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Growing More From Less

Achieving Food Security in the 21st Century

By 2050, we will need to double agricultural production to feed a growing population. How do we do that without further stressing our environment, bringing millions of acres of marginal land into production, decimating our natural forests and further threatening endangered species? How do we grow twice as much without further exhausting our already stressed water resources?

This paper highlights the challenges before us in the 21st century and the essential role modern agricultural technology must play in doubling production on already cultivated land. It describes how a Second Green Revolution can enable us to “grow more from less,” put less stress on our natural environment, and create the conditions for lasting food security for all the world’s people.

Food Security, the Environment and Humanity

In the 21st century, we will need to mount two concurrent and interrelated Green Revolutions — one revolution that cultivates the green plants that sustain human life, and another revolution that cultivates the green forests and habitats to protect the environment of this one Earth we call home.

Earth Under Stress

For all the observations made about our planet, the most important is that there is only one place like Earth.

What is the prognosis for our planet for the rest of this century?

Our world, already under environmental stress, will come under deeper strain as the human population rises from more than 6 billion people today to 9 billion by mid-century. Meanwhile, a growing middle class in nations such as India and China is already demanding the higher levels of nutrition that we in the developed world have long taken for granted.

To feed everyone in 2050, we will have to grow twice as much corn, twice as much wheat, and twice as much rice and soybeans as we do today. In fact, we will have to grow twice of just about everything. And yet we will continue to have only one planet to grow it on.

So where will this food come from?

To state the obvious, humanity can do just about anything with land—except make more of it. Most of the best available farmland on our planet is already under cultivation. Much of that is being lost to urban and suburban development as the world's population expands. Desperate farmers in poor countries, in search of land, are also destroying much of what is left of the Earth's rainforests and other precious habitats. Every year, we lose another 40 million acres of forest to development and agriculture (out of a total of only 2 and a quarter billion acres of forest remaining).

According to the UN's Food and Agriculture Organization (FAO), between 25 and 30 percent of all greenhouse gases released into the atmosphere every year are caused by deforestation.[1]

Our most precious resource, water, is increasingly coming under stress as well. It is estimated that by 2025, nearly 40 percent of the global population will live in a place experiencing serious difficulty in obtaining sufficient water.

California is already under perennial threat of drought, as are other parts of the Southwest. The American Midwest, often called "the breadbasket of the world," relies on the Ogallala Aquifer, which is down by more than 100 feet in some places. Some parts of China resemble the American Dust Bowl, where shortsighted agricultural practices of over-plowing and over-grazing have reaped an environmental disaster.

We need to double food production for feeding and protecting the planet.

A Humanitarian Crisis

At the same time, the world today faces a mounting humanitarian crisis. In 2009, we slipped even farther away from the UN's millennium goals, with the number of chronically hungry and malnourished growing to more than one billion – one sixth of humanity – according to the FAO.[2]

Worst of all, every year, about six million children die from hunger-related illness before their fifth birthday.

With rising populations in the poorest parts of the world, these numbers, as bad as they are, have the potential to get a lot worse.

Caring for our increasingly stressed environment while simultaneously meeting the rising nutritional needs of billions of our fellow humans in the humblest circumstances is—outside of the realm of war and peace—the greatest challenge that confronts us in the 21st century.

Technology makes it possible for about six million children a year to see their fifth birthday rather than die from hunger-related illness.

The Second Green Revolution

The good news is that we have met similar challenges in the past. We have already done things experts once thought impossible.

The greatest example of beating expectations is the Green Revolution. In the 20th century, pessimists believed that much of humanity was doomed to starvation. An agronomist from Iowa named Norman Borlaug disagreed. More interested in practice in the field than theory in a book, Borlaug traveled to Mexico to double that country's output of wheat by doubling the growing seasons, while introducing new disease- and drought-resistant varieties. Building on this success, Dr. Borlaug went on to bring about equally impressive agricultural revolutions throughout Asia and Africa. He continued to work in his lab and advocate for agricultural science up until his death at 95 in 2009.

