Crops, drops and climate challenge: using energy efficiency to configure the perfect sustainability storm

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Abstract

Water availability, at the right time and in appropriate quantity is at the heart of agricultural practices worldwide; and the availability of water is largely dependent on the use of energy to pump it. Energy use also drives many other farm operations – tilling, sowing, harvesting and the manufacture of chemical fertilisers. We have, over the years, tended to overuse both water and energy in agricultural operations; practices that are now at odds with the challenges due to the emerging changes in hydrology and the increasing global concentration of greenhouse gases (GHGs). It has been argued that water-use efficiency and energy efficiency in agriculture are self-regulating phenomena, largely driven by water and energy prices. This is only partially correct now. Climate change requires us to effectively decarbonise our economies by the third quarter of this century. This implies that agricultural operations will need to become fossil-fuel free in the next two decades. We believe that this requires three parallel interventions: (i) enhance water-use efficiency and energy-use efficiency in agricultural operations; (ii) convert agricultural operations to use electricity instead of fossil fuels; and (iii) decarbonise the electricity supply by converting to renewable sources, instead of fossil fuels, as energy sources for electricity generation.

All the three interventions require policies, incentives, and regulations for their initial acceptance, commercial model development, and large-scale replication. However, the first two interventions require actions mainly by farmer-entrepreneurs, while the third intervention requires action both by the farmer-entrepreneurs (through generating their own solar electricity) as well as by electricity generation companies. What would these interventions look like? An example that covers all the three interventions is the promotion of energy-efficient solar pumps for irrigation accompanied by micro-irrigation facilities, with the excess electricity being bought by the electricity distribution company. The micro-irrigation facilities and the energy-efficient pump reduce the requirement for water pumping, and consequently the electricity needed to pump it, thus reducing the cost of the expensive solar panels. At the same time, the purchase, by others, of the excess electricity provides a revenue stream for farmer-entrepreneurs, which enables them to invest in the solar panels, energy-efficient pump and micro-irrigation facilities, as well as minimise fertiliser and water use. Another example is the promotion of energy-efficient electric tillers, harvesters and other farm equipment. These avoid greenhouse gas emissions, at the user level, and provide the potential to contribute to zero-GHG agriculture with the decarbonisation of the electricity grid.

This paper has been prepared from a transcript and the illustrative slides of the presentation.

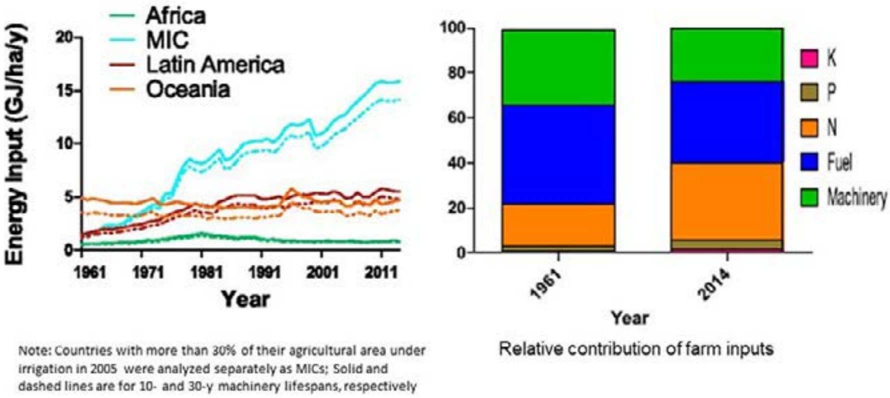

Figure 1. Yields have increased as have fertliser-use and water-use.
Source: Pedro Pellegrini & Roberto J. Fernandez 2018.

