayas could be filtered into an aquifer that underlies parts of India and Pakistan.

We know that much of the world is short of water now and that the future appears to promise more and more serious shortages to come. If we had rational and/or responsible governments they might do something about this but the first job of a politician is to get elected and the second is to keep his job. Other interests are marginal.

But there could be profit here for a businessman who could buy large areas of desert, and re-sell it as arable land when water became available.

These are just ideas at this stage and I don't pretend to have the expertise to guarantee them but, by your standards, it would cost peanuts to check them out. If nothing else you would be supporting students and, if the ideas check out, they could make a difference.

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FARMS AND FARMING

Even if we had endless aquifers we need to think twice about irrigation with groundwater, because it destroys cropland. Rainwater is essentially distilled, but groundwater contains dissolved minerals and, when we irrigate with groundwater, the plants take up the water and some minerals but other minerals are left as salts in the soil. The process is comparable to the way a kettle builds up a coating of 'lime' if it is used to boil 'hard' water and, as a kettle with a coating of lime does not work well, farmland that is *salinated* is ruined.

Irrigation turned most of southern Iraq, once the bread-basket of the Sumerian empire, into a desert.

Farmers around the world abandon about 25 million acres of 'salinated' land each year, [24] and the more we irrigate, the more cropland we lose. Some historians believe that the world's first empire, in Mesopotamia, collapsed when the irrigated fields that it depended on became salinated.[25]

Planning by politicians and officials who don't understand what they are doing is also dangerous. Between 1960 and 1990 planners in the USSR thought they could make the Union self-sufficient in cotton by 'scientific management' of land north of the Aral Sea. To support irrigation they build more than 600 dams and thousands of miles of canals, and by 1993 they had dropped the level of the sea by 50 feet and surrounded it with deserts. In the 1990's high winds moved salt dust from these deserts to drop on fields up to 1,000 miles away, and created new deserts in Kazakhstan, Uzbekistan and Turkmenistan.

The growth of cities takes more than 25 million acres of land a year. About half of this was cropland and around the world we now have only about 0.6 acres of cropland per capita, or about half the amount needed to feed the world to North American standards.[26] The United States is one of the great farming countries of the world but it has only 1.25 acres of cropland per capita, which is about the minimum required.[27]

With today's population we could not live without farms but we might question how long we can live with them. As Prof Montgomery warns us, conventional farming methods destroy topsoil and most farming areas revert to desert. Some of the first grain farmers lived in the Zagro mountains, between Iran and Iraq, about 11,000 BC. The land they farmed is now a desert. [28] Farming made the one-time garden spots of modern Iraq, Iran and Syria into deserts. North Africa was the granary of the Roman empire, but it's now mostly desert. Chaco Canyon in New Mexico was forested before the Pueblo people farmed it, but it's now a desert. The Amazon basin is still forested but, as farmers move in and cut the trees, ecologists predict that it will soon be a desert.[29]

Farms destroy the land in two ways. One is that while plants in the natural world die in place and fertilize the soil they grew in, farms send their crops to market and the nutrients they took from the soil while they were

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24 Houghton, R.A. "The worldwide extent of land use change," *BioScience*, 44(5) 1994, 305-313, cited by Pimentel et al, 2002.

25 Wright, Ronald, *A Short History of Progress*, House of Anansi Press, Toronto, 2004, p 77-8.

26 Doeoes, B.R. "Environmental degradation, global food production, and risk for larger-scale migrations," *Ambio*, 23 (2), 1994, pp 124-130, cited by Pimentel et al, 2002.

27 USBC. 2000. *Statistical Abstract of the United State*s, 200th ed. Washington, DC: U.S. Bureau of the Census, U.S. Government Printing Office, Washington, cited by Pimentel et al, 2002.

28 Montgomery, David*Dirt* -- *The Erosion of Civilizations*, (University of California Press, Berkley & LA, 2007, p 31+.

29 ibid.

growing are lost. The other is that farms require open fields, and the first step in establishing a farm is to clear the forest -- which is a vital part of the ecology.

Many of the activists that loggers and others denigrate as 'tree huggers' tell us that trees protect us from global warming by absorbing carbon dioxide and that's true, but it's just on of the ways that trees make this planet habitable. More important is their role in creating rain, because it's rain that protects us from global warming.

As Prof Hummel explains, the Earth absorbs heat from the sun and if there were no way to dump that heat, the planet would be unbearably hot. It can't radiate heat directly into space because it's covered by a thick blanket of air, and air is a good insulator. The down in a down-filled coat has virtually no insulating value itself, but the coat is warm because the down traps a layer of air.

But much of the world is covered by ocean, and an ocean can shed heat by vaporizing water. For people who like numbers it takes 580 calories of heat to evaporate one gram of water and, if there is no water to evaporate, that same 580 calories will heat 2417g of air by 1 degree C.

The sea is cooled by the evaporation of water and, when conditions are right, thermals lift the moist air to the upper atmosphere where the water condenses to fall as rain.

As it condenses the water gives up the heat that vaporized it and now that heat is above the thickest part of that insulating blanket of air, and it can be radiated into space. Weathermen tell us that Hurricane Harvey dumped about 33 trillion gallons of water on Texas, Louisiana, Tennessee and Kentucky and most of us think that rain was excessive, but -- at 580 calories per gram of water -- I'll let someone else figure out how much heat it got rid of.

There are no trees on the sea, of course, but trees also evaporate water -- through their leaves. When it coms from trees we call it 'transpiration' rather than ‘evaporation’ but the numbers are the same -- 580 calories of heat to evaporate one gram of water -- and a big forest can transpire so much water that it creates its own rain. Because water molecules containing a heavy isotope of hydrogen called deuterium don't evaporate from the sea but are transpired by trees, scientists can tell whether a cloud is made up of water evaporated from the sea or transpired by clouds and, working with data from NASA’s Aura satellite -- which studies the chemistry of Earth’s atmosphere -- climate scientist Rong Fu from UCLA found that many of the clouds over the Amazon basin were made up of water transpired from trees, rather than evaporated from the ocean.[30]

That's no surprise when we consider that the upper reaches of the Amazon, more than a thousand miles from the sea, get plenty of rain. Most of the water evaporated from the sea falls as rain on the lower Amazon, within a few hundred miles of the sea, but water transpired from trees in the lower and middle Amazon can fall as rain on the upper reaches of the basin.

Ecologist Scott Saleska of the University of Arizona says Fu's study may settle a long-standing debate about the role plants play in weather. It suggests that scientists need to consider the effects or deforestation when predicting changes in weather patterns, and that deforestation would help prevent drought.

Northern forests also help to create weather. Working in Finland, Joel Thornton, of the University of Washington, found that the aromatics released by pine trees merge with ozone in the upper atmosphere to form big particles that condense water and form clouds.

Where forests have been cleared to make way for farms and cities there are no trees to transpire water and, because rain quickly collects in wadis (and sewers) which carry it to rivers and lakes, there is much less evaporation

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30 http://www.sciencemag.org/news/2017/08/trees-amazon-make-their-own-rain

from cleared land than transpiration from a forest. We don't know that the Sahara was once forested but we know it was once green, and the coastal desert of North Africa was forested before until it became the bread-basket of the Roman empire. We know that Chaco canyon in New Mexico was forested before the Pueblo people farmed it, and that the farms and the settlements were abandoned when the area became a desert, about 700 years ago.[31]

Malthus' prediction that the human population would outgrow our supply of farmland was, too conservative because, while our population is still increasing, our stock of arable land is actually decreasing. In the 1930s, South America grew and exported twice as much grain as North America. Now Australia, New Zealand and North America export grain, to a world on the edge of famine, but we don't know how long they will be able to do it. As noted earlier, wheat yields in New York State declined from 25-35 bushels per acre in 1780 to 6-9 bushels per acre in 1849 and much of the American drive to the west was driven by the search for new land that had not been destroyed by farming. The prairies were protected by grassland with roots that no plow could break until 1838, when John Deere invented the moldboard plow. Now, islands of prairie land that have not been farmed stand about six feet above the surrounding fields.[32]

In the late 1990s, farms in Indiana lost about a ton of soil for every ton of grain they produce.[33]

In 2007 the U.S. government's *National Resources Inventory* estimated that erosion in Iowa averaged 5.2 tons per acre per year; not much more than the so-called 'sustainable' rate of five tons per acre per year; and that erosion across the whole of the corn belt averages only 3.9 tons per acre per year, but studies by Iowa State University show that, in some places, storms have caused the loss of up to 64 tons of soil per acre in some parts of Iowa and that in 2007 more than 10 million acres of farmland in 440 Iowa townships eroded faster than the sustainable rate. In more than half of these areas, soil was lost at twice the sustainable level.

More, an aerial survey conducted by the Washington-based *Environmental Working Group EWG* in the spring of 2010 suggests that soil erosion and runoff are likely far worse than even the ISU numbers suggest.

Runoff from prairie farmland washes away soil; the fertile legacy of thousands of years of geological processes; and it also carries a potent cargo of fertilizers, pesticides and manure that flows into local creeks and down the Mississippi River to the Gulf of Mexico where it creates the notorious oxygen-depleted 'dead zone' that suffocates marine life when it forms each year.[34]

Where farmland is not eroded or salinated it may be paved. Montgomery says farmland in the United States is being paved at the rate of 100 acres an hour.[35]

Another problem is that, after a harvest, some farmers leave their fields bare. Some of them learned how dangerous that was in the 1930s, when winds blew their topsoil away. On Nov 11, 1933, some farms in South Dakota lost all their topsoil in one day.

There are some sustainable farming methods -- Chinese rice paddies work well and terraced land in Peru's Colca Valley is still in good

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31 http://www.ancient-origins.net/news-evolution-human-origins/unravelling-mystery-chaco-canyon-culture-collapse-001916

32 Ibid, p. 160.

33 Ibid, p 174

34 http://www.ewg.org/losingground

35 Montgomery, 2007, p. 172.

shape after 1,500 years of farming but, around the world, most farming areas eventually become deserts.[36]

Conventional wisdom tells us that the 'invention' of agriculture was the start of civilization. That may be, but it also led to uncontrolled increase of the human population. Until a few years ago most people saw that as a benefit but now -- with an estimated two billion people hungry now and the promise of more in the future -- most of us realize that growth of the human population is not infinitely sustainable. We can try to slow or stop it, but we have not succeeded yet.

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DISASTER IN THE MAKING

We like to think that hybrid crops and genetic modification will solve our problems but, in fact, they create yet another danger.

Some of the new crops are so successful that farmers around the world have adopted them and where we once had hundreds of varieties of each type of grain, we now have only a few dozen. That's dangerous, because reduced diversity makes a crop vulnerable to pests and fungi, and the modern practice of buying new seed every year increases the danger.

When farmers collected and replanted their own seed they did not sort it and alien seeds that blew in from neighboring fields were added to the mix. Author Stanley Johnson cites a biologist who used to find up to twenty varieties of wheat in a single field on the Anatolian plateau. After the distribution of 'improved' seed, each field contained only one variety.[37]

The single variety of wheat found in modern fields is more productive than any of the local strains but, because it is a single strain, it is more vulnerable to pests and disease.

A field that contains many varieties of wheat can resist most pests and diseases because some varieties will resist any given pest or disease better than others and while some may be killed, the more resistant ones will survive. A farmer may lose part of his crop but next year, when he replants with his own seed, the mix will contain more of the resistant varieties and less of the ones that are most vulnerable.

When a whole field contains just one variety of plant a pest or disease to which that variety is vulnerable can wipe out the whole field. If farmers replant with new seed of the same variety, the crop will be lost again next year.

That happened in the United States when a new variety of wheat stem rust wiped out 65% of the 1953 crop of Durum wheat, and the same rust wiped out 75% of the 1954 crop. [38]

Concentration on a single crop caused the potato famine that killed more than a million people in Ireland in the mid 19th century. Peru's Inca empire cultivated about 3,000 different varieties of potatoes but only a few of them made it to Europe. Several were established in Ireland in the late 1600s but Irish farmers concentrated on the one called the *Lumper* because it was the most productive.

