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Water-Smart Agriculture: the Efficiency Drive the World Needs

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We are in the midst of an unprecedented water crisis. South American regions are declaring an agricultural state of emergency, California's wells are running dry, and countries from Belgium to Botswana are facing significant water stress.

In a "business-as-usual" scenario these problems are only set to multiply: "Water scarcity is projected to increase with the rise of global temperatures as a result of climate change," states Sustainable Development Goal 6.

This is not just an agricultural problem – water scarcity has far-reaching effects as people are forced to flee drought- or salinity-ridden areas; a 2018 World Bank report estimated that by 2050 there may be up to 143 million "climate refugees".

Hence water management in irrigated agriculture can have distant and often overlooked humanitarian, economic and societal impacts. And with agriculture accounting for over 70% of the world's fresh water use, innovation has to start here. But if the history of agriculture tells us anything, it's that it consistently brings out the best human innovative spirit.

And this is exactly what's happening around the world, with huge efficiency drives through Climate-Smart Agriculture (CSA). CSA is all about the interdependencies between yields, and impacts and outcomes related to carbon, soil, water use and biodiversity. Spearheaded by the Food and Agriculture Organization of the United Nations, it is "an approach that helps to guide actions needed to transform and reorient agricultural systems to effectively support development and ensure food security in a changing climate". It has three simultaneous goals and interlinking objectives: increased productivity and incomes, adapting and building enhanced resilience, and reducing emissions associated with agriculture.

As an irrigation community, we need to take this further and define a new Water-Smart Agriculture, dealing with each of these goals through improved water efficiency.

Let's look at how each of the CSA objectives relate directly to smart water management.

Objective 1: Increased productivity

Doing more with less has become the mantra of a new sustainability drive in agriculture, and this goes as much for water use as anything else. New innovations are making it increasingly possible to do just this – increased yields (output) while using less resources (input), in ways which would have seemed mathematically impossible just a generation ago.

Ag 4.0. Agriculture 4.0 is moving growing far beyond old-school trial and error, manual measurements, and assumptions, and instead towards ultra-efficiency, sensors, and big data. "Without measuring, we do not actually know how the plant truly reacts towards all external conditions – this is what we want to change with real-time feedback," says Olivier Begerem at Belgian start-up 2Grow. For water efficiency, this means maximizing existing water use by monitoring a plant's vegetative/generative stages to see the exact effect of inputs. As well as sensors, Ag 4.0 also involves use of drones, satellite imagery, and big data, to monitor the exact impact of irrigation cycles. According to consulting firm Oliver Wyman, "Agriculture 4.0 will no longer depend on applying water uniformly across entire fields. Instead, farmers will use the minimum quantities required and target very specific areas" – through precision irrigation.

Precision irrigation. Increased precision is imperative for improving overall Water Use Efficiency (WUE), "the ratio between effective water use and actual withdrawal". This is most often associated with drip irrigation, but also encompasses variable rate application, flow rate monitoring, and precision treatment solutions which alter water at a structural level. Eric Valette, a Switzerland-based water treatment expert says: "Increasing the Water Use Efficiency of irrigation systems through precision irrigation is absolutely key to dealing with water stress and becoming a water-smart grower. New treatment technologies make it possible to get the most out of every drop, maximizing the potential of irrigation systems while ensuring increased and optimized production."

Optimizing water inputs is just one half of the solution – just as imperative is ensuring this moisture stays in the soil long enough for plants to take advantage of it. Growers with irrigation solutions which optimize both the water itself and its behaviour in the soil will have an added competitive advantage going forward.

Moister soils. Simply put, if soils can stay moist for longer, irrigation times and frequency can be significantly reduced. There is plenty of research under way looking at maintaining this soil moisture where it's most needed. This includes everything from using peat moss, perlite (a volcanic glass), membranes and more, to increase absorption properties. Ag 4.0 innovations such as Spiio or Sentek's sensors keep track of soil moisture in real-time, which can save water through maintaining optimum conditions. But focusing on the actual water rather than the soil can have a range of impacts: technologies such as Aqua4D target the irrigation water itself, subtly changing its structure so that it penetrates the soil pores, thus staying moist for longer periods.

