



CO-OPTIMIZING SOLUTIONS: WATER AND ENERGY FOR FOOD, FEED AND FIBER

Executive Summary

Co-optimizing Solutions: Water and energy for food, feed and fiber is a unique solutions-based document that examines some of the most promising, innovative and scalable solutions to the world's interconnected water, energy, and food, feed, and fiber challenges. Highlighting ways solutions can be integrated to reinforce each other, the report reveals how the world's growing demand for nutrition and agricultural products can be met while minimizing environmental impact. It is based on a combination of the most advanced research with a sophisticated quantitative analysis of global linkages and case studies of techniques that forward-thinking companies are using. The private sector is an important part of the solution, and the report introduces some of the cutting-edge techniques already implemented around the world.

Increasing demand for food and other agricultural products will put great strains on land, water, energy and other resources in the coming years, and also heavily impact greenhouse gas emissions and climate change. Food demand is expected to rise by 60% by 2050 due to population growth and increased consumption. Fiber demand for wood panels and paper is predicted to increase by 80-95%.¹ A threefold increase is expected in the demand for biofuels at a time of increasing pressure on water quality and quantity.

Add these projected increases to a world where agriculture is already the world's largest water user, consuming 70% of total water each year. And energy consumption in agriculture is anticipated to increase by 84% in 2050² in a business-as-usual scenario. Additionally, climate change will impact food production in several ways. The disturbing result could be increased greenhouse gas emissions, compounded water requirements, decreased yields, and a potential increase in pests and weeds.

Fortunately, an array of "smart" solutions exist and are being developed to usher us towards agricultural production that is knowledge-intensive, more precise and less wasteful, and which utilizes such innovations as smart seeds, clever crop agronomy, zero-energy farms and integrated logistical systems. These solutions are already available and can be implemented with multiple benefits on yields, energy, water, climate change, land and resource use.

According to the report, many of these solutions can be "co-optimized" to reinforce each other and deliver multiple synchronized benefits of energy and water savings while increasing yields and creating better quality products. Imagine enzymes that help crops grow faster but also aid in the uptake of fertilizer, saving energy and pollution. Or biodegradable plastic mulch that prevents water loss through evaporation, increases soil temperature and accelerates natural nitrogen fixation.

Changing behavior at the retailer and consumer levels to control food waste would also significantly reduce demand for water and energy embedded in products that never reach an end-user.

Co-optimization solutions can go a long way towards addressing climate change mitigation and adaptation. Several solutions do not just improve the productivity of scarce water and energy but also reduce greenhouse gas emissions. Prime examples are the new methods of growing rice that keep methane emissions much lower. Reduced energy consumption in agriculture also immediately affects CO₂ emissions. Meanwhile, better use of water can improve water storage and improve adaptation of climate change fluctuation, and green soil water management adds to improved climate resilience as well.

The prognosis for the future is hopeful with these types of innovations. Business is a key player with its power to innovate toward sustainable harvests, drive change and partnerships, make long-term investments and achieve scale while strengthening supply systems and product sourcing, and reducing waste. There is also great opportunity for businesses to work together all along the value chain – connecting input suppliers, producers, commodity traders, processors and retailers. The private sector is playing a strong role in developing the tools that are key to mitigating water risk not only to their own operations but in the communities they operate in as well.

Companies, as the case studies from BASF, Dow Chemical, DuPont, Evonik, ITC, Jain Irrigation, Monsanto, Novozymes, Pepsico, and Syngenta demonstrate, are leading the way.

Here is a closer look at some of the most promising solution areas. Within each is the possibility of a myriad of more specific innovations adapted to different conditions.



SMART VARIETIES

Although the gains in yields of the world's major crops (wheat, rice, and maize) are slowing down, it is estimated that a 50-100% increase over current maximum yields could still be achieved through genetic engineering and crop selection – including hybrids, pest-smart varieties, and resource smart varieties that are more resource efficient and adapted to a wider range of climatic and soil conditions (drought and saline tolerant, nitrogen efficient).

Corn

BASF and Monsanto pioneered drought-tolerant corn, which yields 6-10% more than conventional hybrids in drought-prone areas. DuPont and Syngenta, in cooperation with the International Maize and Wheat Improvement Centre, also made strides in breeding corn that can yield 15% more than conventional

hybrids in water-stressed conditions. DuPont is testing the combination of drought tolerance with nitrogen-use efficiency due to the traits' synergistic relationship.