The Green Revolution was virtually the product of this one champion's vision for better methods in food production. By the time Borlaug was awarded the Nobel Peace Prize, it was clear that his labors were dramatically increasing the world's grain output. Famine, once endemic for most of the world, receded into history for many countries. In all, Borlaug's Green Revolution is credited with saving more than one billion human lives.

In the 21st century, we will need more than another such effort. We will need to mount two concurrent and interrelated Green Revolutions—one revolution that cultivates the green plants that sustain human life, and another revolution that cultivates the green forests and habitats to protect the environment of this one Earth we call home.

In short, we will need to pull off twin miracles. To do this will require an unprecedented commitment to science and technology – and a frank evaluation of the real environmental concerns of water, deforestation and global warming, and how these interact with food security.

Women and Weeds: The Imperative of Development

The same agricultural technology that protects the environment also has a big and positive impact on human welfare. Consider how agriculture is currently practiced in sub-Saharan Africa, where the main means of weed-control is by hand. To weed the typical one-hectare smallholder farm in Africa (almost 2.5 acres, or a little less than three football fields) requires up to 200 hours of backbreaking labor.[3] Imagine devoting the equivalent of five work weeks, 40 hours each week, hunched over in backbreaking stoop labor just to survive. In fact, weeding takes from 50 to 70 percent of the total labor that goes into producing an African crop.

Women perform most of this backbreaking work. To weed that one hectare, a woman must walk 6 miles in a stooped position, a posture that will eventually deform her spine. Weeding in Africa is such a big job that almost 70 percent of the children of African farmers are forced to leave school and join their mothers to help with weeding. It is no exaggeration to say that weeds are robbing women of their health, and strangling the futures of their children.

Weeds are literally strangling Africa's future. In Sub-Saharan Africa, most weeding is done by hand, and most of that is done by women and children.

Even with all this backbreaking labor, weeds in Africa easily absorb 25 percent of yields. Sometimes they produce total crop failure. The addition of fertilizers unattended by herbicides can make the problem worse, with some weeds absorbing fertilizer faster than food crops.

Answers can be found in modern agriculture. A study in Kenya showed that maize yields rose 53 percent and bean yields rose 94 percent with the increased use of agricultural biotechnology.

One Kenyan farmer named Joshua Muriungi is living proof of the power of technology. Joshua grows his maize, potatoes, cabbage and beans by using safe, modern herbicides to control weeds. Joshua also implements some of the best practices of the developed world to manage his meager water supply.

These new tools and knowledge are allowing farmers like Joshua to grow hardier crops in difficult circumstances. Optimal farming methods are not only liberating his family from generations of stoop labor. They are enabling him to grow a surplus and actually put money in the bank for the first time in his life, helping many move from mere subsistence by steadily increasing their standard of living.

Agricultural technology and modern water management practices have allowed farmers like Joshua Muriungi to grow a surplus on their smallholder farms and actually put money away in the bank for the first time.

Technology and the "iKernel"

Agriculture consumes 70 percent of water used by people, and produces about 20 percent of human-caused greenhouse gas emissions. It is, as we have seen, a prime driver of deforestation. The good news is that agricultural technology has the potential to radically reduce these environmental "footprints."

Two Marvels of Modern Technology: The iPod has an 8-gigabyte flash drive, costs $150, and can hold hours of video. The "iKernel" has three billion base pairs, costs a fraction of a penny and can enable us to feed a hungry world.

How powerful is agricultural technology?

As consumers, we are used to enjoying technological miracles. Consider the iPod. It has an 8-gigabyte flash drive, holds hours of video, and costs about $150. As impressive an achievement as the iPod is, perhaps an even greater miracle can be found in a single kernel of bio-engineered grain. It's a mere speck that costs a fraction of a penny. But with the three billion base pairs in its genome, the "iKernel" can literally save the environment and feed the world.