It was also the one variety most vulnerable to the Phytophthora fungus that appeared in the United States in 1843 and Europe in 1845. The blight struck the United States, Belgium and France before it reached Ireland but, because farmers in those countries grew a variety of crops including at least four varieties of potatoes, it was not a disaster to them.

In Ireland, Lumper potatoes made up half the national diet. The blight struck in August of

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36 Ibid, p 80.

37 Johnson, Stanley, *The Green Revolution,* Hamish Hamilton, London, 1972, p 11.

38 Tatum, L.A. "The Southern Corn Leaf Blight Epidemic" *Science*, March 1971, vol 171, pp 1113-1116. See also Wilkes, H. Garrison & Susan Wilkes, "The Green Revolution" *Environment*, vol 14 no 4, October 1972, pp 32-39.

1845 and by October about 40% of the crop had been destroyed. The next year the whole crop was lost and by 1850 about 1.5 million people, of a population of just over eight million, had died of starvation or fever and one million had emigrated.

The potato blight caused famine in Ireland because almost all Irish farmers grew the same variety of potato. If farmers around the world grow the same variety of grain a blight, and the famine it might cause, could spread around the world. In the 19th century it took only two years for the Phytophthora fungus to migrate from the U.S. to Europe and on to Ireland, and we have to assume that in the 21st century a new pest or disease could travel farther and faster.

We recently came close to losing the fourth most important crop in the world. About half a billion people in Africa and Asia depend on bananas for up to half their daily calories but the *Black Sigatoka* fungus; which appeared in Honduras about 1980 reduces yields by up to three quarters and cuts the productive life of banana plants from about 30 to two or three years.

The fungus threatens only the Cavendish variety of bananas and there are others, but that's not very reassuring. The Cavendish was second choice to a variety called the Gros Michel that dominated the world market until it was wiped out in the 1950s and 60s by the fungus that caused *Panama disease*. If Black Sigatoka wipes out Cavendish bananas growers will turn to another variety, but that will be their third choice and presumably not as good as either the Gros Michel or the Cavendish.[39]

Crop researchers believe they avoid the danger of uniform crops by mixing genotypes, but belief that something 'can never happen' can never be proved. In this case it could be proved false by the development of a blight but if there is no blight this year or next we can not be certain that there will not be one the year after. In fact the longer we go without a blight the more dangerous our situation, if we keep increasing our dependence on a few crops. Pests and pathogens are evolving all the time and no one can guarantee that any single crop is safe.

If a new pest or disease wipes out one of our major grain crops we have seed banks from which to breed new varieties but it takes years to develop a new crop and grow seed. In a world in which tens of millions of people are already hungry, that would be a disaster.

Genetically modified crops that promise to increase food production will be even more uniform than naturally developed crops, and will therefore be more vulnerable if a pest or disease finds their weak point. Genetic modifications may also entail other problems that have not yet been reported or proven.

In fact there is a serious chance that, sooner or later, some genetic or other experiment may go awry and destroy a considerable percentage of our capacity to produce food.

This not only could happen, it nearly has happened. Scientist and author David Suzuki says that a few years ago a German biotech company re- engineered a common soil organism called *Klebsiella planticula* to consume rotting crop waste on farms and produce ethanol fuel as a byproduct.

The company applied for permission to test the new bacterium in the United States and the U.S. Environmental Protection Agency assigned the project to Oregon State University, which in turn assigned it to doctoral student Michael Holmes.

Suzuki says normal procedure would have been to test the new bacterium in sterile soil to avoid the possibility of interaction with other bacteria. Instead, Holmes chose to test it in a

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[39] Uhlig, Robert "Banana's days cut short by rampant fungal disease" report from *Daily Telegraph*, reprinted in *National Post*, Jan 17/03, p A15. See also Pearce, Fred, "Going Bananas" *New Scientist*, Jan 18/03, pp 26-28.

variety of 'living' soils that already contained other kinds of bacteria.

To his amazement he found that every plant that was put into soil containing the engineered bacteria died. It turned out that the modified Klebsiella killed other organisms called mycorrhysal fungi, and that plants can't live without the fungi.[40] If Holmes had followed normal procedure and tested the new bacteria in sterile soil he would not have discovered the danger. If the engineered bacteria had got loose in the world, as killer bees got loose from an experiment in Brazil, they might have wiped out all plants in the areas they infested. Because Klebsiella lives under the soil it might be impossible to eliminate an infestation or even to stop it from spreading.

Another problem is that seeds for genetically modified crops are available from only a few sources. If a disease gets into one of the farms where these seeds are grown or one of the plants where they are processed and packaged, it will spread around the world much faster than would a disease of natural crops. If terrorists or natural disasters knock out the sources of the seeds, there will be no crops.

It's also a problem, and a danger, that our diets are so limited. About 90 percent of the world's food is now produced from only eight species of livestock and fifteen species of plants, any one of which could be wiped out by a new pest or disease. By contrast, anthropologist Richard Lee, who studied the !Kung bushmen of the Kalahari, found that in addition to the mongongo nuts that are their staple they eat 84 other food plants including 25 kinds of fruits and berries and 30 different roots and bulbs. Of the 223 species of animals in the Kalahari 54 are edible, but the !Kung eat only 17 of them on a regular basis.[41]

Lee studied the !Kung in the third year of a disastrous drought, while about 180,000 farmers of the Herero and Tswana tribes in the surrounding area had to depend on the United Nations' World Food Program for emergency relief. Some Herero and Tswana women joined !Kung women in the search for wild foods but, despite the increased competition, the drought that was a disaster for the farmers caused no noticeable hardship to the !Kung.[42]

We like to think that disasters are history but they are also in our future. In fact the disasters we can expect in the future will be much worse than the disasters of the past because through most of history we had a collection of mostly-independent local economies and a total population well within the carrying capacity of the planet. Now we have a global economy and a population that stretches or exceeds the carrying capacity of the planet. Most of us can overlook the starvation of a few million people in Africa or Asia but famines on that scale don't count as disasters any more. When tens or hundreds of millions of people are starving in Europe and North America, it will be too late to worry.

Any single disaster is an outside chance but the odds are cumulative and if we add up all the remote dangers that are possible we get odds that, with the future of humanity at stake, are not acceptable. There is no question whether disasters will happen or not. The questions are which disasters, and when and where they will happen.

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BIG FARMS ARE A BIG HAZARD

Industrial agriculture has done well in the short term but, by concentrating production in a few breadbasket areas with few varieties of crops and making us dependent on transportation to deliver food over long distances, it makes us extremely vulnerable to

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40 Suzuki, David and Holly Dressel, *From Naked Ape to Superspecies,* Stoddart, 1999, pp 120-21. see also http://online.sfsu.edu/rone/GEessays/Klebsiellaplanticola.html

41 Lee, Richard Borshay, *The !Kung San, Men, Women and Work in a Foraging Society*, Cambridge University Press, 1979, p xix, xx, 159, 205.

42 Lee Richard B and Devore, Irven, eds, *Man the Hunter*, Aldine Publishing Co, Chicago, 1968, pp 39-40.

any form of disaster. If every part of the world were self-sufficient for food production then a local disaster would be local. With food production concentrated in a few areas, a disaster in any one of those areas could have global repercussions.

Even without a disaster we waste resources and damage our environment by driving farms farther and farther away from our cities. Many of the vegetables we eat in Canada and the Northern States are trucked from Mexico and the Southern States while some of our best farmland is paved over with highways, shopping malls and parking lots.

I don't suggest that we could do without highways, malls and parking lots but I argue that no matter how much we like our cars, our food supply is more important and that cities and farms can and should be intermixed.

As in fact they once were. Through most of history city dwellers have had their own gardens, some kept by professional gardeners, and in times of emergency home gardens have been primary sources of food.

A hundred years ago about 3,500 acres of small farms within the city of Paris produced most of the vegetables eaten in the city and a surplus that was exported to consumers as far away as London, England. During World War II an estimated 10 million "war gardens" in the US produced an average of a half-ton of food each per year.

Even now, one United Nations report says that in the 1980's over 90% of the vegetables and over half the meat and poultry consumed in the world's 18 largest cities were produced in urban areas.

In Singapore, about 10,000 licensed farmers work more than 17,000 acres of city land on three or ten year leases. Some of the land is worth a fortune but the farmers' rent is geared to the value of their production rather than to the value of the land. About 45% of the vegetables consumed in Hong Kong are grown within the city and more than one third of the dollar value of all agricultural produce in the United States is grown within urban metropolitan areas.[43]

We need to look to urban farming, Singapore style. Most big cities have thousands of acres of vacant lots, power-line corridors and other empty land. Some of it could and should be used as parks but we can also consider government programs to rent vacant land to people who will use it to produce food. Some of the empty land in big cities is polluted, of course, but a rational government would not allow it to stay polluted. If private land is polluted the owner should be required to either clean it up or sell it to the city, province, state or nation at a bargain price. The government would then be obliged to clean the land and rent or resell it. Because the sale price would be higher than the purchase price, this would cost the government little or nothing. We can assume that the owners of polluted land would protest, but should a government allow land to stay polluted?

Even now, millions of people are starving and in Feb 2004 a report leaked from the Pentagon predicted that by 2020 winters in Britain may be like present-day Siberia.[44] A smaller change than that predicted in the leaked Pentagon study, could push us into a famine; and a rational government would start now to prepare for it. As they say in Japan, hope for the best but prepare for the worst.

Most Americans think they will always be able to buy food from other countries -- even if the inhabitants of those countries are starving -- and if they can’t buy food they will be able to

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43 *Urban Agriculture: food, jobs and sustainable cities*, UN Development Program, NY, 1996.
See also Heimlich, Ralph E, ed, *Land Use in Transition in Urbanising Areas*, published by The Farm Foundation, in cooperation with USDA Economic Research Service, Wa DC, 1989.

44 My information comes from the *Agence France* Press report of February 22, 2004. This is one of 50,300 hits that came up when I entered the search “pentagon AND famine AND report” into the Google search engine.

take it by armed force; but that's an illusion. People who are themselves starving are not likely to give up what food they have easily. If the famine is caused by volcanic eruption or meteorite strike, it might not be possible to ship food even if it is available.

Common sense argues that every nation must produce enough food to supply its own citizens, and preferably a surplus to help neighbors.

And we need to stockpile emergency supplies as soon as possible, because we have no idea when a global famine will start. We think that modern science will warn us of an impending famine but in fact it has warned us, and the warning is being ignored. We are on the edge of disaster now and we have no guarantee of any food supply beyond whatever we have in storage.

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A DEARTH OF EARTH

Some dangers sound so unlikely they are hard to believe, but experts tell us they exist. We know we're going to run out of oil some day and some parts of the world will run out of water -- but would you believe we could run out of dirt?

More than thirty years ago agricultural economist and, founder of the Worldwatch Institute Lester Brown[45] says, the world will probably run out of dirt before it runs out of oil. Apologists for modern farming say that Brown is 'an alarmist,' but he is an alarmist with 25 honorary degrees, a MacArthur Fellowship, the 1987 United Nations' Environment Prize, the 1989 World Wide Fund for Nature Gold Medal, and the 1994 Blue Planet Prize. He seems to be a well-qualified alarmist.

One scientist who takes him seriously is David R. Montgomery, Professor of Earth and Space Sciences at the University of Washington in Seattle and a member of the Quaternary Research Center.

We will never run out of subsoil but, as Montgomery explains, the topsoil that plants grow in is a complex mixture of minerals plus dead organic matter and live worms, bacteria and fungus, and it's only a few inches deep in most places.' A teaspoonful of good agricultural topsoil has about 600 million bacteria, approximately three miles of fungal hyphae, 10,000 protozoa and 20 to 30 beneficial nematodes but no root-eating nematodes. [46]

In the 1930s the United States lost a total of about 3 billion tons of soil a year, but by the 1970s the loss increased to four billion. By 1945, about 1.2 billion hectares (2 billion acres) of American farmland had been degraded.

