
Sustainability and the Needs of 2050 Agriculture: Developed and Developing World Perspectives

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I will discuss the topic described on the conference agenda: *Sustainability and the Needs of 2050 Agriculture*, but I will turn it around. Rather than talk about the needs of agriculture in 2050 from developed- and developing-world perspectives, I will talk about what the developed and developing worlds will need from agriculture by mid-century, and how sustainability is inextricably linked to meeting those needs.

NEEDS BY 2050

In short, by 2050 the world will need food security, meaning that all people, at all times, have access to sufficient, safe, nutritious food to maintain healthy and active lives. Agriculture already plays an essential role in the supply of this food.

However, the reality is that, even today, we do not have food security. An estimated one billion people go to bed hungry every night. Childhood hunger remains particularly acute. Approximately 200 million children suffer the irreversible effects of chronic under-nutrition, including heightened vulnerability to illness and diminished cognitive development.

Food security is not only a matter of supply. Even where there is an adequate food supply, there is not always adequate food access because of income limitations. Also, poor dietary use can cause nutritional imbalance. It is estimated that poor nutrition is the underlying cause of the deaths of 3.5 million mothers and children under age five each year (Thousand Days, 2011).

These under-nutrition woes are not limited to the developing world, though. In developed countries, half of those over age 75 and in hospitals are thought to be nutrient deficient, as are, ironically, many obese people (Anonymous, 2011).

On the access-to-food issue, consider that, already in 2011, the UN Food Price Index has eclipsed its previous all-time global high (FAO, 2011). We last saw comparable escalation in food prices in 2007 and 2008. That spike was mitigated by favorable weather that helped farmers deliver record grain harvests, and by a severe recession that helped temper demand.

But the forces elevating demand and constraining supply have only grown stronger in the intervening years. Demand increase is coming not just from population growth, but from a growing global middle class that is moving up the food chain, consuming more grain-intensive products such as meat, milk and eggs. At the same time, the United States in particular is converting more grain into fuel. As a result, the price of grain is now linked to the price of oil as it becomes more profitable to convert carbohydrates into hydrocarbons (Henshaw, 2011).

Access and affordability issues are in play even here in the United States, where approximately 49 million people—including 17 million children—live in households struggling to put enough food on the table. In fiscal year 2010, our government spent an estimated \$80 billion to subsidize meals and food purchases for more than one in four Americans. Minnesota is not immune from the problem. According to Hunger-Free Minnesota (2011), a statewide coalition, hunger in Minnesota has doubled in five years. The coalition notes that one in ten Minnesotans run out of resources before the end of every month, missing an average of ten meals every 30 days. That's 100 million meals missed every year, with devastating effects.

Despite steady improvements in agricultural productivity, enabling food security on a global basis will be more challenging in the next 40 years. By 2050, there will be an estimated 2 billion more people to feed as the global population grows from the 7 billion it is expected to reach this October to more than 9 billion. And while 9 billion was previously expected to be a population plateau, in May of this year the United Nations revised upward its estimates for global population growth for the balance of the century. The new UN data estimate a global population of 10.1 billion by 2100 (UN, 2011). Much of the growth will be concentrated in Africa, where the population could more than triple, reaching 3.6 billion by the end of the century.

SOBERING REALITY

To ensure food security for the global population at mid-century will require producing twice as much food as we do today. By the century's end, according to Jason Clay (2011), a senior leader at the World Wildlife Fund, feeding the planet will require producing an amount of food that is 2.5 times the amount that all human societies have produced in the last 8,000 years. If not daunting enough, that increased output will have to come from less land and less water. As often-cited World Wildlife Fund research points out, continuing with business-as-usual in food production will require the resources of three planet Earths to support human activities (WWF, 2011).

Less Land

Agriculture already uses an estimated 40% of the globe's arable land, with some 3.75 billion acres in production. So, among the questions confronting us are how we double agricultural production without further deforestation and its attendant problems of soil erosion and of pollution of streams and waterways.

Again, this is not a problem unique to the developing world. In May, 2011, in a letter to the House and Senate agriculture committees, groups representing grain and feed traders, livestock producers, fertilizer manufacturers, meatpackers and others urged Congress to put back into production millions of acres of farmland that are now enrolled in the Conservation Reserve Program (Brasher, 2011). The land in the program serves to prevent soil erosion and the degradation of streams and rivers, sequesters carbon and also serves as valuable habitat for wildlife. It is expected that any effort to put these acres back into production will face ferocious opposition from environmental and wildlife-advocacy groups.