While perhaps not as entertaining as an iPod, the iKernel – unlike other technologies – can make endless copies of itself. In addition to producing enough food to feed a growing population, it can break the world's dependence on oil, husband scarce water resources, protect our environment and respond to the challenge of global warming.

How? Simply put, genetically modified plants, in combination with efficient and environmentally safe pesticides, can do the job of growing more food from less land and less water.

We're only at the beginning stages of this Second Green Revolution, but modern agricultural technology's ability to grow more from less has been amply demonstrated in the last 20 years – perhaps nowhere so dramatically as in the United States. Starting from a very high base-line, with some of the most advanced agricultural practices in the world, the United States has been able to continually increase the productivity of many of its staple crops. From 1987 to 2007, corn averaged gains of 2.2 bushels per acre per year. That amounts to a 41 percent increase in productivity. Cotton productivity per acre increased 31 percent in the same 20 year period, and soy yields climbed an impressive 29 percent.[4]

These dramatic productivity increases occurred in tandem with lessening stress on the environment. Consider soil run-off, which the U.S. EPA identifies as the primary cause of water pollution. Since 1987,

soil loss in corn farming has declined approximately 69 percent per bushel. Irrigation water use in corn farming has declined 27 percent; and energy use has decreased by 37 percent.[5] No-till and conservation farming also means fewer passes by the tractor and thus dramatic reductions in the use of fossil fuels.

A large number of productivity-enhancing plant technologies are presently in the R&D pipelines of the major research-based seed companies, and some are already here. For example, new seed treatments have been found to stimulate root growth in plants, raising yields and making them better able to withstand stress, such as drought. Others dramatically cut the need for irrigation. One product, applied to wheat, can increase "Crop per Drop" efficiencies as much as 35 percent. Some bio-engineered varieties can thrive with dramatically less water and grow in salty soil that would wither most plants; and even in the absence of pests, some fungicides give plants bigger and greener leaves.

Of course, companies must steward how their products are used, guarding against the misuse of technology. Industry must educate farmers how to properly deploy technology. But the non-use of technology is a far greater danger than the misuse of technology.

Merely utilizing existing technologies in much of the world could significantly boost world productivity. It's estimated that modern farming methods and technologies could boost productivity in Asia some 20 percent in 10 years. The beneficial effects on the environment would be just as striking. Consider flood irrigation, a traditional means of weed control in much of Asia that wastes as much as half the water used. The effective application of herbicides could well eliminate the need for this type of weed control and allow us to better safeguard our world's increasingly insecure supply of water.

But the benefits that modern technology brings to the environment may be even greater still . . .

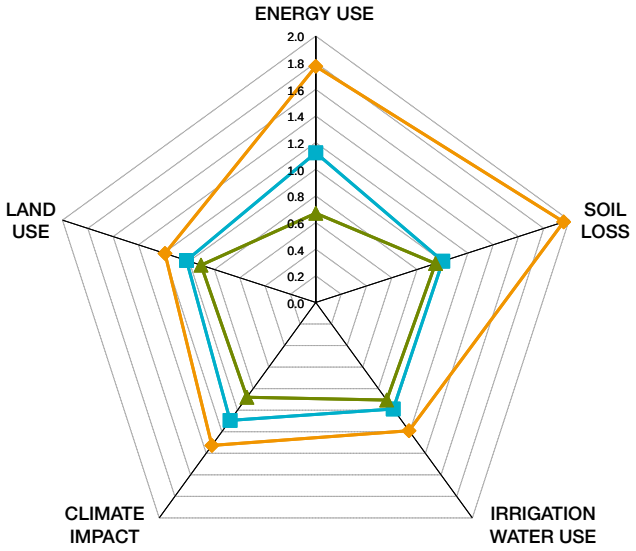
Feeding the World With Advanced Agricultural Technology

- Brazil has nearly doubled soybean production in the past ten years on the same amount of land.
- It's estimated that Asia could boost agricultural productivity by 20 percent in 10 years simply by adopting current technology.
- In Russia and Ukraine, the winter wheat yield rose 75 percent in one program following the adoption of modern crop protection technology.