Around the world, about a third of all farming soil has already been degraded and, if current rates of degradation continue, all of the topsoil could be gone within 60 years, FAO deputy director general of natural resources Maria-Helena Semedo told a forum in Rome. Unless new approaches are adopted, she said, the total amount of arable and productive land per person in 2050 will be only a quarter of the level in 1960, due to growing populations and soil degradation.[47]

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TERRA PRETA

But there is hope because while farming destroys topsoil, humans can make it. Conventional wisdom holds that there was no

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45 http://www.earth-policy.org/about_epi/C32

46 Montgomery, David R., *Dirt; The Erosion of Civilizations*, University of California Press, Berkley & Los Angeles, 2007, p. 175.

47 https://www.scientificamerican.com/article/only-60-years-of-farming-left-if-soil-degradation-continues/

native civilization in the Amazon basin and that the area can not support farming but we now know that there was at least one civilization (which was probably destroyed by diseases brought by the first explorers) and that, while the natural soil of the Amazon will not support farming, someone in the Amazon made more than an estimated 150,000 square kilometers of the 'synthetic' farmland that we now call Terra Preta. Crystal McMichael, a paleoecologist at the University of Amsterdam, has been studying it. The average plot of terra preta, she says, is about one hectare, but some are as large as a couple of hundred hectares. [48]

Terra Preta is darker than most Amazon soil and it has charcoal and pottery sherds mixed in it. Even though it was made from about 2,500 to about 500 years ago, it is still fertile.

So, in a world short of farmland, why not have a modern factory to mass produce Terra Preta? If it were built on a ship or a barge it could move up and down the Amazon -- and/or other rivers around the world -- making and delivering good soil where needed.

Terra Preta takes lots of charcoal, which would be no problem in areas where forests are being cleared for farmland, but I see another possibility. Power plants and factories that burn coal send a lot of carbon up the chimney and many of them do not properly process their smoke -- but what if they could sell soot?

There are filters and centrifuges available now that can clean smoke quite well, and Prof emeritus Richard Hummel of the University of Toronto is working on an air cleaning system that he hopes will remove particles down to one micron in size.

A company that makes Terra Preta might consider it worth while to install it's own flue cleaners on appropriate chimneys, offering free cleaning to the coal burners. In countries that charge a 'carbon tax' the owner of the chimney might get a refund for the carbon collected.

We might also be able to generate large volumes of cheap soot by burning waste gases from oil wells and some industrial processes in an oxygen-poor environment. In many cases these gases are 'flared' or burned off anyway and, when flared, they produce CO2, so burning them to produce soot could also offer an environmental benefit.

If chimney soot is not good for making Terra Preta, it might be packed into lumps that would serve. There would be some cost, but I think a cost that converts a pollutant into an asset is justified.

Mass production of Terra Preta might be profitable in the long run, but I don't see much chance of a typical for-profit company taking the chance on investing in it. Since the potential benefits are obvious, I suggest that a wealthy foundation might consider some of the type of companies that I would describe as 'profit optional,' -- which might hope to make a profit in the long run, but which have the primary aim of filling a need and/or, perhaps, starting a trend.

One key component of terra preta is manure -- both animal and human waste. Some farmers put animal waste on their fields but, for one reason or another, most city people are disgusted by the idea that human waste might be used to fertilize food crops, and they seem to mind it being put into their drinking water.

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DRIP IRRIGATION AND TERRACES

A foundation might also encourage and subsidize drip irrigation and terrace farming around the world.

Drip irrigation is a no-brainer -- it saves water and reduces salination. The only problem is that it takes capital to set it up, and many of the farmers who need it most -- even in the U.S. -- don't have much capital to spare.

A big foundation might also consider a program to develop and popularize terrace farming. Modern farmers like big flat fields where they can use machines but most of the

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48 http://web2.fit.edu/research/portal/project/15/analysis-and-detection-of-amazonian-terra-preta-sites

world's big flat fields are already in use, one way or another.

Some modern farmers plough hillsides along the contours, rather than up and down, but this is practical only on gentle slopes and, even there, it is not complete protection against erosion.

Traditional farmers around the world have cut hillsides into terraces, offering more protection against erosion and enabling cultivation of slopes that most modern farmers would consider too steep to farm. In some cases -- as in the terraced rice paddies of some southeast Asian countries -- the terraces are flooded, but terracing also works for dry crops.

Besides making use of land too steep for conventional farming, terracing can also enable farming in areas that are not warm enough for profitable flatland farming. In Peru, for example the terraced fields of the Inca enabled farming at higher altitudes where, even if flat fields existed, farming would not be successful.

The difference is that in most of the world the sun is seldom, if ever, directly overhead; so most of the sunlight strikes at an angle and its effect is reduced. The farther from the equator the lower the angle, and the less warming, but at the same latitudes the sunlight may strike a south-facing (or southeast or southwest-facing) hillside at a more direct angle, increasing its effect. If the field is terraced the sunlight still strikes the flat terraces at an angle, of course, but it also strikes the vertical retaining walls. Some of the sunlight that strikes a retaining wall is reflected back to the terrace below the wall and, more important, sunlight that strikes the wall warms the wall and the earth behind it, creating a warmer overall environment for plants in the terrace above the wall.[49]

Studies have also shown that the Inca's terraced fields also retained moisture better than flat fields. Many of the Inca terraces were abandoned after Spanish invaders forced Inca farmers to adopt Spanish methods and Spanish crops, but some are now being rehabilitated by a development charity called the Cusichaca Trust, formed by American archaeologist Ann Kendall in 1977.

Terrace farming is also popular in southeast Asia and, according to some reports I have read, terraced fields are not degraded as flat fields so often are. I suggest that if it were studied, supported and perhaps promoted on a global scale, terrace farming would help to relieve the world's present shortage of farmland.

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THE GLOBAL MARKET

Globalization is another problem. When we transport natural and artificial products around the world we also transport pests, including some that destroy crops. Agricultural ecologists estimate that imported pests, including more than 1,000 species of mites and insects, now cost Americans about $137 billion a year.[50]

The concentration of farm production in a few "breadbasket" farming areas is another aspect of globalization, and one that makes us dangerously vulnerable to natural disasters.

Because we have not seen a global disaster in our time we think it can't happen but we forget that the human era is just a blink in geological time, that human history is a tiny fraction of that and that the modern era -- in which we actually know what happens over much of the world -- is little more than a century old.

In his book *Catastrophe* writer David Keys describes problems caused by the eruption of

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49 http://www.smithsonianmag.com/history/farming-like-the-incas-70263217/

50 Pimentel, David; Lach, Lori; Zuniga, Rodolfo and Morrison, Doug; Environmental and Economic Costs of Nonindiginous Species in the United States, *BioScience*, Vol 50 no. 1, Jan 2000, pp 53-63.

volcano Krakatoa in 535 AD which blew the island of Java in half, created the Sunda Strait and left the island of Sumatra as a separate land mass. Ash from that eruption is found in strata and in icefields around the world and several histories record the lack of sunshine, the failure of crops and the famines that followed.

The next year Volcano Ilopango, in what is now El Salvador, produced what has been called "the second-largest volcanic eruption in the last 200,000 years" and 18 months of crop failures and famine around the world. Between them, they are suspected to have caused the 'dark ages.'[51]

Another candidate for that honor is the 1257AD eruption of Volcano Samalas on the island of Lombok, Indonesia. Dust from that event triggered a volcanic winter and cooling that lasted for several years and caused famine around the world. Records show that the death toll in London, England, was between 15,000 and 20,000 people, and the eruption may have helped trigger the Little Ice Age.[52]

In 1815 three months of explosions blew the top 1,300 meters off *Mount Tambora*, on the island of Sumbawa, killing at least 12,000 people on Sumbawa and 44,000 on the neighboring island of Lombok. The ash cloud from that one -- at least 100 times as great as the ash cloud from Mount St. Helens -- cut off sunlight around the world. In many parts of the world there was no summer that year, and where there was no summer there were no crops. In Ireland, half-way around the world from Mount Tambora, about 65,000 people starved.

The most recent eruption of *Krakatoa* in 1883 was heard 4,000 miles away, blew about five cubic miles of lava into the air and spread ash over about 300,000 miles of the earth's surface. The death toll has never been calculated but the eruption killed all life on and around the island of Krakatoa and the 120-foot tidal wave it created killed about 36,000 people in coastal communities on Java and Sumatra. In today's crowded world, of course, the toll from any one of these events would be much higher,

And even these eruptions were pipsqueaks compared to some of the volcanoes of pre-history, and some that may erupt in our time. Seventy-odd thousand years ago the volcano Toba, in what it now northern Sumatra, produced about 2,500 times as much ash as the 1980 eruption of *Mount St. Helens*.

That eruption nearly wiped out the human race, and the modern world just might experience one of comparable power. In the past few years vulcanologists have learned that Yellowstone Park -- all 3,468 square miles of it -- is actually the mouth of a huge volcano that seems to erupt about every 600-700,000 years. The last time it erupted, about 630,000 years ago, it spewed about 480 cubic miles of lava or nearly 100 times as much as Krakatoa. If the land that is now the United States had been a thriving civilization before that eruption, it would have been mostly empty desert afterward.

The eruption of *Vesuvius* that buried the Roman city of Pompeii in AD 791 was a polite burp. In fact many vulcanologists now think that Vesuvius is just a pimple on the side of super-volcano *Campi Flegrei*. The crater of the super-volcano is marked on maps as the Bay of Naples, and the last time it erupted it may have wiped out most of Neanderthal man.

The caldera volcano that lies under Long Valley, California, about 120 miles east of San Francisco, is another major threat. The only time it is known to have erupted was about 760,000 years ago, when it ejected about 144 cubic miles of lava that buried several hundred square miles of land up to 350 feet deep. The

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51 https://www.earthmagazine.org/article/aag-eruption-el-salvadors-ilopango-explains-ad-536-cooling

52 https://en.wikipedia.org/wiki/1257_Samalas_eruption#Europe

US Geological Survey keeps watch on all volcanoes in the U.S.A. and it does not predict a major eruption in the foreseeable future, but parts of Yellowstone Park are now rising and the Long Valley caldera has spewed gas and killed dozens of square miles of forest since 1980.[53]

Are these signs of impending eruptions? We don't know because no modern human has ever seen an event of this magnitude.

Another threat is the possibility of the kind of world-shaking underground explosion that scientists of the Geomar earth sciences institute at Kiel University in Germany call a *Verneshot*. They suggest that the Chicxulub crater -- generally believed to be evidence of a meteorite impact that killed the dinosaurs -- was actually caused by debris from a "Verneshot" explosion in India, and they have evidence that four other massive global extinctions were also caused by Verneshots.[54]

We also have to worry about asteroids. In 1908 an asteroid about 200 feet in diameter exploded about three and a half miles above the Tunguska area of Siberia with energy equivalent to about 10 megatons of TNT, and flattened about 750 square miles of forest. Surveys of asteroids and comets whose paths could intersect Earth's orbit suggest that there is about a 10 percent chance of an similar event happening in this century.[55] If one should occur in a modern 'breadbasket' farming area or a major transportation hub it would be a disaster for tens or even hundreds of millions of people.

About 70% of the Earth's surface is ocean, and if an asteroid hits an ocean it could raise a mega-tsunami that could destroy every city and farming area near that ocean.

Ordinary tsunamis are caused by undersea earthquakes and are, even when they destroy coastal cities, relatively gentle. Mega-tsunamis may be caused by landslides that drop huge chunks of land into the ocean, raising waves that may be hundreds or even thousands of feet high. The asteroid that many scientists believe created the *Chicxulub* crater and wiped out the dinosaurs would have raised waves several kilometers high.[56]

But we don't have to look to ancient times or outer space for danger. In 1958, a mega-tsunami caused by an avalanche into Lituya Bay near the Gulf of Alaska destroyed the forest to more than 1,700 feet above sea level. If that wave had struck a relatively flat coast, how far inland would it have gone?[57]

In June of 2017 a landslide more than 3,000 feet long and 900 feet wide from a cliff beside at Karrat Fjord, in Greenland, started a mega-tsunami that crested at about 300 feet as it rolled down the fjord.[58]

Scientists around the world are keeping an eye on the *Cumbre Vieja* volcano on La Palma, in the Canary Islands. Its last eruption in 1949 was nothing special but the next time it goes; which could be tomorrow or any time within

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53 www.usgs.gov/yv, search the site for "caldera" and "Long Valley."