> Energy-efficient solar pumps with micro-irrigation facilities are already less expensive, on a lifetime cost basis, as compared to flood irrigation by inefficient diesel or electric pumps. Similarly, electric machinery is cheaper than diesel-run machinery, though the capital cost is higher for electricity-driven machinery, such as electric tractors which require onboard storage of electricity in batteries. The major challenge that these interventions face is the creation of demand for the zero-GHG energy-efficient options (so that economies of scale can drive down prices); and the availability of capital (loans) for farmer-entrepreneurs to invest in these options. These are challenges that have been successfully overcome in the past – in enabling the Green Revolution, and more recently in building the market demand for energy-efficient refrigerators and air conditioners, buildings, etc. Drops for crops are essential; energy efficiency provides us with the entry point to enable a perfect storm for change – which addresses the wellbeing of the farmer-entrepreneurs and local water availability, as well as global climate concerns.

This paper is about ways of enhancing energy efficiency and the use of renewables in agriculture, as a key entry point to ensuring that we are able to stave off the third Malthusian doom. Energy efficiency, as can be expected, enhances productivity and therefore enhances profits. By using energy efficiently, the farmer can achieve much better managed water use, with lower carbon dioxide emissions at the same time.

The water challenge in farming

As a result of the Green Revolution, yields have increased, but at the same time we have increased water use (Figure 1). Windows for irrigation at critical growth stages in all crops – for example, rice and wheat – are small (Figure 2), and therefore farmers have tended to over-irrigate to ensure enough hydration at those critical stages. If the plant cannot access enough water at those times, you have a crop failure. Where the water source for irrigation is groundwater, we see over-extraction of groundwater. As a result, the groundwater level falls and more energy is needed to pump it up, to guarantee crop production.

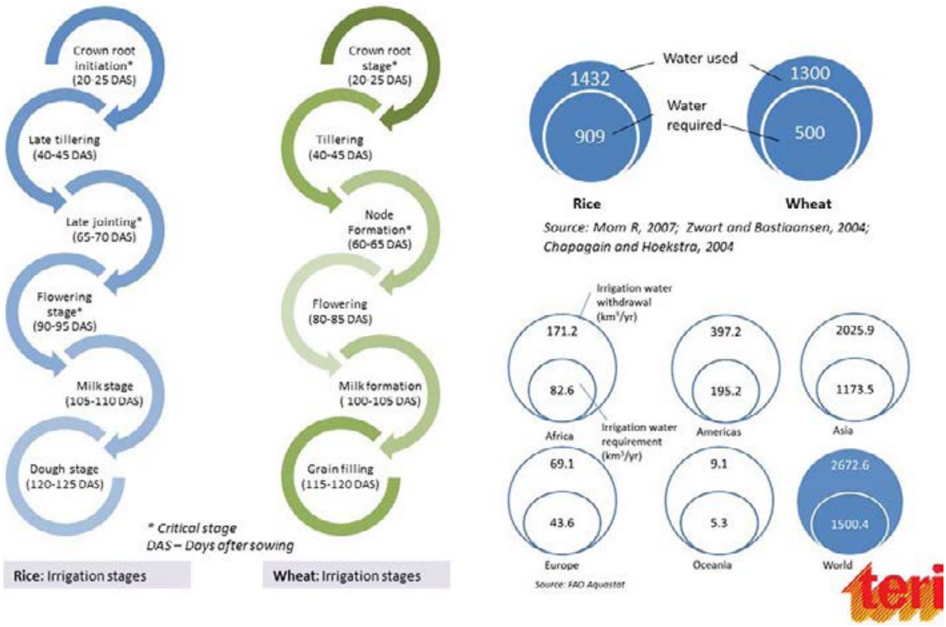

Figure 2. Windows for irrigation are small.
We have tended to over-compensate and over-irrigate.

With climate change, we already experience greater volatility and unpredictability of weather, affecting agricultural productivity (Figure 3). The latest statistical analysis of monsoons indicates that while the total amount of water available available from the monsoon has not decreased, the number of rainy days has dropped, and there are periods of drought in between. This tests the ability of farmers to have the soil wet at the times when they need it.