Hi-tech Agriculture's Improved Environmental Footprint

Soybean Efficiency Indicators

Per Unit of Output, Index 2000 = 1



YEAR	2000	UNIT
Energy use	0.044	Million Btu/bushel
Soil Loss	101.0	Pounds soil/bushel
Irrigation Water Use	19.4	Thousand gallons/ Incremental bushel due to irrigation
Net Carbon Emissions	2.2	Pounds Carbon/ bushel
Land	0.026	Acres/bushel

Values are expressed as 5-year centered averages.

Agriculture's Shrinking Environmental Footprint

This "spider graph" of U.S. soybean efficiency shows a dramatically declining environmental footprint brought about by modern agricultural technology over the last 20 years, with yields up 29 percent, soil loss down 49 percent, irrigation water use improving 20 percent, energy use down 48 percent and greenhouse gas emissions down 38 percent.

Sustaining Our Most Precious Resource

Crop for Drop, this wheat field uses 35% less water.

Within 15 years, almost 40 percent of the global population will be experiencing severe water stresses. Modern agricultural technology can help relieve those shortages by decreasing the amount needed for farming, which is by far the largest user of available fresh water in the world today.

New bio-improved varieties can thrive in arid, salty conditions, and seed treatments and crop protection applications can help plants grow larger root systems and smaller stems, enabling farmers to increase yields while using dramatically less water. One product, applied to wheat, can increase “Crop per Drop” efficiencies as much as 35 percent.

Irrigation

In the United States alone, more than $30 billion worth of crops were lost in 2007 alone due to drought. Throughout the world, great stress could be taken off the environment and billions of dollars in crops saved by employing technology that uses water more wisely.

This is an example of traditional flood irrigation [in Asia] side by side with drip irrigation. The latter technology is about 95 percent effective in delivering water directly to the plant’s root, cutting the amount of water wasted in watering a plant from half to a mere 5 percent.[6] New hybrid rice varieties can also reduce water use.[7] New drought-tolerant crop varieties, like tropical sugar beets, can replace water-hungry crops like sugar cane. Plant regulator products can cause wheat to grow longer, finer roots to reach deeper for water and nutrients in drought-prone areas.[8] Seed treatments can help plants cope better with environmental stresses, including drought.[9]

Technology like this has the potential to prevent the waste of enough water to replenish rivers, lakes and other watersheds around the world.

Traditional flood irrigation wastes half the water used.

Organic Farming is 40% Less Productive…

Many people in Europe and the United States prefer to eat "organic" foods when they can. While this is a perfectly valid life-style choice for those who can afford it, from the perspective of feeding a growing world population, we have to take into account that organic farming is about 40 percent less productive per acre.

The lower productivity of organic agriculture, in fact, is a large component of the higher prices in popular organic retail stores such as Whole Foods. It also poses a serious dilemma for policy makers: How do we double agricultural production in the world by adopting methods that are less productive?

Before his death, Norman Borlaug offered some sobering observations on these anti-biotech policies:

"If our new varieties had been subjected to the kinds of regulatory strictures and requirements that are now being inflicted upon the new biotechnology, they would never have become available."[13]

In other words, the current state of public policy in many countries has the potential to stamp out the coming Green Revolutions in food production and environmental enhancement.

The dilemma before us is which way will policy go?

Agriculture's Positive Carbon Footprint

Just as important is the role of no-till agriculture in preventing the release of carbon-dioxide (CO2) into the atmosphere. Plowing releases massive amounts of CO2 from decomposing organic matter in the soil. No-till agriculture keeps that CO2 sequestered in the soil. And less plowing reduces the burning of fossil fuels.

