TRANSFORMATIVE TECHNOLOGIES FROM A HUMANITARIAN FUTURES PERSPECTIVE: IMPACTS ON WATER, FOOD AND ENERGY

Introduction

At the end of October, the Rockefeller Foundation launched a research and advocacy initiative on **Leveraging Humanitarian Spending to Create More Sustainable Food Systems**. With that objective in mind, a Consultation Group of 25 current and former practitioners was formed to provide perspectives on the following:

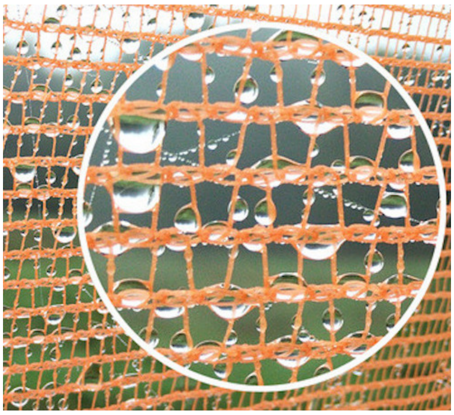
- Ways to leverage humanitarian spending to create more sustainable food systems
- The role of donors and the future of finance for Food Security
- Impacts and implications of conflict, climate change, and environmental crises
- The need for a gender lens
- Linkages to social safety nets / cash assistance
- Engaging private sector and other partners

One of the issues which *Humanitarian Futures* felt should be considered is the impact that transformative technologies could have on creating more sustainable food systems. Leveraging resources for the right sorts of technologies to meet these needs would be a major step towards achieving the Rockefeller Foundation's overarching objective.

Key themes

The water dimension

There is a wide range of technologies already in use, or will be in the foreseeable future, to have positive impacts on water and food production. Regarding water, for example, Nigeria's use of space-based sensors has begun to identify how much water is needed for agricultural production by providing information about what each square inch of ground needed, including customised fertiliser and water.[1]



In the Sidi Ifni region of Morocco, where entire villages had suffered from severe water shortages, innovators decided to use the one thing that the region had in abundance, fog. By using fog-harvesting to create water, the looming water crisis, was offset[2] In India, during this same period, over 181,000 solar power pumps were being used to harvest water, which ironically resulted in many instances in over-irrigation.[3]

Looking across the decade, there are emerging technologies that are beginning to address the consequences not only of lack of potable water but lack of sufficient water in general. At local levels, desalination is having significant impact on municipal water supplies in urban coastal centres. In some instances this accounts for an estimated 10% of water needs. By 2030 that figure is expected to increase to approximately 25% of municipal water supply in urban coastal centres worldwide.

In a related vein, China had proposed, in 2015, to turn 16 flood-prone urban areas into 'sponge cities', designed to absorb and reuse at least 80% of rainwater. The effectiveness of the programme has resulted in a commitment by Chinese authorities to create a further 14 such sponge cities by 2030. Israel, a country comprising 50 percent desert, had developed desalinisation plants to deal with severe water shortages, beginning in the 1990s. Since its programme was launched, the country now gets over 85% of its drinking water supply from desalinisation plants, and has become