Less Water

Water availability is equally constraining to output growth. Of the fresh water utilized by man, which is a fraction of what is available on earth, 70% is used by agriculture. However, this varies widely by region of the world and by crop. For example, in the United States only 15% of corn is irrigated; the rest is largely rain-fed.

But crop losses due to water scarcity are becoming endemic throughout the world, as exemplified by the crop-destroying drought and fires in Russia in 2010, and severe droughts in Texas and the Southwest United States in 2011.

In India and China, groundwater withdrawals are increasing at an unsustainable pace. Here in the United States, we are also on an unsustainable water-use curve. The Ogallala Aquifer, which supplies 70% to 90% of the irrigation water for three of the top grain-producing states, is fast becoming depleted. Groundwater levels have declined by more than 100 feet in some areas according to US Geological Survey data (USGS, 2011). Without water for irrigation from this aquifer, this region—the breadbasket of the world—would be dramatically less productive.

ROLE OF SUSTAINABILITY

In this rather bleak picture, what is the role of sustainability? In a word: essential. It is inextricably linked to solving the global food-security challenge.

“Sustainability” is used in many contexts today. Sometimes the term is applied to organically produced crops or commodities, to locally grown produce and to small-scale farming operations. There are merits and elements of sustainability in all of them.

It is incorrect, though, to juxtapose intensive farming against organic, small scale or locally grown options in ways that suggest intensive operations are not also sustainable. Therefore, “agricultural sustainability” is used here in the context of efficient employment of finite, scarce resources in a manner that results in beneficial outcomes for the environment. That means thinking about sustainability in the context of growing more from less through the smart use of proven practices and a suite of agricultural technolo-

gies. Agricultural sustainability refers to a system that can meet global requirements for food, feed, fiber and fuel indefinitely, with beneficial economic and environmental effects in areas such as water and fossil-fuel usage, biodiversity preservation, land stewardship, carbon sequestration and more.

Defined in that fashion, sustainability is, clearly, fundamental to food security. Simply put, intensive farming, done sustainably, improves efficiency of use of resources. Consider, for example, the impact of crop losses. On a global basis, cereal-crop losses—to weeds, pests and disease—are estimated to average about 40% of the attainable yield (Oerke and Dehne, 1997). Given the food-production challenges we face to achieve global food security, how can that be tolerated? Said another way, natural resources—the soil and water utilized by the unattained yield—would be more efficiently used if the crop losses are mitigated by smart use of chemical and biological inputs, improved tillage practices and other crop-protection technologies and techniques associated with intensive farming.

The resource conservation that results from intensive farming—done sustainably—is not theoretical. A Stanford University study concluded that a land mass larger than Russia has been saved from cultivation because farmers have used modern technology to grow more on their farms in the last 50 years (Burney *et al.*, 2010). Russia covers more than 17 million square kilometers. That means an area more than twice the size of the continental United States has not been put into cultivation to support global food, feed, fiber and fuel needs even as the population has grown.

In Brazil, the rate of deforestation plunged to a historic low in 2009 even as agricultural productivity increased there at a rate faster than that of any other country in the world (Anonymous, 2010). By contrast, European restrictions on the use of certain inputs—genetically engineered crops, among others—mean that feeding Europe consumes the agricultural production of a non-European land mass the size of Germany (von Witzke and Noleppa, 2011).

Brazil's example underscores a profoundly important point: the absolute necessity of growth in agricultural productivity and the absolute necessity of conservation of scarce resources and the preservation of our environment are not in conflict. In fact, they can and should be in harmony.

BENCHMARKS BEYOND BUSHEL

What can the developed world do to debunk the perceived conflict between productivity and sustainability? What can the developed world do to propagate a sustainable form of intensive agriculture that will help remedy our global food-security challenge, create economic opportunity and improve social stability? Of myriad opportunities, I will discuss three contributions the developed world can make to putting us on a sustainable path to global food security. Those contributions are in three categories:

- Incorporation of outcomes-based sustainability measures into our mindset;
- Investment in the development and dissemination of technologies that enable improvements in these sustainability outcomes, including productivity; and

- Use of market power of buyers of major commodities to propagate adoption of sustainability principles and practices among producers while respecting producers' legitimate interests.