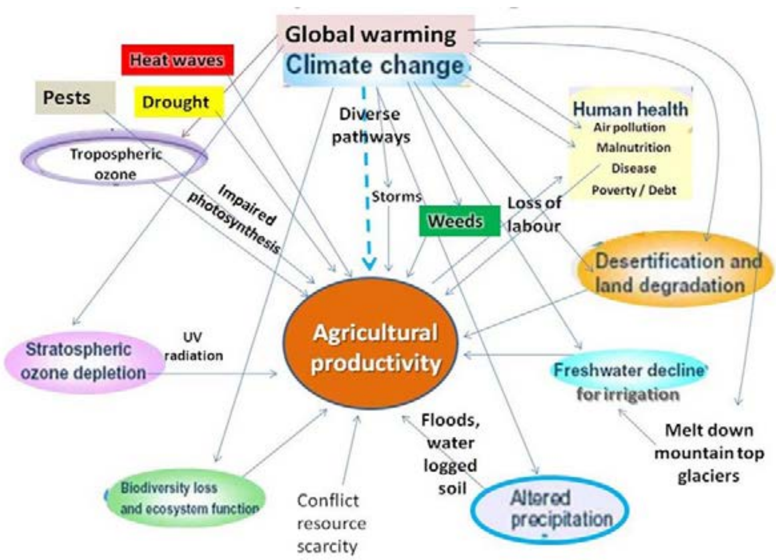

Figure 3. Multiple impacts of global warming and climate disruption on agriculture.

Improving the efficiency of energy use

Instead of the natural tendency to over-compensate and over-irrigate, I would strongly argue that we need to ensure that water use efficiency is maximised.

One of my roles is Chair of the Global Energy Transitions Commission, and in that body we have tried to make sense of how countries and companies should address climate change impacts, to help prevent the world warming by 2°C above preindustrial levels. We agreed on a four-stage process, and that the first thing we have to do is reduce the amount of energy that is used: to maximise energy efficiency. Once you have minimised the amount of energy needed for a process, then you can go ahead and decarbonise the electricity sector, using renewable energy technology (Figure 4).

In India, we have been relatively successful in doing that. For example, a kilowatt-hour of electricity from solar generation today costs less than a kilowatt-hour of electricity from coal. Although that is only true when the sun is shining, we are moving in the right direction, and tomorrow or the day after tomorrow when storage batteries are cheaper the equation will change completely. I would argue we are in a process of transition, moving away from fossil fuels, towards renewables and storage, for mainstream electricity supplies.

As part of our analysis (Figure 4) we considered industry. India and similar countries are producing increasing amounts of steel and cement, that need large amounts of energy throughout each 24 hours. Those industries have invested in fossil fuel energy production, because currently renewable energy cannot supply