Rice

With more than 34 million hectares of land being affected by salinity, DuPont Pioneer developed salinity-tolerant rice hybrids to allow rice-shrimp farming in Southeast Asia without compromising rice yields due to salt water use.

Alternative crops

The potential of a diversity of traditional crops, such as a range of cereals native to Africa and Ethiopia's unique Arabica coffee varieties, remain largely untapped despite hardiness, resilience to extreme environments and high nutritional value.



SMART CROP MANAGEMENT AND EFFICIENT FERTILIZER PRODUCTION

Fertilizers

Most of the increased agricultural production over the coming decades is expected to come from agricultural intensification, bringing with it more extensive use of fertilizer. Particularly in sub-Saharan Africa, the world's major agricultural frontier, a system of sustainable intensification could double productivity on the continent. In areas of the world where fertilizer is overused, including parts of China, India, North America and Europe, using fertilizer more efficiently would reduce agricultural energy consumption, groundwater pollution, eutrophication (reduced oxygen in water that causes species extinction), land degradation, soil acidification, and nitrous oxide emissions – the most active greenhouse gas.

Solutions include more precise application of fertilizer in terms of timing, quantity and type. Real-time crop sensors for the application of nitrogen represent a technological breakthrough in this area. Field tests carried out by DuPont show increased income and 50% higher nitrogen-use efficiency with the use of sensor treatments. Similarly, smart fertilizers, which incorporate a mechanism controlling nitrogen release based on crop requirements, and chemigation, which incorporates chemicals such as fertilizer or insecticides into irrigation water, also allow for more precise application of chemicals, thereby reducing energy use and increasing yields. Using rock dust as a bio-fertilizer, an ancient technique, offers promise in Africa, where there are no fertilizer plants but quarries providing source minerals.

Production of fertilizer also represents an energy drain, about 1.2% of global energy consumption. Overhauling less-efficient plants, closing down poorly performing ones and moving towards natural gas-fired facilities, rather than coal-based plants, could reduce energy consumption by 10-25%.



Bio-stimulants, improved disease control and nanotech pesticides

Although not widely used on a global scale, fungi-based compounds and micronutrients, such as zinc and boron, offer promising ways to stimulate plant growth, leading to increased yields of 10% or higher.

With global pesticide use of 2.5 million tonnes every year and their associated health hazards and damage to the environment, "smart" solutions for disease control make good sense.

Integrated pest management, using practices such as pest-resistant crops, rotations, and intercropping have been successful at reducing pesticide use up to 90% in some cases. Nanotech pesticides, although still in the experimental stage, may one day offer pesticides that release their active ingredient *only when inhaled by an insect*.



MIXED FARMING SYSTEMS

Some researchers call mixed cropping a new agricultural frontier due to its many benefits: pest control, increased biodiversity, improved nitrogen use and nutrient uptake, increased soil fertility and resilience in resource-limited environments, among others. Intercropping of cereal and legumes, for instance, makes it possible to use significantly less water without impacting yields. Similarly, when trees are incorporated in the cropping system, helping soil moisture and nutrients and reducing pests, yields can be 20-60% higher than monocultures.



BLUE AND GREEN WATER MANAGEMENT

With little renewable untapped water left, higher blue water (surface or groundwater) productivity will be critical in achieving desired outcomes that are conducive with sustainable agriculture. Precision irrigation, such as root zone irrigation and micro-sprinklers, offer promising alternatives. Studies on corn show water savings of up to 40% when using subsurface drip irrigation, one of the most advanced field irrigation technologies available.

Irrigation is the largest water consumer (70% of the world's freshwater withdrawals), and rice paddy fields are the largest single user. One ambitious research project is experimenting with growing rice like wheat, rather than the traditional flooding technique, saving water and reducing methane gas emissions. PepsiCo has been working with farmers in India in "direct" (dry) seeding efforts. Syngenta has also been active in providing such farmers with products and services to increase productivity.

Rainfed (green water) systems produce 58% of global food, and by 2050 the area is expected to increase some 70 million hectares.

Conservation agriculture, utilizing reduced plowing, diversified crop rotations, and keeping a vegetative cover on bare land, offer multiple benefits such as a 60-90% decrease in soil erosion and 40-69% less runoff.