54 "Four days that shook the world," *New Scientist*, May 8, 2004, pg 33.

55 Schweickart, Russell L., Lu, Edward T., Hut, Piet and Chapman, Clark R. "The Asteroid Tugboat," *Scientific American*; Nov/2003, Vol. 289 Issue 5, pp 54-62.

56 https://physics.stackexchange.com/questions/94391/can-a-mega-tsunami-have-a-height-of-30-000-feet-or-more

57 https://qz.com/193139/the-biggest-tsunami-recorded-was-1720-feet-tall-and-chances-are-good-it-will-happen-again/

58 https://news.nationalgeographic.com/2017/06/video-shows-greenland-deadly-tsunami-landslide-spd/

the next 1,000 years; it could split the mountain and drop an enormous slab of rock into 4,000 feet of water.

That will produce a wave that will be about 300 feet high when it hits the West African coast, 33 feet high when it hits Lisbon and about 40 feet high when it hits the south of England. There it will roll up the Thames estuary and destroy most of London.

On the western shores of the Atlantic the wave will be about 40 feet high as it approaches the coast but it will pile up in shallow water or constricted areas and the tsunami that hits a city may be 50 or 100 feet high. It will roll right over the Bahamas and parts of Florida and travel up rivers to cause major destruction in every city on the east coast.[59]

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FOOD FOR THE FUTURE

Most Americans don't worry about famine, but they should. Most of the famines of history were local -- crops might fail in Africa or India or Europe but they were good in other areas and with modern technology we could ship food from areas of plenty to areas of shortage. Maybe we could, but we never did in the past. English farmers in Ireland exported grain while Irish peasants starved during the 'potato famine' of the 19th century and, in the 20th century, corporate farms in East Africa exported food while local peasants starved.

More than a billion people are hungry now, the climate is changing, we are running short of agricultural land and water and there are factors in the modern food supply equation that neither Malthus nor Ehrlich knew about. Some of the models of global warming may be faulty but scientists have been telling us for more than fifty years that our climate is cyclical and due for a change, and we have evidence that it is now happening. Some people deny the possibility of climate change but we have seen it in the past -- in the "little ice age" of a thousand years ago, when some Europeans cannibalized corpses from graveyards to stave off starvation -- and it seems to be happening now. Let's not forget that one of the leading deniers is the former American president who ensured 'peace' in the middle east by invading Afghanistan and Iraq.

Some scientists say our consumption of carbon-based fuels and production of carbon dioxide is liable to make the change greater than it would be otherwise but other people; notably those who sell or use the most carbon-based fuels; insist that they know better than scientists.

The popular view is that the world is getting warmer but some climatologists believe we may be entering a new ice age, and the change-over may be much faster than we expect. Volcanos may have started the 'little ice age' but that was a short-term (by the standards of ice ages, at least) event.

On suggestion is that an ice age starts when more snow falls in winter than melts in summer. In some areas, that could happen soon.

When the Arctic Ocean was covered with ice there was no evaporation, the air of the arctic was dry and there very little precipitation. Now that the sea is open it provides a source of water for rain or snow that fall on land. Snow and ice reflect the sun's heat and if the snow lasts through the summer the area it covers does not warm up. Year by year the snow builds up and forms glaciers, which are driven into once-warmer areas by the weight of snow behind them.

Another theory suggests that an ice age can be started by the failure of the system of the ocean currents that some call the *Atlantic Conveyor*, which moderates climates from the

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59 A Google search for 'tsunami AND Canary AND Island' produced 35,000 hits.
See also Scott Stinson, "Scientist fears east coast tsunami," *National Post*, Aug 10/04, p A3.
see also 1rhttps://www.cityofboston.gov/images_documents/La%20Palma%20Canary% 20Island%20Generated%20Tsunami%20Study_tcm3-31980.pdf; see also http://www.livescience.com/25293-hawaii-giant-tsunami-landslides.html

Atlantic side of Northern Europe to the Indian Ocean and beyond. It's driven by the increasing salinity of the Gulf Stream as it moves north and water evaporates until, somewhere south of Iceland, the heavier super-salinated water sinks to the bottom and is driven south, past South Africa until it finally turns around in the Indian Ocean. From there it's driven back around South Africa and into the Caribbean, and it leaves the Caribbean as the Gulf Stream.

But if fresh water from melting glaciers in Iceland and Greenland reduces the salinity of the North Atlantic then, sooner or later, water from the Gulf Stream will not plunge to the bottom and the conveyor will stop distributing heat around the planet.[60] While the two theories (one that an ice age results from loss of ice on the Arctic Ocean and the other that it results from stoppage of the Atlantic Conveyor) differ, they do not conflict; and it could be argued that an ice age is more likely if both conditions occur.

We also know that the Earth's orbit and attitude are cyclical, and it may be necessary that one or both of the foregoing conditions develops while the planet is at a specific stage in its orbital or attitudinal cycle. It's all to easy to ascribe a change to a single cause, when a combination may be required. Some of the people who choose to deny climate change may see this as a justification, but the fact is that we know that the climate has changed in the past -- even in historic time -- and that weather patterns in the past few years has been different from those of, for example, the previous fifty years. Common sense suggests that, with or without absolute proof of change and the direction the change may take, it would be wise to prepare for all reasonable possibilities.

The possibility of an ice age might sound threatening but in fact it may be our best hope because, as English philosopher James Lovelock (who formulated the Gaia Hypothesis) observes, life has recovered from several ice ages but it might not recover from global warming.[61] He says that analysis of carbon dioxide levels found in ice cores shows there was more vegetation on the world in the last ice age than there is now.[62].

That may sound unlikely, but consider the facts. We know that mean sea level has risen by hundreds of feet since the last ice age because the glaciers tied up so much water, and Lovelock estimates that the land area flooded by the rise in sea level was about equal to the continent of Africa. Most of the land that was not covered by glaciers was well watered during the ice age but deserts now cover almost a third of the world's tropical and temperate land areas. If global warming continues the way some climatologists expect it will flood quite a lot of the world's existing farmland and convert most of the remaining land between 30 degrees north and south of the equator into desert.

There is also the fact that most of our evolution as humans occurred during the last ice age, which lasted from about 2.5 million years ago to about 20,000 years ago. Granted that what we now call 'civilization' seems to have evolved since the end of the ice age the fact is that only the last million years or so of our ancestors were humans, and that we don't seem to have evolved much in the past 20,000 years. We are children of the ice age and, in fact, there is some reason to believe that the first human civilizations developed in the ice age. We call Atlantis a legend but, since Schliemann found Troy, modern archaeologists recognize that some legends are founded on fact. More, we know that mean sea level rose by several hundred feet as the glaciers melted, and that must have sunk more than one island.

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60 Broecker, Wallace S. "The Great Conveyor," *Scientific American*, Nov/95, Vol. 273 Issue 5, p62, 7p. see also http://web.vims.edu/sms/Courses/ms501_2000/Broecker1995.pdf

61 Lovelock, J.E. *The Revenge of Gaia*, Basic Books, NY, 2006, p 40.

62 ibid, p 53.

I don't pretend to know whether we are in for global warming or an ice age but I do know that any major change in the world's weather would probably affect our food supply. Rather than quibble about which way the change will go, with the knowledge that we will never be absolutely sure until after the fact, the rational course of action is to prepare for both so we will be able to eat no matter what happens.

Millions of people are hungry now and, unless we develop new foods or new techniques, we have to expect a serious shortage in the not-so-distant future because while the so-called green revolution increased the production of food, it also increased our consumption of water and even now we are running short.

Researchers say that while about 18 percent of Africans are under-nourished now, that will increase to 27 percent by 2050.[63]

Perhaps the last comment on the agricultural revolution should be left to the late Jack Harlan, Professor Emeritus of Plant Genetics at the University of Illinois. In *The Living Fields* he wrote: "We must realize, however, that famine and starvation are an integral part of agricultural systems, and (that) agricultural systems are fundamentally unstable." [64]

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OUR OPTIONS

So much for the gloom and doom. What could a philanthropist do to avert disaster?

My suggestion -- let the eggheads argue about whether we're headed for global warming or an ice age and the politicians and big business argue that nothing is ever going to change. Common sense tells us that change is possible -- perhaps even likely -- and that we should prepare for every reasonable possibility.

Step one, I suggest, is to diversify our crops. Even if we had a thousand different varieties of wheat growing in each field there is no guarantee that some pest or blight could not strike all of them, but why limit ourselves to wheat?

The ancestors of modern wheat were domesticated in the Middle East perhaps 10,000 years ago and it is the dominant crop in the world today largely because the nations that dominate the world today are descended, directly or indirectly, from empires that were built on wheat.

Rice is also a major crop because, like wheat, it was domesticated in an area that evolved powerful empires. Corn was a staple of at least two American empires but, perhaps because those empires were conquered by wheat eaters, we use corn mostly as feed for animals.

The potato was a staple of the Inca, who were probably the most advanced farmers of their time. After the Spanish conquest Inca farmers were forced to grow wheat for the Spaniards but they also grew potatoes to feed the slaves who mined silver. A few potato plants were sent to Europe as curiosities and decorative flowers but it took Europeans more than a hundred years to realize that the potato was a useful food. In time it became so important that the potato blight was a major disaster in Ireland, and the failure of the 1916 potato crop was a major factor in Germany's decision to ask for an armistice in WWI.

Inca farmers also developed the Lima bean but most of the native crops of the Americas and Africa are now just local curiosities.

Still, many crops that have never been commercialized are as good as or better than our staples. An ongoing series of studies by the United States' National Research Council has identified dozens of grains, legumes, tubers,

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63 Wood, Anthony, "New study indicates dramatic fall-off in global crop yields by the year 2050," *Gizmag*, July 31/14, cites MIT as the source.(since this article was written, *Gizmag* has been re-named *New Atlas*).

64 Harlan, Jack R., *The Living Fields*, Cambridge University Press,1995, p. 115.

fruits, vegetables and other crops that have been domesticated by other cultures but never adopted by mainstream European or American farmers. Even without the benefit of modern plant breeding some of them are more productive and/or more nourishing than the crops we are used to, and many of them could be improved. Some nearly-forgotten African grains can survive harsh conditions and one even grows wild on sand dunes at the edge of the Sahara.[65] It's not practical now because the seeds are hard to crack, but new varieties could be developed. A foundation could perhaps subsidize an experimental farm to grow and perhaps develop some of the most promising crops studied by the National Research Council.

Market forces drive most commercial farmers to concentrate on the most popular crops, but a foundation could subsidize farmers who grow less-popular crops, and could pay marketing experts to promote them. This would be an expensive operation to start but, if well-handled it could be self-supporting and even profitable in the long run.

A well-funded marketing operation could also promote some nourishing foods that most of us are familiar with, but do not recognize as food. One of the staples of the Aztecs was a type of algae called spirulena that grew in Lake Texcoco. The lake is no longer there but spirulena is now sold in some health food stores and another variety of algae called chlorella, also sold in health food stores, offers another cheap and nutritious food.

Chlorella is the slime that forms on decaying organic matter in fresh water and most of us don't think of eating it but, grown under controlled conditions, it could be a valuable crop. Experimenters at the Carnegie Institution of Washington were able to grow high-protein chlorella with up to 88% protein or high-fat chlorella with up to 75% fat. All types were rich in vitamins and most contain all the essential amino acids that we need.[66]

The Carnegie Institution experimenters calculated that a commercial chlorella farm could produce up to 40 tons of dry chlorella per acre per year. The raw materials are water, sunlight, carbon dioxide and any convenient source of fixed nitrogen. Because little of the water is actually consumed most of it can be recycled and a chlorella farm could flourish in a desert.[67]

Many North Americans would reject the idea of eating 'slime' but that's just a cultural prejudice. In fact we can digest chlorella in its natural state but it's hard to digest grains until they have been processed by cooking or fermenting. Our ancestors did not eat grain until they learned to use fire or to brew beer. I won't try to predict the forms in which we might eventually eat chlorella or other algal cultures, but I suspect there are many. Some types of algae, yeasts and fungi are grown from waste-water, in tanks called bioreactors, and are even now among the ingredients of many commercially prepared foods.