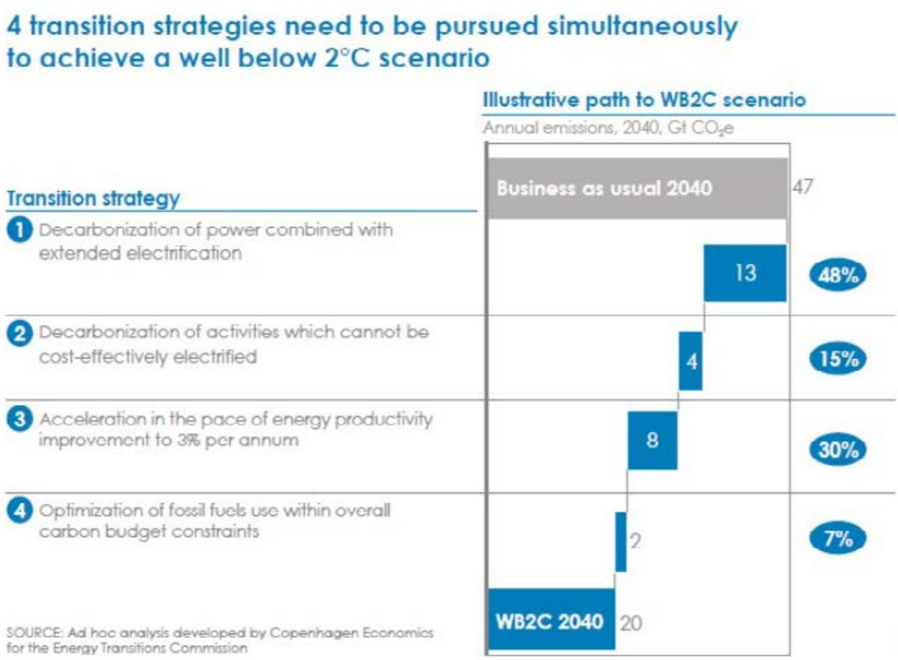

Figure 4. Achieving the Paris goal needs action on several fronts in the agricultural sector. *Source*: Adhoc analysis developed by Copenhagen Economics for the Energy Transitions Commission.

their needs. So, for heavy industry, we need to optimise the use of fossil fuels within India's overall carbon budget constraints by 2040 (Stage 4 in Figure 4).

In the agricultural sector, however, investment in technology development – to decarbonise electricity, and maximise use of electricity instead of fossil fuels – is important if we are to reduce the sector's greenhouse gas emissions.

Decarbonising the agricultural sector

For decarbonising agriculture, we need to enhance water use, and energy use, and fertiliser use efficiency. A move to biological sources of plant nutrition, such as mycorrhizae, and away from manufactured fertilisers, is likely to be part of that; however, we are still learning.

We also need to convert agricultural operations so they use electricity instead of fossil fuels, such as for tilling and sowing, and also to convert electricity generation to renewable sources and away from fossil fuels. Changing over to renewables has a capital cost, but that can be eased by using the right business models, the right kinds of bank loans. It should not require subsidies, but rather a reorientation of how finances flow into this sector.

A large solar pumping program was introduced in India, to encourage farmers to irrigate using electric pumps, at zero or near-zero cost because there were huge subsidies. However, the free electricity led to over-pumping, and over-extraction of groundwater.

The new program that has been launched in March 2019 provides for the solar-pump-generated electricity to be sold to the electricity grid when it is not being used for pumping water. That gives farmers an additional revenue stream (Figure 5). And for the grid managers it is far more attractive to get electricity generated lcoally in a rural region than to get it from a power station far away, with associated losses along the transmission line.

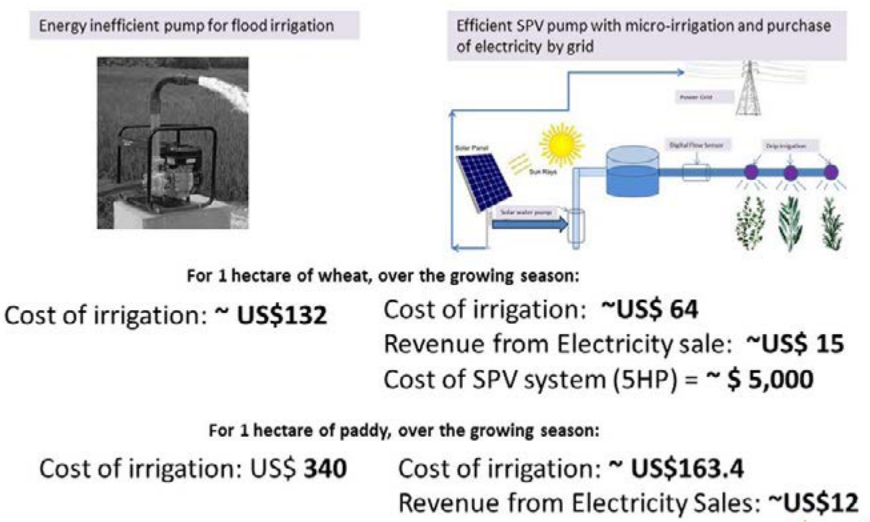

Figure 5. Green farming, and typical costs for water pumping and water use.