Soil-less. Moving away from soil entirely, interest in hydroponics, aquaponics and aquaculture is gathering pace all the time, and may have a big role to play in sustainably feeding the mega-cities of the future. Hydroponics in particular may come to be seen as the poster-boy for Water-Smart Agriculture, as at its most efficient it uses just 10% of the water required for traditional soil crops.

Epecially when combined with other technologies, hydroponically grown plants experience faster nutrient uptake, can grow up to twice as fast, and obtain higher yields.

Objective 2: Enhanced resilience

With an increasingly erratic climate, water-smart irrigation management needs to take into account significant fluctuations and an increase in extreme events. For example, the ENSO cycle, responsible for El Niño and La Niña effects, are varying unpredictably in length, playing havoc with irrigation scheduling.

In a 2018 paper, Gelcer et al detailed an innovative AgroClimate tool from Mozambique which keeps track of ENSO phases (El Niño and La Niña) in real-time, to assist with irrigation timing and minimize water stress. On the other side of the world, agronomist Enrique Rebaza reports that to combat this unpredictability, growers have been adopting water treatment to help deal with fluctuations in water availability, as well as salt movements through soils. Innovative water treatment can reduce water on the surface, improve humectation of the soils and gain a better infiltration, while leaching salts away from the rhizosphere.

Combatting electroconductivity through sustainable leaching. The issue of salt accumulating in soil is as old as agriculture itself, and 'salinity crises' resulted in the collapse of ancient civilizations. With soil salinization increasing exponentially across the globe, the impacts are ever greater and the need for a solution more pressing. Current figures estimate that up to 20% of all cultivated land and 33% of irrigated agricultural land worldwide is at risk if salinity.

The issue has gained traction in recent decades, as have a range of possible solutions. But chemical leaching and steaming are just short-term fixes and bring their own problems. The FAO asked almost 30 years ago, "Can agriculture make use of marginal quality water such as saline water in a way that is technically sound, economically viable and environmentally non-degrading?" Sustainable leaching solutions are now answering this call and are becoming more widespread, including more sustainable land management, chemical-free water treatment, and changing fertilizer practices. A sustainable, long-term solution to soil salinity would have a huge impact on millions around the world – good water management is intricately connected to good land management.

Objective 3: Reduced emissions

Xiaoxia Zou from the Chinese Academy of Agricultural Sciences (CAAS) writes that emissions from irrigation activities (including water pumping and conveyance) account for 50-70% of total emissions in the agriculture sector. "The GHG emission intensity of irrigation depends largely on water use efficiency," says Zou, "So improvement of water use efficiency (both technical and managerial) can be an effective way to reduce emissions".

Small changes can have large impacts: Gaihre et al noted that rice farmers in China who drain their irrigated rice fields mid-season reduced their methane emissions by 50%, while a 2014 study in Spain by Abalos et al illustrated that selective adjustment of irrigation frequency can reduce nitric oxide emissions by up to 46%, and CO₂ by up to 21%. Meanwhile, innovative water treatment can improve the quality of irrigation water, accomplishing more while using less, thus saving significant pumping energy.

But this goes beyond pumping: the same water treatment can also unclog and improve overall system functioning. When a system is optimized and running like clockwork, staff can get on with more important tasks, thus improving labour efficiency too. France-based Morel Diffusion recently found exactly this after irrigation upgrades which solved clogging issues: "We previously needed 6 people to work on the maintenance of the drippers," says Morel. "In the month following the new installations, these 6 people could start working on something else instead."

Conclusion

In applying these three objectives to irrigation management, we usher in a new era of water-smart agriculture which will benefit growers, plants, and planet alike. Many of these solutions involve cost-effective upgrades or subtle changes in irrigation