Bioreactors also grow the lipid oils used in many suntan lotions and other cosmetics and they can grow edible fungi from materials that we generally see as waste. At the University of Waterloo Dr. Murray Moo Young found a way to grow a type of fungus called neurospora on virtually any cellulose. With his process sawdust, wood chips, straw or corn stover could be turned into food or animal feed that would be cheaper and more nourishing than soy meal.

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65 *Lost Crops of Africa, vol 1, Grains*, National Academy Press, Washington, 1996, pp 262-64.

66 https://books.google.ca/books?idFAO-4gEjZbUC&pgPA142&lpgPA142&dqCarnegie+Institution+chlorella&sourcebl&otsa8kWe4V_c_&sig95Vdz4wxpg0SrbD3NHiO-SBIdIM&hlen&saX&ved0ahUKEwiXyYP8s_TSAhUMbxQKHVJxCBgQ6AEIJTAC#vonepage&qCarnegie%20Institution%20chlorella&ffalse
see also http://publicationsonline.carnegiescience.edu/publications_online/algal_culture.pdf
see also https://en.wikipedia.org/wiki/Chlorella
see also http://www.telegraph.co.uk/lifestyle/wellbeing/6028408/Chlorella-the-superfood-that-helps-fight-disease.html

67 Milner, Harold W. "Algae as Food," *Scientific American*, vol 189 No 4, Oct/53, pp 31-35.

Sawmills across Canada burn sawdust by the ton, to get rid of it. Instead, it could be used to grow neurospora fungus that can be dried for storage and that is about as nutritious as beefsteak. I've tasted dried neurospora and I think that with the right marketing it could be marketed as a snack food, like potato chips, nachos or cheese puffs. We can't expect commercial companies to work on this because they need fast returns and they can't afford long-term projects, but a commercial company backed by a well-funded foundation could.

Chlorella, yeast and fungi are also easy to store. The Inca kept stores of food that could feed their people for years and, for a tiny fraction of our annual defense budget, we could make and store enough concentrated ready-to-eat food to help us through an unexpected shortage.

Most western countries have stocks of grain but grain is not a good emergency food. One problem is that to use grain we need to cook it and refugees from a famine or a disaster may not have pots, firewood or enough water for cooking. Another is that grain alone is not an adequate diet. At the very least, humans who live on grain need a legume for balanced nutrition.

The most practical way to store food for famine relief would be in bars or wet packs that could be made from surplus crops, chlorella and/or waste that would otherwise be thrown away.[68]

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MEAT ANIMALS

We need vegetable food and some of us are willing to live on it but most of us like meat. Some see this as a perversion but our cousins the chimpanzees eat meat when they can and while science tells us that the right mix of vegetable food can be nourishing, it also tells us that meat is more nourishing than any single vegetable. It's also more digestible -- we can eat raw meat but not raw grain or potatoes.

But while our ancestors ate meat before they were human they didn't eat big animals until after they developed weapons, just a few tens of thousands of years ago. Through most of prehistory we were probably carrion eaters and, like chimpanzees and many modern people, we ate small animals and insects.

Conventional wisdom tells is that big animals produce more meat than small ones, but conventional wisdom is not always correct. A study published by The National Academy of the U.S. notes that a 1,300-pound steer eats one ton of hay in 120 days and gains 240 pounds of weight from it. Three hundred rabbits would together weigh about the same as the steer and would also gain about 240 pounds from eating one ton of hay, but they would do it in one quarter the time. The report also notes that where a cow produces one calf per year, a rabbit will produce about 30 offspring a year.[69]

Rabbit was a popular meat in Rome and it was Romans who spread rabbits over most of Europe from their original home in Portugal. Romans also ate stuffed dormouse and analysis of scats shows that some people of the Americas, including the Aztec and the Anasazi, ate mice.[70]

We don't think of mice as a source of food for humans, but they could provide more meat than the farm animals we keep now.

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68 Several companies produce 'granola' and other bars that are represented as food, but most of them are primarily candy. The food bars I suggest for famine relief would not sell well in a corner store but they would be food on which people could live for months at a time. I have also seen at least one proposal for a 'famine food' that would actually be a kind of soup, packaged in a plastic bag, that would provide water as well as food.

69 Microlivestock, little known small animals with a promising economic future, National Academy Press, Washington, 1990 (BOSTID), p 9.

70 Callen, Eric O. "Food habits of some pre-Columbian Indians," Economic Botany, 19, no. 4 (1965): 335-43. See also "Analysis of Tehuacan coprolites," in *The Prehistory of the Tehuacan Valley: Vol. 1. Environment and Subsistence*, University of Texas Press, Austin, 1967, pp 261-89.

A typical cow will produce her first calf when she is a few months more than two years old and will then produce a calf every year. Steers are slaughtered when they are about two years old so, leaving the cow to bear again, we can afford to eat less than one-third of our total beef herd every year.

A common house mouse begins to breed at the age of about 10 weeks and one female mouse can produce a litter of eight to twelve young every five weeks. If we ate mice, we could afford to eat 500 to 800% of our total stock every year.

If we didn't eat them a single mouse and her descendants could produce about 4,880 descendants in one year. In the next year each of her 2,440 female descendants could produce another 4,880 descendants, a total of 11,907,200. In the third year the original mouse would be dead, but her family would number in the billions.

We see this, occasionally, in the natural world when conditions are right for the mice and there are not enough predators. In one episode of the *Crocodile Hunter* TV series host Steve Irwin visited an Australian farm so badly overrun that the mice literally looked like a moving rug.

If each mouse weighed one ounce, two year's progeny from one mother would weigh more than 370 tons. In two years the progeny of one cow would weigh less than two tons. It would be a challenge to process hundreds of tons of mice for human consumption, but sardine canners have conquered a comparable one. We eat the bones of sardines and we also eat the bones of quail and other small birds.

The guinea pig was domesticated about 7,000 years ago in the Andes and is still a popular meat animal in many countries. Official numbers suggest that the 25 million people of Peru eat about 65 million guinea pigs a year[71] but official numbers count only animals raised for sale by businesses that report to the government. Because many rural Peruvians raise their own guinea pigs, the real number must be much bigger. In some parts of the world the meat of some rats sells for more than beef, because it is generally considered to be better tasting.[72]

A shift to meat production by small animals might also help the environment because even if enormous numbers of small mammals produce as much methane as smaller numbers of cows, small animals can be raised indoors and the methane they produce could be trapped and used as fuel rather than released to the atmosphere. Because methane is lighter than air, it would naturally collect under an airtight roof.

Insects are another potential food source. If that surprises you remember that most of us eat shrimp and lobsters, which are similar to insects and both of which are carrion-eaters. Some insects are carrion eaters but others, such as the locust that is one of the most popular insect meats in the world, eat only fresh green plants. Locusts and grasshoppers are specifically named as kosher food in *Leviticus, 11:22*, and are also permissible under Muslim Halal food laws.[73]

In parts of France and Italy, cheese with fly larvae in it sells for more than the same cheese without larvae. Professor Julieta Ramos-Elorduy of the National Autonomous

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71 Nikkah, Roya and Zachary Abraham, "Grilled guinea pigs are low on cholesterol," *National Post*, Oct 25/04, p A2.

72 *Microlivestock, little known small animals with a promising economic future*, National Academy Press, Washington, 1990, p 4.

73 According to *Matthew 3:4* and *Mark 1:6* John the Baptist lived on 'locusts and wild honey.' Some people insist that the 'locusts' he ate were the fruit of a carob tree but, whether John ate insects or not, most people in that part of the world used to and many still do. There is no question that the locusts named as kosher in *Leviticus* are insects.

University of Mexico says that 1,417 species of insects are eaten in 113 countries by more than 3,000 ethnic groups.[74]

In Mexico City, she says, a pound of ants sells for about 10 times the price of a pound of beef. Grasshoppers, red agave worms and the eggs of an insect called the water boatman sell for about twice as much as beef and white agave worms sell for about 14 times the price of beef.

In August of 2017 the Swiss supermarket chain Coop test-marketed burger patties and meatballs made out of beetle larvae. The burger patties we spiced up with rice, carrots, oregano and chili and a pack of two sold for more than $10 American. The meat balls contained only meat, and sold at the same price for a a pack of 30.[75]

Insects reproduce and grow at incredible rates. The fastest growing animal in the world is probably the larvae of the female goat moth, which multiplies its weight about 28,000 times in six months.[76]

The growth of other insects is less spectacular but, even so, an indoor insect farm the size of a typical dairy barn could produce tons of meat every day.

Insect farming will be a very profitable business some day, and it could be started right now. Some small businesses now raise insects for pet food and big business could raise them as a high-protein feed supplement for farm animals.

Mass-produced insects could also make fish farming more practical. We once thought of the sea as an inexhaustible source of food but stocks of wild fish are now depleted and many fish farms are not sustainable because the fish they farm are carnivores which are fed mostly on the wild fish we are now running out of. We can't afford to feed fish with fish, but we could feed them insects.

Earthworms are also a huge and potentially valuable source of food. A research team headed by biologist Dr. Maurizio Paoletti of Padova University in Italy analyzed the food value of worms eaten by Yakuana Indians of the Upper Orinoco River in Venezuela and found that the meat is slightly more nutritious than beef. It's especially high in iron and calcium, making worms an ideal diet for women who have just given birth. Yakuana women traditionally eat only earthworms and cassava for at least a month after giving birth.

Some of the worms the Yakuana eat are about the size of a man's arm. They must be cleaned before eating because earthworms have no teeth and, like birds, they swallow gravel that they store in gizzards to grind the food they cannot chew. Once cleaned they are eaten raw, smoked, dried or roasted.[77]

Paoletti reports that Yakuana Indians collect adult worms and cocoons during their mating season, when they are easily collected, and move them to river and stream banks where they will be more convenient to harvest the next year.

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74 Ramos-Elorduy, Julieta *Creepy Crawly Cuisine*, translated from Spanish by Nancy Esteban, Park Street Press, Rochester, VT, 1998.

75 Weiss, Richard, Bloomberg, "Swiss Retailer swaps meat for larvae" printed in *Toronto Star*, Aug 15/17, p B1.
se also http://www.coop.ch/de/ueber-uns/medien/medienmitteilungen/2017/coop-bietet-die-ersten-insekten-burger-von-essento-an.html

76 I got this number more than 50 years ago from Dr. Howie House who was, at the time, a researcher at the Canadian federal government's *Entomology Research Laboratory* in Belleville, Ontario. Dr. House, who sparked my interest in insects as food, also researched and planned diets for NASA.

77 *Minilivestock Environment Sustainability and the Local Knowledge Disappearance*, by Paoletti, Maurizio Guido and Leandro Dreon, Department of Biology, Padova University, Padova, Italy.

Most of the insects and worms we see are small, but there are more of them than most people suppose. As a rule of thumb, when a good pasture in temperate North America is being grazed by all the cattle it can support the total weight of insects in the field is about twice the total weight of cattle, and the total weight of worms under the field is three to four times the weight of the insects.[78]

It would probably take most of us a while to get used to the idea of eating insects and earthworms but; in a world threatened by pandemics; we might learn to prefer them, because they do not share diseases with humans. Anthropologist and author Hugh Brody says that many of our most damaging diseases are transfers from animals. We got measles, tuberculosis and smallpox from cattle, the flu from pigs and ducks, whooping cough from pigs and dogs and at least one form of malaria from birds. We got the 1918 flu that produced one of the greatest pandemics in history from birds and, in the past few years, governments in Asia have slaughtered uncounted millions of chickens to protect the world from threatened epidemics of bird flu.[79]

Diseases can transfer to us from mammals and even birds, because we are fairly close relatives, but we are so different from worms and insects that, as far as we know, any disease they can catch can't affect us.[80]

In most cases we would eat the larvae rather than adult insects, but we also need to consider the possibility of catching and using wild insects. Swarms of locusts eat thousands of tons of grain a day in Africa and governments spend millions of dollars to poison them. The poison also harms beneficial insects and is eventually eaten by humans.