Also promising in terms of water management is biodegradable plastic mulching applied as a thin foil over the soil surface to reduce evaporation, control weeds, protect from erosion and stimulate nitrogen enhancing microbial activity, leading to substantial water savings of 26-50%.



EFFICIENT FARM OPERATIONS, MECHANISATION AND BRIDGING THE YIELD GAP

Innovations in farm operations and equipment are also key to saving energy. Retrofitting and replacing energy-inefficient farm equipment, integrated planting systems utilizing tailor-made equipment, and zero-energy farms, using new generation greenhouses, offer exciting benefits.

Recently, smaller and smarter machines have been developed that can act unattended and use less fuel. Syngenta's breakthrough PLENE technology utilizes equipment that does not compact soils, uses less fuel and helps overcome labor shortages. It also allows sugar cane to be replanted more frequently, leading to 15% higher yields and lower costs.

Currently, fully energy-independent farms are experimental, but they may be the wave of the

future. For instance, greenhouses that produce energy are part of an innovative project in the Netherlands.

Role of small farmers

Care must also be given to improve the productivity of small farms and make them viable businesses in their own right. Small farmers will be responsible for a significant part of the increase in production in the future, but they are largely excluded from innovation systems and poorly linked to markets, institutions and service providers. Businesses are increasingly co-organizing extension services and making use of modern media, smart phones and agricultural television. Syngenta Foundation India, for example, holds frequent meetings, field demonstrations and presentations of latest technologies.





MAKING USE OF TRADE

International trade in agricultural commodities is expected to increase but only moderately. It appears to be “pulled” by efficiency gains more than “pushed” by land and water scarcity. Governments have a role to play by revisiting the current complexity of global farm subsidies. Governments must also support business by creating enabling policy frameworks that support innovation.



REDUCING FOOD LOSS AND WASTE

An estimated 32% of food produced globally, about 1.3 billion tonnes, is lost or wasted along the food chain every year. In developing countries, most waste (25-35%) occurs early in the food chain (at harvest, storage and processing), while in developed countries most waste (18-24%) happens at the retail and consumer level. Reducing waste could decrease demand for food by an estimated 10%, saving land, energy and water resources.

Wageningen UR Food & Biobased Research participated in the development of an innovative chip with sensors to monitor the quality of perishables from right after they are harvested until they reach the store, reducing food loss and waste.



Sustainable agriculture, water stewardship and energy production are central to achieving a vision where “the global population is not just living on the planet, but living well and within the limits of the planet.” This is the vision of the WBCSD taken one step further to the delivery of tangible outcomes through the Action2020 initiative. Action2020 sets out Societal Must-Haves in Priority Areas that require urgent attention, including the release of nutrient elements, water, climate change, and food, feed, fiber and biofuels.

For more information on *Co-optimizing Solutions: Water and energy for food, feed and fiber*, please visit the water section of www.wbcds.org and www.action2020.org

About the WBCSD

The World Business Council for Sustainable Development is a CEO-led organization of forward thinking companies that galvanizes the global business community to create a sustainable future for business, society and the environment. Together with its members, the Council applies its respected thought leadership and effective advocacy to generate constructive solutions and take shared action. Leveraging its strong relationships with stakeholders as the leading advocate for business, the Council helps drive debate and policy change in favor of sustainable development solutions.

The WBCSD provides a forum for its 200 member companies – which represent all business sectors, all continents and combined revenue of more than US\$7 trillion – to share best practices on sustainable development issues and to develop innovative tools that change the status quo. The Council also benefits from a network of 60 national and regional business councils and partner organizations, a majority of which are based in developing countries.

Acknowledgments

Written by Cecilia Borgia and Frank van Steenberg, MetaMeta

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Water Cluster leadership group (as of May 2014)

Co-chairs: Borealis and EDF. Members: BASF, Bayer, Deloitte, DSM, DuPont, GDF Suez, Greif, Kimberly-Clark, Monsanto, Nestlé, PepsiCo, PwC, SABMiller, Schneider Electric, Shell, Suncor Energy, Unilever, Veolia.

This piece of work was led by WBCSD water team

Violaine Berger, Joppe Cramwinckel, Tatiana Fedotova, Julie Oesterlé.

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World Business Council for Sustainable Development

Maison de la Paix, Chemin Eugène-Rigot 2, Case postale 246, 1211 Geneve 21, Switzerland, info@wbcsd.org, Tel. +41 (0)228393100