How important is this? The U.S. Department of Energy estimates that the extensive adoption of no-till and other conservation methods would reduce our nation's carbon emissions by up to 50 billion tons a year. That's as if we could remove all the carbon emissions of all the fossil-fuel burning cars, trucks, buses, factories and power plants in America—seven or eight times over.

Add to that sequestration the potential of new biofuels.

Corn ethanol has a small positive greenhouse gas footprint compared to oil, and a much bigger advantage compared with gasoline production from Canadian oil sands. Other biofuels, like those made from cellulosic sources from wood, grasses or the non-edible parts of a plant, far exceed the environmental profile of fossil fuels. In Brazil, sugarcane ethanol has replaced 50 percent of the gasoline used in light vehicles, while producing about 75 percent less greenhouse gases than oil.[11]

No-Till Agriculture: A Boon To the Environment

Herbicide-enabled no-till agriculture allows farmers to grow crops without plowing, the age-old method of weed control. Stalks, husks and leaves are left on the ground to act as mulch, retaining water and nutrients and preventing soil erosion and run-off into streams and water-ways (identified by the EPA as the primary source of water pollution in the U.S.)

The United States, a world leader in adopting modern crop protection technologies, is also the leader in no-till farming, with 22 percent of all U.S. land under cultivation farmed by no-till methods. According to the US Department of Agriculture, we saved 43 percent more soil on U.S. cropland between 1982 and 2003, largely due to no-till and conservation tillage.[12]

Is Crop Protection-Enabled No-Till Agriculture the Solution to Global Warming?

According to the U.S. Department of Energy, no-till agriculture and other crop management strategies could lead to the retention in the earth of some 40 to 50 billion tons of carbon. How much is that? It saves seven or eight times the amount of carbon emissions from every fossil-fuel burning car, factory and power plant in America.

Protecting Our Planet

When we think of pollution and greenhouse gases, the first things that come to mind are cars, airplanes, homes and factories. Less understood is the role agriculture plays in reducing water pollution and global warming.

Of course, it is easy to see the environmental impacts that occur when land is deforested for agriculture—and the resulting peat bogs or deserts. What is less obvious is the potential for tillage practices to have a much greater positive effect on the global environment than even massive reductions in greenhouse gas emissions by industry and consumers.

What is the connection?

First, water pollution: The U.S. EPA ranks sediment runoff as the number one pollutant in the waterways of the United States. This runoff is a result of traditional agriculture, in which farmers' only sure way to control weeds is by plowing up the land. This tearing and re-tearing of the Earth's surface results in erosion and sedimentary runoff that pollutes waterways and damages fragile ecosystems.

Thanks to herbicide technology, farmers are increasingly turning to no-till agriculture, leaving crop residue from previous harvests on the ground, limiting evaporation of water, sediment runoff and erosion. No-till farming can also be more productive. When it was introduced in Ghana, farmers who practiced this form of conservation agriculture reaped a 45 percent increase in maize yields.[10]

Policy at a Crossroads

Despite the success of the Green Revolution, progress remains in a footrace with population growth. More than 30 countries currently face food emergencies.

The tools of modern agriculture—from the best agrarian practices, to genetically modified food, to the use of pesticides—is our only hope of doubling food production for the hungry, while also protecting our land, water and air. There is no scientific reason why these goals cannot be achieved. Failure can only result from a lack of will, either in the form of inaction or in the form of questionable public policies that are at odds with sound science.