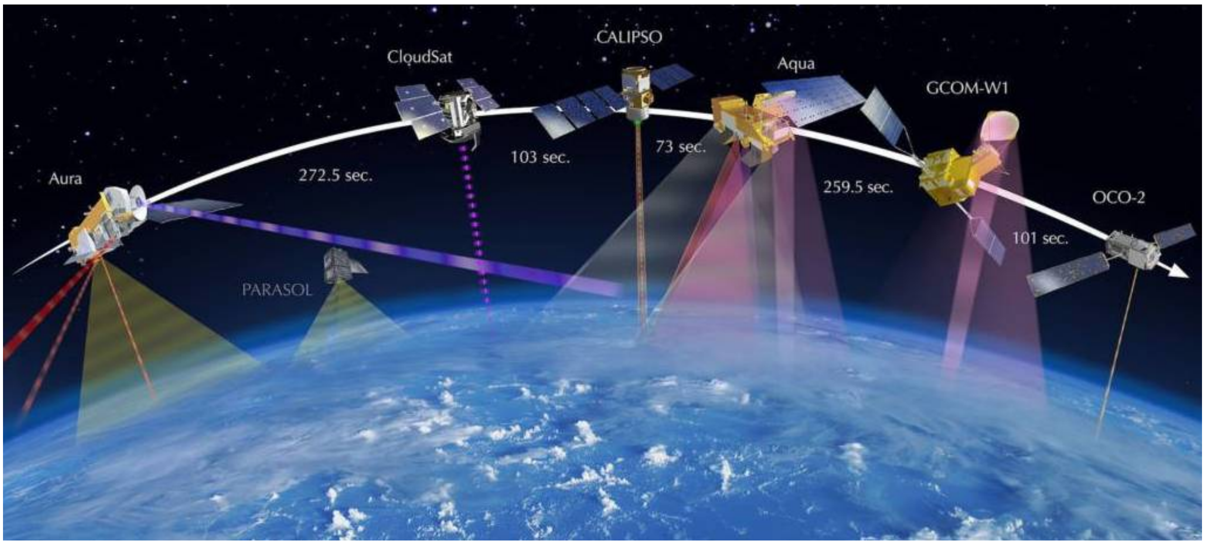
[1] Alec Ross, ***The Industries of the Future: How the Next Ten Years will Transform our Lives at Work and Home***, Simon & Schuster, New York, 2016, pg. 163

[2] Fog collector panels were mounted on the slopes of the region's Mount Boutmezguida. Though only harvesting 6,300 litres of water daily, it was nevertheless a demonstration of yet another way that looming water crises might be offset.

[3] The International Water Management Institute therefore recommended that one way of dealing with this was to incentivise farmers to return excess power back to the grid. https://energy.economictimes.indiatimes.com/news/renewable/india-installed-181000-solar-power-pumps-for-irrigation-in-three-years-under-pm-kusum-scheme/73030827?redirect=1

a world leader in the development and operation of 400 desalination plants, across 40 countries, including China, India, Australia and the US.[4]

Remote sensors, drones and blockchain technologies are also increasingly able to provide precise, real-time information about sources and availability of water throughout the world.[5] This will increasingly include linking water infrastructures to the Internet and enable real-time monitoring via sensors. In other words, 'pipes, wells, treatment plants, just about anything can become smarter once they are hooked up to the Internet. Loss management and loss detection then becomes much easier'.[6]



Another example is measuring evapotranspiration using satellite to monitor the amount of water being expelled by plants, crops and surface areas. This sort of information is designed to enable farmers, for example, to better calculate crop water requirements, helping them use water more efficiently and better plan irrigation.[7]

A second transformative factor involves the use of nanotechnology (nanocellulose materials) to provide stable, long-lasting methods for removing bacterial and chemical contaminants, including

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[4] It is worth noting that as of October 2022, Israel draws and desalinates 75 percent of its drinking water from the Mediterranean Sea. And, where the US reclaims just 4 percent of its wastewater for agricultural purposes, Israel repurposes nearly 90 percent. Rebecca Lindell, 'A Closer look at how Israel Manages its Precious Water Resources,' Northwestern Now, 19 October 2022 http://news.northwestern.edu

[5] In 2021, the Surface Water Ocean Topography mission, a joint satellite mission between Nasa and France, will have used radar technology to provide the first global survey of Earth's water, measuring how bodies of water change over time. The satellite will survey at least 90 per cent of the planet, studying lakes, rivers, reservoirs and oceans roughly twice every 21 days.