Farmers and governments try to poison locusts because they see them as pests and; perhaps more important; because big companies and their agents make profits when they make, sell and apply the poisons. Whether they pay bribes or offer campaign contributions or not these people certainly make an effort to be friendly with government officials, and the officials listen to their advice.

But the locusts, up to four inches long, are edible and very nutritious. In fact a swarm of locusts consists of hundreds of tons of high-quality meat and, instead of trying to harvest it, people try to poison it. In some areas locust meat is believed to be good for diabetics and governments have to warn people not to eat them because of the poison.

If we could capture them all there are probably more locusts than people in the area could eat but the surplus could be sold as fodder or plowed under as fertilizer.

A plague of locusts is a flying meat farm, but how to catch them? I don't pretend to have a final answer, but I can offer suggestions.

Some fishing nets are several hundred meters wide and ten or more kilometers long. They're too heavy to catch locusts, of course, but the point is that big nets are not a radical idea. Nets to catch locusts could be made like the lightweight plastic mesh used to protect gardens from birds, or to bag some fruits and vegetables.

Imagine a net perhaps 100 meters wide and a kilometer or more long, cast by a line of mortars or catapults to fall over a swarm of locusts and drag it down. Because the locusts will be sold the operation might make a profit and, even if it does not, it would be much less harmful than poison.

A single net might not be big enough to capture a whole swarm of locusts but we might use several lines of nets, one behind another.

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78 I forget where I first learned this but I have confirmed it with Dr. David Pimentel, professor of agricultural ecology at Cornell University.

79 Brody, Hugh, *The Other Side of Eden*, Douglas & McIntyre, Vancouver 2000.

80 Insects can carry germs on the outsides of their bodies, but that is something else. The fly that lands on garbage and then on your steak is a potential hazard, Just as it would be if you used your fork to stir garbage and then, without washing it, to eat the steak. Insects raised for food would not have access to sources of infection.

The mesh for these nets is already in production and a well-organized world could keep nets in reserve because there is a swarm somewhere every few years and each swarm continues for a year or more.

The same type of net cast the same way might be used to capture the Quelea birds that are pests in Zimbabwe. These birds are small but estimates place the total numbers at between 100 and 150 billion and a flock will strip a field of grain in a few hours. Quelea birds roost in trees but after a few million of them have roosted, a grove of trees is reduced to bare sticks.

The birds are said to be good eating but, because farmers and governments try to poison them, the government of Zimbabwe warns people not to eat them.[81]

If we develop cast nets large enough we could trap birds in the fields, or perhaps as they approach a field. If not, perhaps we could cast a net over a section of forest where the birds roost. In that case the birds would still be in trees and hard to catch but if they were trapped by a net they could be caught, somehow.

One drawback to this idea is that chemical companies and their agents now make millions of dollars in profits from the poisons they sell, and it's a safe bet that government officials in some third-world countries share the pie. Another is our old friend the Einstellung effect -- if their predecessors used poisons, they will use poisons.

For a plague of mice, like the one shown on the *Crocodile Hunter* TV series, a big vacuum cleaner might could collect tons of meat, and save tons of grain, in a few hours. Vacuum cleaners that could do the job are already in production, for street cleaning and even to dig holes without breaking buried pipes or wires.

Mice that have been collected by vacuum cleaner may not be suitable for human consumption but fish are not choosy. If no other use can be found for them insects might be fed to chickens, cattle, pigs or fish, and mice could be fed to fish. It might not be safe to feed mammals to birds or mammals -- that's how mad cow disease got started -- but diseases do not jump from insects to mammals or from mammals to fish.

Plagues of locusts, Quelea birds and mice don't seem to be a North American or European problem but they all occur on our planet and they all contribute to planetary food shortages. We spend millions on foreign aid, but projects to control these problems might be self-sustaining.

We might also reconsider our ideas about seafood. Most whales -- the biggest animals in the world -- live on the marine animals and plants we call plankton.[82] and biologists tell us that -- even though their numbers are declining in some seas -- there are more than enough plankton in the world to feed all of humanity. Whales collect plankton by filtering it out of the water and human fishermen (planktoners?) could do the same, by towing filters behind their boats.

There may be a problem though, because some plankton -- the variety fishermen call the "red tide," make shellfish that eat them poisonous, and would probably be poisonous to people and the tentacles of Jellyfish (which are a type of plankton) are toxic to the touch, let alone eating. Before we can introduce plankton to the human diet we will need studies to determine which species are edible and which may be dangerous, and develop ways to sort out the dangerous varieties or make sure they are not part of the catch.

Then the challenge will be for businessmen to process it into the most attractive form, and to convince people to buy it. Like insects and worms, plankton might first be processed as animal feed and then developed into a gourmet food -- to be sold at a high price and with an obscene profit margin -- after which the rest of

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81 *Lost Crops of Africa, vol 1, Grains*, published by the Board of Science and Technology for International Development, National Academy Press, Washington, 1996, p 273.

82 Zooplankton are considered to be animals, phytoplankton are seen as plants.

us will accept it because it is seen as fashionable.

At some point biologists will begin to breed and businessmen to farm plankton.

So, Bill, what should all this mean to you? Simple.

We can't expect commercial farmers to take up any of the new crops or food animals I list here because they are new and, without an established market, they might not be profitable. Besides, they would probably need some development to be practical.

But a philanthropist invests for progress, not profit and the cost of developing and marketing new crops would be small, by your standards. Suppose an agricultural school or college got a grant or subsidy to develop some of these and other new and/or experimental crops.

The first products could be sold as cheap, high-quality protein to chicken, fish and pig farmers and, as the project develops some of the products would be served in the school's food court and reported in the local press. The next step would be gourmet shops -- I visualize six frozen caterpillars neatly packaged in a plastic tray, and sold for ridiculously high price -- then finally in restaurants and regular grocery stores around the world.

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WASTE NOT WASTE, WANT NOT

In the western world, we often let food go to waste. On beaches beside the Great Lakes I have seen tons of dead alewife fish, and I recall news reports of a lake in northern Saskatchewan that was poisoned by fish that died when the lake froze so completely that they ran out of oxygen, and another of tens of thousands of caribou that were drowned in Labrador when a dam released water as they were crossing the river. Within the past few years a plague of grasshoppers cost western farmers millions of dollars.

All these kills are potential sources of fish and animal feed or, at the very least, fertilizer. A well-managed operation to collect them should pay for itself, add to our food supply and reduce pollution -- all at the same time.

But rather than make the best use of food, we sometimes destroy it. In times of plenty even edible crops may be destroyed to maintain prices.[83] In a rational world all food would be valued and waste would be seen as a crime against humanity.

Many Americans are revolted by the idea of using human waste to fertilize food crops, but they don't mind seeing it dumped into their drinking water. More civilized people don't mind seeing it spread on the land, but they try to keep it out of their drinking water.

I suggest that much of our problem is that we see waste as a problem to be treated rather than as a resource to be exploited. We spend money to clean it up but we don't see much benefit from our investment because the benefit we're looking for is that we don't see pollution.

But we might get a positive benefit. Some cities process municipal sewage to sell as fertilizer but they use an expensive process and, relative to the amount of sewage we need to get rid of, their efforts are minuscule. We need cheaper processes that can be run at a profit.

Bamboo offers one option. It grows quickly, and it has many uses. In Asia they use it as a building material -- for the building itself and for scaffolds -- but I can't see that gaining popularity in the States.

Still, it could be processed. I've read that one attempt to make particle board of bamboo was abandoned because the finished board was so hard that carpenters couldn't drive nails into it, but that might also be an advantage.

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83 Foot, Richard, “Millions of tonnes of potatoes destroyed,” *National Post*, Jan 28/05, p A9.

Carpenters need particle board they can drive nails into but there must be some use for very hard and strong particle board. Glue-lam building beams made with bamboo fibers or even whole stalks might be very strong and, in China, they use bamboo as a raw material to make Rayon.

In warm areas we might spray municipal waste directly onto large bamboo farms. In an experiment by the University of Guelph (Ontario) agricultural school a few years ago, they found that if sewage is macerated and sprayed on fields in sunny weather, it's sterile before it hits the ground. Since some types of bamboo grow up to two or three feet day, I assume they consume water and nutrients quickly. This might make a good study for a grad student.

We might also use municipal sewage to fertilize a reed-bed, which could be harvested to make paper.

Even where there are no farms we cut forests to make paper. According to the Rainforest Action Network, the United States has less than 5% of the world's population but it consumes more than 30% of the world's paper.[84] What would we do without the newspapers, magazines and official paperwork that support so many people?

But do we really need to destroy forests to make paper? It used to be made from hemp, and some activists tell us that William Randolph Hearst began his campaign against marijuana because a new machine made hemp-based paper -- which used to be expensive -- cheaper, and Hearst saw a threat to the millions he had invested in forest land and paper made from trees. If we made paper from hemp -- or from reeds or bamboo -- we could save the forests. The word 'paper,' in fact, is derived from the Egyptian papyrus reed.

The difference is that bamboo and reeds can grow in a year, (perhaps in sewage) but it takes ten or more years to grow a tree.

Another idea for water treatment centers on zebra mussels. They grow fast and, I've read, they clean water so effectively that fish and other filter-feeders starve around them. They also clog up water intakes and other underwater fixtures, but that can happen only if they grow wild.

Suppose we feed waste water through large holding tanks and, in the tanks, we have wires or steel nets primed with zebra mussel spawn. We also have a calendar and before the mussels are mature enough to spawn, we pull the wires or nets and run them through rollers that crush and remove the mussels. The crushed mussels would make great chicken feed, fish feed or fertilizer.

We might also use salt-water shellfish to clean the waters of Chesapeake Bay, and the 'dead area' of the Gulf of Mexico which, I understand, is caused by fertilizer run-off from prairie farms. Another suggestion is that we might use floating aquaculture farms -- which grow plants in styrofoam floats on fertilized water -- on the Mississippi and on rivers flowing into Chesapeake Bay. We would have to leave room for river barges to pass, of course, but the farms could be tens of miles long and would not have to be wide. Again, this is a project for grad students to evaluate.

If any of these ideas work well enough it might be worthwhile for a commercial company to actually buy sewage from towns and cities and sell the products (bamboo or crushed zebra mussels, or vegetables from floating farms). The only problem I see is that it would take a backer with deep pockets to commercialize the bamboo farm and/or zebra mussel projects, because construction companies that build conventional sewage treatment plants would oppose them.

Another waste-cleanup project that could conceivably cover its own costs would look at

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84 https://www.ran.org/

the floating debris in the Pacific Gyre -- a huge eddy in the Pacific ocean.[85] After the Japanese tsunami I half-expected some entrepreneur to charter a big barge and some tugboats to drift with the debris, collect anything of value and sell or ransom it. I don't know whether that would pay or not, but would have been a useful project. Conservationists say the Pacific Gyre contains a lot of floating plastic and other waste -- but how to clean it up?

Some organizations such as the *Plastic Pollution Coalition* and the *Plastic Oceans Foundation* are trying to get individuals and businesses to use less plastic, but a wealthy foundation could do much more by funding a recycling facility to collect and process the plastic for re-sale. If nothing else, a study of the practicality of processing scrap plastic might be worthwhile.

Some fishing nets are miles long, and it might be worthwhile to anchor one or more of them to catch and hold floating plastic in the gyre, and send a ship every once in a while to collect the 'catch.'

It might even be possible to process it on the spot. One group of ecologists seems to have developed a practical way to process scrap plastic into diesel fuel. If I had big bucks I would check out the project reported in this link (http://newatlas.com/reactor-waste-plastic-diesel/48833/?utm_sourceGizmag+Subscribers&utm_campaign927b38f79a-UA-2235360-4&utm_mediumemail&utm_term0_65b67362bd-927b38f79a-90195581) and, if it looks good, I would consider mounting one of their converters on a big barge and setting it adrift, with a couple of tugs to service it, in the gyre. Depending on the grade of the fuel produced the operators of the barge might be able to sell it to passing ships -- at a premium price because there is little competition in mid-ocean -- and it might be an advantage to yachts, fishermen and other small ships to fill up there.