Business model. The key to achieving this solution is to have a suitable business model – because farming profitably with one crop is difficult; with one crop and electricity sales, it is easier; and with two crops and electricity sales it is better still. The structuring created for this program enables the farmer to put in a solar pump and pay for it from the electricity he sells to the grid.

Scaling up. We have about 20 million pumps that would need to be changed to solar pumps. In my view, this is clearly the best thing to do. The challenge here is to bring down the cost of solar pumps. Creating demand is the key issue, to achieve economies of scale. Possibly loans for zero-carbon options would be a way of stimulating demand.

These are exactly the kinds of issues that we faced when we were looking at the multiplication of high yield varieties during the Green Revolution. It was exactly the same challenge: how do you scale up a good solution to be taken up widely, and enable price reductions? Public commitment to agricultural production and growth was high during Green Revolution. Similarly, public commitment to clean and resource-efficient technologies (solar pumps, micro-irrigation, etc.) is high now in the agriculture sector, and can be included in broad strategies to promote sustainable food and land use systems.

In summary, success in this energy-efficiency and water-use-efficiency program depends on initial investment and demand creation.

A different example that succeeded

In 2012 a LED bulb in India cost about 500 Indian Rupees. The LED bulb paid for itself, because of its energy efficiency, in three years. But nobody bought it. I didn't buy it. We all understood that price was an issue.

What we did was create a special purpose company, launched in 2015: the Unnat Jyoti by Affordable LEDs for All company (UJALA). That company then made agreements with you and me, through our electricity companies, that they would sell us LED bulbs, with no subsidies, but they would recover the money at 10 Rupees a month, and keep on recovering it until they got all their money back. And they would change the bulb if it failed, no questions asked.

More than 900 million LED bulbs have now been delivered across the country. The UJALA scheme is making an enormous impact by securing annual energy savings, and reducing CO_2 emissions per year and electricity generation (Figure 6). It has completely changed the Indian market.

For our solar pumping program, it is this kind of aggregation on the one side and bulk procurement on the other that we foresee succeeding. The scheme should reduce water extraction, because now the farmer thinks, "Should I extract water? Or should I sell the electricity that is available?". Therefore he is doing a kind of a trade-off. If he does produce more water than he needs, he thinks, "Should I sell it to the farmer next door?".

Thus, in spite of this third wave of Malthusian pessimism, we do have options that help us move towards an optimistic solution.

Figure 6. India's experience with LED bulbs, as it might be applied to solar pumps.

References

Pellegrini P., Fernández R.J. 2018. Crop intensification, land use, and on-farm energy-use efficiency during the worldwide spread of the green revolution. *Proceedings of the National Academy of Sciences* 10.1073/pnas.1717072115, 115, 10 (2335–2340).

Dr Ajay Mathur is the Director General of The Energy and Resources Institute (TERI), New Delhi, and a member of the Indian Prime Minister's Council on Climate Change. He earlier headed the Indian Bureau of Energy Efficiency and was responsible for mainstreaming energy efficiency through initiatives such as the Star Labelling program for appliances, the Energy Conservation Building Code, and the Perform, Achieve & Trade program for energy-intensive industries. He was a leading climate change negotiator and was the Indian spokesperson at the Paris climate negotiations. He served as the interim Director of the Green Climate Fund during its foundational period. At TERI, he has spearheaded the move to accelerate action towards a low-carbon and cleaner economy through the adoption of renewable energy in the Indian electricity sector, enhancing efficiency in buildings and industry, and promoting environmental quality through recycling of material wastes and biotechnology-based solutions. He co-chairs the global Energy Transitions Commission, and one of the climate initiatives of the One Planet Summit.