[6] Dominic Basulto, '6 innovations to cope with the threat of a megadrought', Washington Post, 19 February 2015

[7] Aries Keck, NASA Earth Science, 'Evapotranspiration: Watching Over Water Use,' 19 August 2021; Anita Gibson, OECD Directorate for Science, Technology and Innovation, E-mail: anita.gibson@oecd.org , August 2020, 'Keeping track of the world's water supplies: satellites contribute to the understanding of the global water cycle and to improved fresh water management. Clouds, water vapours, precipitation and sea-levels are all measured from space, in co- ordination with in-situ systems. Already in many OECD countries, satellite data are used to monitor daily the quality of water bodies, detecting in particular natural and man-made pollutants (e.g. harmful algal blooms, oil spills).' See: http://oe.cd/spaceforum

dyes, oils and pesticides from polluted water. Closely linked to nanocellulose water purification, a third factor is increased access to graphene to enhance desalination membranes in producing potable water for an estimated 140 countries.[8]

Such innovations would, in less than a generation's time, become a norm, in no small part due to changes in the nature of food itself. Food availability may well go far beyond traditional agricultural lands and equipment, and will have to go well beyond potentially hazardous genetically modified foods. [9]

The food perspective

New foods that are globally accessible and environmentally sustainable are inching their ways on to the market place. Solein, for example, is produced using hydrogen-oxidising bacteria, electricity from solar panels, a small amount of water, carbon dioxide drawn from the air, nitrogen and traces of minerals such as calcium, sodium, potassium and zinc – and the result -- foods consisting of 50 to 60% protein and the remainder carbohydrate and fats.[10] NoVo Nutrients, Air Protein and Solar Foods are following similar paths – all using 'constituents of air, waste CO2, and water to make plentiful amounts of nutritious protein'. [11]

30-meter-tall vertical 'farms', robotically managed, are forecast to be created in urban and semi-urban areas. Some even specialised in what were described as 'delectable' flour beetles and black soldier flies as part of

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[8] Thomas Sumner, 'New desalination tech could help quench global thirst: Scientists seek cheaper strategies for producing freshwater', Science News, 9 August 2016.

[9] We suggest that those wishing to have an interesting entry point into the consequences of such forms of bio-engineered foods and immediate alternatives should look at the 2020 documentary, Kiss The Ground https://kissthegroundmovie.com

[10] Solein had by 2019 already been selected an incubation project by the European Space Agency.

[11] John Cumbers, 'Food From Thin Air: The Forgotten Space Tech That Could Feed Planet Earth', Forbes, 6 March 2020. It is worth noting that the technology used for creating these foods were the result of NASA's initial experiments for feeding astronauts in outer space.

changes that would contribute to human nutrition….[12] Urban farming,[13] under-water farming[14] and 3D Ocean Farming[15] are all foreseen as ways that the human species might feed itself in the future.

The energy catalyst

Whether it comes to food production or access to water, the energy factor will be fundamental to both. Technological transformations will have affected the use and access to energy, both negatively as well as positively over the next three decades. Some analysts forecast that energy usage would increase in relation to Gross Domestic Product, but that growth would be slower—an average of about 0.7 percent a year through 2050 (versus an average of more than 2 percent from 2000 to 2015). The decline in the rate of growth would be due to digitization, slower population and economic growth, greater efficiency, a decline in European and North American demand, and the global economic shift towards services, which used less energy than the production of goods.[16]

Nevertheless, it was assumed that by 2050 electricity would have accounted for a quarter of all energy demand, compared with 18 percent in the 2020s. China and India may have generated 71 percent of such outputs. How will that additional power be generated? In 2016, a leading consultancy firm estimated that by 2050 more than three-quarters of new capacity (77%) would come from wind and solar, 13 percent from natural gas, and the rest from other sources. The share of nuclear and hydropower were also expected to grow, albeit modestly.[17] This would include the recent

[12] 'Farming Insects: Grub's Up', The Economist, 6 July 2019, p. 71

[13] While the degree to which urban farming could significantly reduce the need for rural space is very uncertain, it is worth noting that the US Department of Agriculture had been promoting the idea, and noted in its 2016 Urban Agriculture Toolkit that, 'while a large-scale aquaponic facility located in a warehouse-type building may be a multi-dollar investment, a small aquaponics system housed in a greenhouse could be built for a few thousand dollars, or even less if you are able to use salvaged material.' US Department of Agriculture, ***Urban Farming Toolkit***, item #1, 2016