In the 2009 G-8 Summit in L'Aquilia, Italy, the leaders of the world's advanced economies took a major step forward. They agreed to invest in efforts to increase agricultural productivity and fight hunger, with food security strategies "based on sound scientific evidence."[14]

Shortly afterwards, Secretary of State Hillary Clinton announced that global food security is a "key policy objective" of the Obama Administration. She met with UN General-Secretary Ban Ki-Moon to follow up to the G-8's commitment of $20 billion over three years to fund a food security effort through the World Bank. "We will invest," Secretary Clinton said, "in everything from research to develop better feed and seeds . . ."[15]

In fall, 2009, the G20—the world's 19 largest economies plus the European Union—supported the creation of a multilateral trust fund to rapidly scale up agricultural assistance around the world. The leaders of these 19 wealthiest nations called for increased food productivity to meet the twin challenges of climate change and food security.[16]

There is growing understanding that traditional agriculture, as it is practiced in the poorest regions of the world, cultivates a cycle of harm, from deforestation—to sediment pollution and erosion—to the releasing of greenhouse gases—to the degradation of women and children and maintaining an agricultural economy of subsistence. We are also seeing that agricultural technology can break this cycle of harm and replace it with a virtuous cycle of hope and productivity.

Yet, the declarations of our international organizations are not always consistent with the policies of some of the very nations that make up these bodies.

Many European nations persist in anti-biotech policies, for instance, and the European Parliament recently so tightened the approval process for pesticides as to virtually ban them. These decisions have been made on a political, not scientific basis – in fact they run contrary to repeated scientific studies carried out by individual European nations and the EU itself attesting to the safety of modern agricultural technology.

In 2001, for example, the research Directorate General of the EU released a summary of 81 separate scientific studies, all financed by the EU rather than private industry. All found genetically modified products to be safe for consumers (similar conclusions were announced by the French Academy of Sciences and Medicine, and the Royal Society of London). Similar findings on the safety of pesticides have also been routinely ignored in the political fervor to ban chemicals.

Some Non-Governmental Organizations have also persistently discouraged the use of genetically modified foods throughout the developing world, as well as put out scientifically unfounded concerns about pesticides in the developed world.

The victims of these policies will not be Europeans or North Americans, who will always live in lands of plenty. It will be the poorer trading partners of the EU, as well as developing-world governments that can be needlessly frightened away from biotech and modern agriculture.

A World of Abundance

Faced with the global challenge of doubling global food production and addressing climate change, we cannot afford to restrict the technologies and future investments that represent our only hope of increasing food yields while protecting our environment.

The challenge is daunting if we look, as some have done since the times of Thomas Malthus, at human population and environmental resources as a zero-sum equation, in which one side of that equation can only prosper if the other side loses. The good news is that technology has a way of liberating us from the straightjacket of zero-sum thinking. It has a way of changing the boundaries of what is possible.

To harvest the benefits of agricultural technology, however, we must also take politics out of policy and rely on sound science.

If we follow the path of sound science we can bring agricultural productivity up to a level that it will once again grow faster than world population. In doing so, we can liberate millions from chronic malnutrition and fear of starvation. We can end the remorseless cycle of low productivity and under-development.

And we can create a future of abundance that allows us to both feed the world and protect the Earth — this one planet that gives us all life.

[1] http://www.fao.org/newsroom/en/news/2006/1000385/index.html

[2] http://www.fao.org/news/story/en/item/20568/icode/

[3] Field to Market: The Keystone Alliance for Sustainable Agriculture, First Report, January 2009.

[4] Field to Market: The Keystone Alliance for Sustainable Agriculture, First Report, January 2009.

[5] Syngenta “Drought Tolerant Crop Varieties.”

[6] Ibid.

[7] MODDUS.

[8] CRUISER.

[9] Croplife.org, conservation techniques prevent water loss.

[10] Scientific American, July 2008

[11] Robert Berendes, “Feeding the World.”

[12] Several sources, including Mike Mack’s Pan African Chemical Network speech, has it as high as 200 hours per hectare.

[13] G-8, joint statement, 7/10/09.

[14] Department of State press release, 9/26/09; Department of State, Sec. Clinton speech,9/25/09.

[15] Leadership statement, 9/24-25.

[16] “The Frankenfood Myth,” Praeger, 2004, Henry Miller, et al.

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