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PROFIT-OPTIONAL BUSINESS

Some projects are simple enough, and urgent enough, that I think it would be worthwhile to form companies to go ahead with them. This would take some investment and we can't expect a normal commercial company to try any of these ideas but they would offer benefits to the world and they might pay for themselves and even make a profit in the long run. Production and marketing of sustainable foods could be a start.

But there are other possibilities. How about a generalized company with some well-trained employees and lots of equipment to supply and help volunteers and local emergency forces around the world? If this company were backed by a wealthy foundation it could charge for its services to customers who can afford to pay, and donate them to customers who can't.

After hurricanes Katrina, Sandy and Maria we know that government agencies are not likely to be much help after a disaster but a foundation might establish a profit-optional company to produce and stockpile supplies for disaster relief. Many disasters destroy or pollute water supplies and a disaster-relief company would keep stocks of drinking water in single-serving cans, plastic bottles or drink boxes at strategic locations around the world. It might also make arrangements with local breweries or soda-pop bottlers to shift production to water; and/or stock reverse-osmosis filters that people could set up and use themselves.

People also need food and, to people living in wreckage with no water or cooking facilities, a bag of wheat or even flour is not food. After the Indian Ocean tsunami American navy ships delivered military MREs (meals-ready-to-eat) which are useful but not ideal, and too expensive to store in the quantities that might be required. Better would be the kind of food bars and/or soup packets described earlier,

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85 https://www.youtube.com/watch?vy5y1W5xduiE
see also http://www.nationalgeographic.org/encyclopedia/great-pacific-garbage-patch/

which could also be used for famine relief, and in refugee camps.

People also need to sleep, and sleeping bags of mylar or aluminized bubble-pack plastic would cost only a few cents each. They would be waterproof and warm enough for most conditions, and the bubble pack would provide a sleeping pad. Rolls of sheet plastic, or of large diameter plastic tubing, could be used to make tents or temporary patches for damaged buildings.

And we all need latrines. We don't normally supply these to disaster survivors but where crowds of people lack them, disease can spread quickly. A first- response disaster kit should include air-portable latrines that could be used for a week or so after a disaster and disposed of when they are no longer needed. They could be made of corrugated cardboard, with plastic bladders, and they need not be expensive. Mass-produced and cheap, they could also be used for special events. The heavy-duty corrugated cardboard they could be made of is already in production -- to make boxes that hold up to a ton of plastic pellets for commercial injection-molders -- and it has also been used to make houses that are expected to last at least thirty years.

When New Orleans was flooded thousands of people were trapped on roofs and about 20,000 at the infamous Louisiana Superdome, which had been designated as a 'shelter of last resort.' Helicopters could not evacuate them all but could have delivered food, water, latrines, sleeping bags and pads.

Because volcanic dust can be deadly, disaster-response supplies might also include hundreds of thousands of paper face-masks. Because some deadly germs are spread through the air, these masks might be fine enough to provide some protection against germs. Such masks are already in common use in some Asian cities. For disaster relief a profit-optional company might also stock a few thousand emergency medical kits. Most of these would include only bandages and antiseptics and perhaps pain killers but more complete kits, for distribution to doctors and paramedics, could include more sophisticated supplies and equipment.

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RESCUE SCOOTERS

One project that might develop into a profitable business is the design and production of heavy-duty motor scooters, running on wide flotation tires and with cargo beds wide and long enough to take a stretcher. These could work as ambulances and supply trucks in disaster areas -- when streets are filled with so much rubble that conventional four-wheel-drive vehicles can't get through -- and they would also be useful for farmers, hunters, campers and others.

This could develop into a good business. Armand Bombardier's first "snowmobile" was a half track about the size of a city delivery van but when he sent one as a gift to a boyhood friend who was working as a missionary in the north the friend could not use it because it was too wide to follow the trails made for dogsleds, which often passed through willow thickets. That inspired Bombardier's second project -- originally called the "Ski Dog" but now known as a "Ski-Doo," -- which is now copied and used around the world.

The 'freighter' scooter I suggest might also become a world standard, for use on mountain trails and forests, construction sites and even within factories as well as in ruined cities. If it were hybrid gas/electric it would be practical to make it two-wheel drive and, as a bonus, it could serve as an emergency power supply to a first aid station, hunting camp, worksite or other facility.

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FIGHTING FIRE

A profit-optional company might also develop a world-class fire-fighting capacity.

Wildfires, peat fires and controlled burns on farming lands kill more than 300,000 people worldwide each year, according to one study.[86]

Most of those deaths are concentrated in sub-Saharan Africa, where an estimated 157,000 people die as a result of being exposed to such fires annually. Southeast Asia ranks second with 110,000 deaths.

"I was surprised at our estimate being so high when you consider that the exposure to fire smoke is quite intermittent for most people," said Fay Johnston of the University of Tasmania.

"Even in Southeast Asia and Africa, (fire) is a seasonal phenomenon. It is not year round," she said at the *American Association for the Advancement of Science* annual meeting in Vancouver, where she presented her research

But death by wildfire is not unique to the third world. In August of 2007 a series of forest fires in southern Greece killed more than 60 people. Near the town of Zaharo in the western Peloponese Peninsula where one blaze engulfed several villages, trapping dozens of people and killing at least 37. In the north of the peninsula, 60 mainly elderly people were said to be trapped in a mountain village after refusing to abandon their homes. By Aug 27 hundreds of homes and some 70,000 hectares of land had been consumed by flames.[87]

In June of 2017 more than 60 people were burned to death after flames -- thought to have been sparked by a lightning strike -- tore through villages in the central Pedrogao Grande region of Portugal. Many of them died in cars that failed to make it through flames that blocked a road, but 12 people, including a disabled 95-year-old woman, survived the fire by taking shelter in a domestic water tank.[88]

In February of 2009 more than 700 homes were burned and at least 84 people died in a series of bush fires in the Australian state of Victoria. Many of them died in cars as they tried to flee the fires and the small town of Marysville was virtually wiped out.[89]

In 2017 large areas of land and some towns in in California were burned over, hundreds of thousands of people were displaced. The official death toll is not impressive but it might total thousands if we were to include people who die from the after-effects of stress and smoke inhalation.

TV news programs showed converted commercial airliners, presumably owned and operated by free-lance contractors, dumping huge loads of foam on burning bush and villages. These planes look impressive in action but they have to operate from airports -- where they might have to wait their turn to land or take off -- and even with fire hoses it must take a while to refill them between runs.

One Canadian company makes a specialized amphibious water-bombing plane. Skimming the surface of a lake or river a Canadair CL415 water bomber can pick up more than 6,000 liters of water in 12 seconds, mix it with foaming agent and drop it on a fire a few minutes later. If the lake is 8km from the fire a single CL415 can make a drop every five and a half minutes, and can maintain the pace for two to three hours. In two hours, at that rate, it could deliver 120,000 liters of foam. By comparison the *Evergreen Supertanker*, a converted Boeing 747 that was billed as the biggest firefighting plane in the world, carried just over 74,000 liters of water and foam on a load. If it takes much more than an hour to find an airport, land, fill up, take off and return to the fire, it is less effective than the much-smaller CL415.

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86 http://newsinfo.inquirer.net/148611/wildfires-kill-339000-people-per-year-study#ixzz4mCEr4ouG

87 http://www.cbc.ca/news/world/death-toll-reaches-63-as-fires-rage-in-greece-1.671375

88 http://www.dailymail.co.uk/news/article-4617228/Burned-cars-people-died-fleeing-Portugal-fires.html#ixzz4mCA268RS

89 https://www.theguardian.com/world/2009/feb/08/australia-naturaldisasters

Most forestry services have helicopters which can help fight fires, but which are not practical as dedicated fire-fighting aircraft. They are much more expensive to buy and operate than comparable fixed-wing airplanes, they are slower than fixed-wing planes, they take longer than the CL415 to pick up a load of water, they require more maintenance and they don't have as much range. With bladders to convert its water tanks to fuel tanks a CL415 could fly non-stop to anywhere in the world and, with autopilots that would slave a group of planes to a leader, most of the pilots of a squadron could sleep most of the way and be fresh and ready to work on arrival.

I'm sure such a service would be welcome in many American states, and probably abroad. I recall news stories, a few years ago, about a forest fire that surrounded a Greek village before it was evacuated and, I believe, most of the residents were killed. Imagine the effect on international relations if a squadron of American or American-owned water bombers had been able to open an escape route in that case.

The United States spends untold billions on its War on Terror but the fact is that while one bullet may kill one terrorist, it might make a dozen of them. On the other hand disaster relief and perhaps a squadron of fire-fighting planes might convert at least some terrorists into friends and supporters. As noted earlier we can't be certain about the long-term effects of the climate change that seems to be in progress, but the evidence so far suggests that the need to protect Americans and others from wild fires may be at least as great as the need to prepare for war.

In a perfect world I think the United States would reactivate some of the aircraft carriers it has in mothballs and outfit them with helicopters, fire-fighting water-bombers, field hospitals, rescue gear, emergency supplies, power-line repair and maintenance crews and perhaps oil-spill recovery equipment; and station them at critical ports around the world. Rescue carriers would not scare potential enemies but they might convert some enemies to friends. This is not the sort of thing an foundation could do, but it is something a foundation might lobby for.

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AMPHIBIOUS FIRE TRUCKS

Wildfires can also be fought on the ground but conventional fire trucks are of limited use for forest fires because most forests lack roads, and fire hydrants. I suggest that there is a need, and probably a market, for specialized forest-fire fighting vehicles.

Imagine an amphibious cross-country truck, with a few tricks up its sleeve. For a start, the fact that it is amphibious gives it a double advantage. One is that it can cross lakes and rivers to get to a fire, and in some cases it could work as a fire-boat, fighting a fire from a lake. Another advantage is that, to be amphibious, it would need large flotation tanks which could carry large amounts of water when it is working on land.

I visualize such a truck traveling on lakes or rivers to reach a remote area, then filling up with water as it climbs onto land. It would, of course, have all-wheel drive and over-size tires, and it would be able to carry miles of hose to lay a water line from a lake or river to a fire.

I can't imagine any of the established truck makers producing such a truck but if a foundation were to have a few of them them made, I suggest that it could probably find a market in a world in which large, disastrous fires are becoming more common. If the trucks were owned by the appropriate level of government, or by a multi-national company, one base in North America and another in Europe could keep several dozen of them to be sent by rail to wherever they are needed. In wealthy areas, such as North America and Europe, a company that owned a fleet of such trucks might well make a profit and, considering the welfare of the planet as a whole, it would probably be worthwhile for a wealthy foundation to operate such a service at a loss.

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OIL SPILLS

A profit-optional company might also be equipped and prepared to clean up oil spills. When an oil-tanker barge went down in the Gulf of St. Lawrence, quite a few years ago, I dreamed up an idea that might help.

Suppose we had a huge sheet of heavy-duty canvas -- the kind of stuff they use for a web in paper mills. Total area would be an acre or more but, of course, it would not have to be in one piece. Sections could be laced together with rope, ideally to form a big dome.

At the top of the dome a hole, perhaps six feet in diameter, connects to a sectional canvas hose -- also six feet in diameter. The sections would be of a convenient size, and we would need enough of them to reach the surface.

This equipment would be made, tested, and then stored until needed. Because it might be needed anywhere in the world, the logical place to store it is at an airport.

To cope with an oil spill from the bottom -- as when the barge sank in the Gulf of St. Lawrence or when the BP Deepwater Horizon well blew out in the Gulf of Mexico -- ships would drop anchors in a pattern around the site, and an empty tanker or barge would stand by. When the canvas arrives it is assembled, with enough hose to reach the surface, and winched down to the anchors. Obviously, it would be winched down sideways and flattened out when it get to its station -- as close as practical over the source of the leak.

Now the oil is caught in the dome and guided to the surface, and the waiting tanker, by the hose. Crude oil does not flow well in cold water, but our hose is six feet in diameter and it could be bigger if necessary. Water pressure at the bottom and the buoyancy of oil would lift it well above sea level at the surface.