[14] Through the work of the Italian Ocean Reef Group, crops such as strawberries, red cabbage, lettuce, beans and basil emanate from a cluster of balloon-like pods pegged to the seabed by ropes half a dozen or so metres long. Rich McEachran, 'Under the sea: the underwater farms growing basil, strawberries and lettuce', The Guardian, 13 August 2015

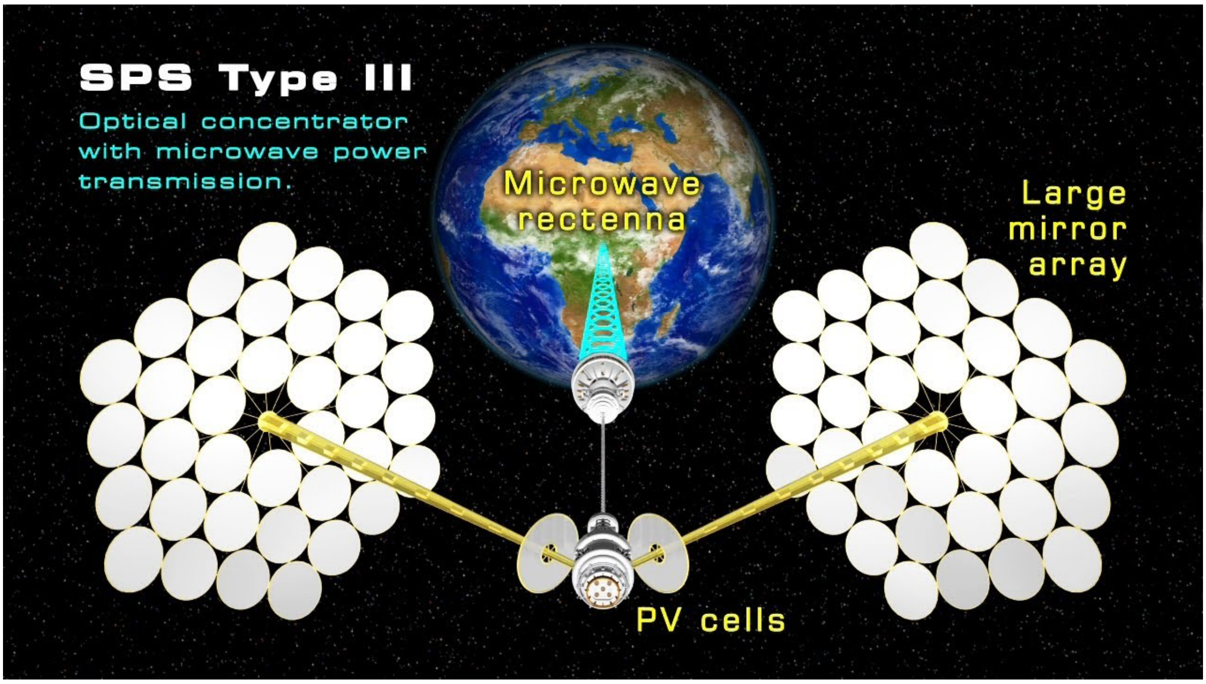
[15] 3D ocean farming is a system that grows a mix of seaweed crops and shellfish - including mussels and oysters - under the water's surface. This polyculture vertical farming system requires zero input because the sea plants filter and sequester carbon, making it, at this moment, the most sustainable means of food production on the planet.