For surface spills, (or if there is no tanker available to catch the spill at the surface) Prof Hummel has demonstrated in a laboratory experiment that a squadron of small boats towing underwater vanes could 'herd' an oil slick into a deep pool that can be held or moved around as required.

The boats would circle the slick, towing underwater vanes that would suck water out from under it. For this the company running the operation would need to supply the vanes, but almost any commercial fishing boats could pull them. Prof Hummel may have a video of his laboratory test.

If the oil is spilled at sea it is legitimate salvage, and a tanker-full of oil or the oil spilled in an undersea blow-out would be worth quite a lot. It would take considerable investment to make the canvas trap that I suggest and the vanes that Hummel suggests, but it might pay well in the long run. I would not expect a commercial company to take a chance on the profit but, given that profit would be a secondary concern in controlling an oil spill, I think it would be a good investment for a profit-optional company.

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WATER BAG LEVEES

Floods are another problem around the world and authorities often use piles of sand bags to build temporary levees. My suggestion is that a company devoted to coping with emergencies could keep a supply of huge waterproof canvas bags, each one maybe six feet in diameter and 100 or more feet long. Lay a bag in place, pump it full of water and, presto! Instant levee. They might need internal braces to hold their shape but, if they do have internal braces, they could be piled up to make a higher levee. The bags could be supplied free in some cases, or rented to state or local governments.

Considering the frequency of need it might be worthwhile to keep at least two stocks of water bag levees, one in North America and another in Europe, stored on railcars which could deliver them when and where required.

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A DOUBLE EXPANSION ENGINE

It might also be worthwhile to back a student to reconsider double-expansion gas or diesel engines.

The first steamships could not carry enough coal to cross the Atlantic but the development of double and triple-expansion engines solved that problem. You may have heard that the higher the compression ratio of an engine, the more efficient it is. That's so, but the term 'compression ratio' could lead you astray.

The compression ratio refers to the amount the air or fuel-and-air mixture is compressed before it is fired. In typical gas engine that runs less than 12-to-1 but in diesel engines it runs much higher. You can't run high compression in a conventional gas engine because the fuel is mixed into the air before it is compressed, and if you compress the mixture too much it will explode. That's bad news because you want it to burn, not explode, and you can't control when the explosion will occur.

Diesel engines compress the air first, and then add fuel. The fuel burns as it's injected but, because it's not mixed with the fuel, it can't explode.[90] Most of the diesel engines in big trucks run about 18-to-1 compression and in the VW Rabbit diesel car I once had it was about 23-to-1.

Because we use the term "compression ratio" many people think the extra compression makes the fuel burn more efficiently (and maybe it does, for all I know) but that's a side-effect. The inverse of the compression ratio is the expansion ratio -- the amount that the steam in a steam engine or the gases produced by burning fuel in a gas or diesel engine is allowed to expand before it is exhausted. If the charges are the same it's an obvious advantage to allow the steam or gases to expand as much as possible before we let them out.

When water is converted to steam it expands about 1,200 times but it would not be practical to build a steam engine with a 1200-to-one expansion ratio. On the other hand it's no problem to build an engine with one 10-to-1 cylinder and, instead of exhausting from that cylinder to open air, feed the steam from that cylinder to another, also with a 10-to-1 expansion ratio, for a total expansion ratio of 100-to-1. The steam going to the second cylinder would be at only one-tenth the pressure of the steam going to the second cylinder but you can compensate for that by making the second cylinder bigger in diameter. If the piston-head of the second cylinder has ten times the area of the piston-head in the first cylinder, the torque they generate will be about the same.

The development of double and triple-expansion steam engines made steamships and steam trains practical, and several inventors (including Rudolph Diesel) considered adapting the idea to internal combustion engines. They were not developed in an era of cheap fuel because the two-stage engine was slow to accelerate and, more dangerous, decelerate. Now, cheap fuel is long gone and, in a hybrid system, the engine can run at a constant speed while batteries and electric motors actually move the vehicle.

In more recent times the last generation of piston engines for big aircraft -- notably the DC7 and the B36 bomber -- ran the exhaust gases from the piston engine through a turbine to get extra power. At least one modern European diesel engine does the same, but this works well only for engines that normally run at a constant speed.

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90 Burning is a gradual process but an explosion happens all at once. If you set fire to a stick of dynamite it will burn quietly. If you shock it with a detonator, it will explode.

Rudolph Diesel's idea was to adopt the steam engine solution, and run the exhaust gases from the primary cylinder into secondary cylinder with a bigger diameter.

I visualize a three-cylinder in-line engine with small four-stroke cylinders at each end and a large-bore secondary cylinder in the middle.[91]

I don't think any conventional commercial company would consider development and production of a double-expansion auto engine -- they can't sell three-cylinder cars in the United States, even though they are more efficient than four, six or eight-cylinder cars -- but it could be much more efficient and proving it could be a good project for a post-grad engineering student. If the concept is proved, manufacturers might take a serious look at it. If nothing else, most big trucks are custom-built -- with engines and other components specified by the purchaser. If tests show that a double expansion engine would save -- say -- 10% on fuel, that would mean millions of dollars a year to a big trucking company and if they 'spec' it for their trucks, others will follow. Elon Musk's much-touted electric semi-trailer truck is a bit of a joke, in practical terms, (you can see that if you consider how much diesel fuel a typical truck stop sells in a day, and figure how big a generating plant or sub-station it would take to produce equivalent energy) but a hybrid truck with a double-expansion diesel engine could work. In fact some big-truck transmissions include electric generators, motors and super-capacitors to make conventional big trucks into hybrids.[92]

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AN ELECTRIC SPACE SHIP

The last idea in this set could be a mInd blower, because I'm going to suggest an electric launch for a space rocket.

First, I need to make a point. Orbiting satellites are useful, but space flight beyond orbit is for comic books. It might be possible but it will never be practical with chemical rockets and, while the makers of chemical rockets have much political power, we will never develop anything better.

Conventional rockets are not practical because it takes tons of fuel to get more tons of fuel off the ground. I don't know any real figures but I would guess that in the first launch of a big rocket it could take a ton or more of fuel to lift it one foot off the ground.

Canadian inventor Gerald Bull had a better idea and for years he shot satellites higher and higher with big cannons and, eventually, he built a huge cannon that could shoot a rocket nearly into orbit. He began his tests for the Canadian and American governments and he designed his big gun for NASA but NASA backed off and, eventually, Saddam Hussein started to build it. The project was stopped when Bull was assassinated, supposedly by Israeli agents, and American bombs destroyed the test model in the First Gulf War.

The rocket lobby argued that Bull's gun was a weapon but in fact the barrel -- more than 500 feet long with a bore more than three feet in diameter -- was supported on a mountainside and it could not be aimed at any military target. It could swing a few degrees right and left but if it were to try to drop a shell in Israel, for example, that shell would have to go around the world three times before it could land in Israel.

Bull's big gun had the advantage that a rocket launched from a gun does not have to lift its first stage propellant off the Earth. The

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91 This is the arrangement diesel favored, but his double-expansion engine was going to run on coal dust. He never built it, possibly because another engine fueled by coal dust, exploded and nearly killed him. Several diesel-type engines have been built to run on dry fuel -- coal dust and, in at least one case, chopped straw -- but they all have one drawback. In every case the fuel was blown into the cylinder by a burst of compressed air and, sometimes, the fuel-air mix exploded outside the cylinder. Liquid fuel has the advantage that it can be sprayed in by a pump, with no air included in the spray.

92 http://www.google.ca/search?qtruck+transmission+makes+hybrid&hlen-CA&gbv2&oqtruck+transmission+makes+hybrid&gs_lheirloom-serp.3...1148504.1160864.0.1162385.31.15.0.16.8.0.171.1285.13j2.15.0....0...1ac.1.34.heirloom-serp..9.22.1233.tCJafPmAv2o

disadvantage is that acceleration in the gun is more than any human could stand, and a severe test for any instrumentation in the satellite.

My idea is for an electric launch, from a maglev train. In a perfect world the launch site would be in either Kenya or Ecuador -- both of which have high mountains very close to the equator -- but there are dozens of peaks over 14,000 feet high in California, Colorado and Washington state.

A maglev train is driven by magnets between the rails and it's not practical for long distances -- because it needs magnets along the whole route -- but it can be very fast. One that serves the Shanghai airport hits 217 mph in two minutes from start and has a top speed of 268 mph.[93]

I visualize a maglev track that would run flat for a few miles, then climb a mountain. The 'train' would be a single flat-car, big enough to carry a rocket, and power from local generators could be built up over several days and stored in super-capacitors. Because even the level section of the track would be at a much higher elevation than Shanghai (which is less than 300 feet above sea level) it could get a higher speed on the level and, as it climbs to higher altitude on the mountain, it could go very fast. Much faster than the train to the Shanghai airport, for example, because the Shanghai train has to stop at the end of the run and at 268 mph it would take several miles to slow and stop, while a rocket-launching train would keep accelerating. With no people or delicate equipment aboard the train that lunches the rocket could be stopped, after the launch, with brutal deceleration -- or it might be possible for the launching train to double as a glider and be piloted back to its base. It might even have its own rocket engine, to give an extra boost to the space vehicle before it separates.

Because it could take miles to get up speed, acceleration would be easily tolerable for human passengers.

The rocket would be carried horizontally on the train but as the track climbs the mountain it would point up and -- like the flight deck of British ‘ski-jump’ aircraft carriers -- be nearly vertical at the end of the run. The rocket would be fired a little below the peak to boost the speed and, more important, to test it while there is still time to abort the launch. When the rocket is released to fly on it's own it would be thousands of feet above sea level and already traveling several hundred miles an hour. It would still take some fuel to reach orbit, but not nearly as much as from a static launch at near sea level.

Like the shuttle it would return as a glider. Rockets that land on a pillar of flame look good in comic books and sci-fi movies, but in the real world they have to carry the fuel for that flame into orbit at a totally impractical cost. There is also, of course, the danger that the rocket might fail to fire in time for the landing.

The government will never build an electric launch system because the rocket lobby won't allow it, but if private money can build a 're-usable' rocket, it could also build an electric launcher -- most or all of which would be 're-usable' and which would produce much less air pollution.

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WRAPPING IT UP

I don't think any of these projects would be very expensive, by the standards of international aid, but they could make a big difference in years to come. Their one drawback is that they do not promise big profits for anyone and that most private industry -- which seems to like big profits -- won't make anything on them.

Much of your philanthropy has supported medical and vaccination programs and I don't knock them but I suggest that big pharma --

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93 https://en.wikipedia.org/wiki/Shanghai_Maglev_Train

which can certainly afford it -- could take them up directly. More important now, I suggest, is that we all need to eat and the way things are going it looks as though that may soon be a problem even in the developed world. Even now, statistics published by the WHO in 2014 tell us that more than one of every 200,000 Americans die of malnutrition every year.[94] That's about 180,000 people -- or 60 times as many as died in 9/11. I don't have world numbers for malnutrition but news programs tell us we that about a billion people are hungry now, and that real famine threatens tens of millions.

As I said in the beginning I'm addressing this to you because I think it's a good way to get attention -- from you and others -- and I want to get the ideas out there. I don't claim copyright on any of them -- I probably couldn't if I wanted to -- and they're all out there for anyone to use. Even if no foundations are interested, they might give grad students some ideas to work on.

I think you and Warren Buffet are doing good work but while I realize that flakes (like me, for example) can be a nuisance, I think it's a mistake to accept ideas only from 'professionals.' If they really are professionals they're doing it for money, and they must be under pressure to offer solutions that will be profitable for them (or their sponsors) even when cheaper solutions are available. If they're trained for the business they are also vulnerable to the Einstellung effect.

In *The General Theory of Employment, Interest and Money* economist John Maynard Keynes wrote .... "Worldly wisdom teaches that it is better for reputation to fail conventionally than to succeed unconventionally."[95]

For a professional, reputation may be more important than results. For the world, results are the only things that count.

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94 http://www.worldlifeexpectancy.com/cause-of-death/malnutrition/by-country/

95 Keynes, John Maynard, *The General Theory of Employment, Interest and Money*, p 158 in the 1970 reprint by St. Martin's Press, London.