[16] Scott Nyquist, Energy 2050 from the Ground Up, McKinsey & Company, November 2016 <mckinsey.com>

[17] Ibid.

breakthrough in nuclear fusion which, in the foreseeable future then, could result in “near-limitless energy”.[18]

What had increasingly to be taken into account, however, was that in a generation’s time energy might also reflect the emergence of giant space-based solar farms, which could offer a completely environmentally friendly answer to longer-term energy crises. The first is what has been described as ‘sun-powered chemistry’ where the manufacture of many chemicals important to human life and comfort would no longer rely on fossil fuels, but instead on the use of sunlight to convert waste carbon dioxide into needed chemicals. In so doing, it would use unwanted gas as a raw material, and sunlight – not fossil fuels – as the source of energy for production.[19]
A second example were the benefits arising from *space-based solar power* (SBSP). In this instance, solar energy would be transmitted from outer space through a number of large platforms positioned in high earth orbit where they can collect and convert solar energy into energy on earth on a global scale.[20] According to one analyst, power captured in outer space through such platforms could provide an energy source that would be continuous, clean and unlimited.’[21] To a very significant extent, SBSP could eliminate the need for fossil fuels, recycled or otherwise, and pose far fewer hazards than nuclear energy, with far greater certitude and continuity than tidal or wind generated energy sources.



[18] ‘What is Nuclear Fusion? – The Science and a New Milestone Explained,’ World Economic Forum, 15 December 2022

[19] Javier Garcia Martinez, ‘Sun-powered chemistry,’ Scientific American, December 2020, p. 30

[20] Pallab Ghosh, BBC, ‘The European Space Agency will this week likely approve a three-year study to see if having huge solar farms in space could work and be cost effective’, 22 November 22.

[21] ‘Space-based solar panels beam unlimited energy to Earth, Business Insider, p.1, [http://uk.businessinsider.com/space-based-solar-panels-beam-unlimited-energy-to-earth-2015-9/R=US&IR=T]

In a related vein, the severity of climate change may necessitate radical approaches, such as the reduction of sunlight reaching the Earth's surface as part of efforts to reduce greenhouse emissions. Known in climate change circles as solar engineering or solar radiation management (SRM), it is forecasted to have achieved its climate reduction objectives by amongst other methods positioning 'sunshades' in space.[22] That is not to say, that SRM does not pose threats. For example, there are well founded concerns that its sunshade methods might result in rain reductions for those dependent upon traditional agricultural methods. The importance of reconciling such concerns is increasingly evident even among SRM's most enthusiastic proponents.

Since the 1970s there had been many such proposals considering solar panels in outer space, which would orbit about 22,000 miles above the Earth, gather sunlight and "beam" the energy back down to the surface. The photovoltaic array of solar satellites could 'harvest' sunlight, convert it into radio frequency electrical power (microwave) sent wirelessly to ground-based receivers. They would not be affected by the Earth's atmosphere.

The receivers would take the form of giant wire nets measuring up to four miles across that could be installed across desert or farmland or even over lakes. Its potential, even at an early stage of development, had been compared to the largest earth-based solar facility, namely, in Aswan, southern Egypt. The latter produced a maximum of 1.8 gigawatts, the former could produce 2000 gigawatts. And, industrial giants such as Northrup Grumman had as far back as 2015 committed themselves to the project, and similarly so had the governments of China and Japan. [23]

Less than a decade after the Northrup Grumman announcement, the Co-Chair of the multi-institutional Space Energy Initiative (SEI) had said that the power that could be generated by harvesting solar energy could be almost limitless. 'In theory it could supply all of the world's energy in 2050.'[24]

In conclusion

When considered in their totality, there can be little doubt that the sorts of transformative technologies that are emerging could have profound and positive consequences for access to water, food and energy sectors globally. For those concerned with the growing number of vulnerable peoples who will need humanitarian assistance, the sorts of transformative technologies discussed in this paper clearly should help move from the dystopic to more optimistic visions of the future. And, when it comes to **Leveraging Humanitarian Spending to Create More Sustainable Food**

[22] Solar Radiation Management: The Governance of Research – Royal Society https://royalsociety.org › solar-radiation-governance

[23] Space Solar Power Project, CalTech <spacesolar.caltech.edu>

[24] 'How solar farms in space might beam energy to Earth', World Economic Forum in collaboration with EcoWatch, 9 November 2022

Systems, surely resources to initiate such technological initiatives must offer profoundly important ways forward.