Sustainability Measures

With respect to measuring sustainability outcomes, a new perspective must take hold in agriculture in the developed world. This new perspective will be enormously helpful to propagating the sustainability outcomes that will close the gap on food security and determine the practices in production agriculture that truly result in improvements. It can best be summed up as a “benchmarks beyond bushels” approach to measuring sustainability in agriculture. As a practical matter, this will mean measuring productivity not only on the basis of yield in terms of bushels per acre, but also on the basis of resource utilization per bushel produced. If we measure output in this more holistic fashion, productivity becomes integral to how sustainability is defined and measured, and maintains focus on the environmental, economic and social outcomes to be achieved.

Intensive farming can stand this scrutiny. Consider the facts on corn production. In the United States, although corn yields have steadily increased, the environmental footprint is smaller in every category. Data from the Keystone Center show that in the two decades ending in 2007, land use per bushel of corn produced, soil loss per bushel, irrigation-water use per bushel, energy use per bushel and greenhouse-gas emissions per bushel all declined (Anonymous, 2009).

Field to Market: The Keystone Alliance for Sustainable Agriculture is an initiative of the Keystone Center comprising forty-six diverse stakeholders that include Cargill, Conservation International, Monsanto, Environmental Defense Fund, National Corn Growers Association, General Mills, The Fertilizer Institute, Syngenta, and the Nature Conservancy. The outcomes-based focus represented by Field to Market's measurements is critical. Many parties are at work on defining a standard way to measure agricultural sustainability. Some of those definitions characterize sustainability by specifying inputs, such as prohibition of genetically engineered crops. Others advocate definitions based on outcomes, such as improving water-use efficiency by some targeted percentage. The accepted approach will likely affect sustainability ratings and consumer-product labeling. A concern, however, is that an inputs-based approach could restrict farmers' freedom to operate and to make the best choices for improving productivity and efficiency on their land. That is why Syngenta supports and participates in Field to Market's model for measuring agricultural sustainability.

Field to Market's initial suite of metrics includes indicators encompassing soil loss, irrigation-water consumption, land and energy use and climate impact. We believe this outcomes-driven approach is more likely to motivate the kinds of innovation and improvement needed to meet sustainability and food-security challenges. Prescriptive practices, on the other hand, tend to motivate compliance rather than invention.

Investment in Technology

Improved performance on outcomes-based measures of sustainability can be enabled by further investment in the development and deployment of productivity-enhancing technologies. The range of opportunity is broad, encompassing everything from technologies to increase yields, to improve plant performance and to enhance nutritional content. For example, precision breeding—what we at Syngenta call Gene Blueprinting—and genetic modification technologies are enabling new crop capabilities that typically serve sustainability, including productivity. Among them are improved disease resistance, drought tolerance and nitrogen-use efficiency, to name a few. For example, Syngenta introduced for planting in 2011 hybrids containing Agrisure Artesian™ technology, which preserves yield under drought stress. In field trials, this unique trait, developed through work solely within the corn genome, has shown the ability to preserve up to 15% of the yield that might be lost to moisture stress without inflicting a yield penalty under adequate moisture.

We are also becoming proficient at developing nutrient-enriched crops. Examples include vitamin-enhanced rice, canola with enhanced omega-3 oil content, and tomatoes with higher concentrations of the antioxidant lycopene. These innovations overcome the nutrient deficiencies mentioned above as an element of food insecurity globally. But they can only do that if their adoption is not constrained for non-scientific reasons, as has been the case with vitamin-enriched rice in parts of Asia.

Meanwhile, new output traits are helping enhance the use of crops in downstream processes. For example, Syngenta's Enogen™ corn amylase is the first corn optimized for ethanol production. It produces within the kernel an enzyme that helps convert starch to sugar. Sustainability benefits accrue from the reduced use of water, electricity and natural gas required in the Enogen-enabled production process. For example, in a 100-million-gallon ethanol plant, Enogen corn amylase can save 450,000 gallons of water, 1.3 million kilowatt hours of electricity and 244 billion BTUs of natural gas. Those energy savings translate into a 106-million-pound reduction in greenhouse-gas emissions, the equivalent of taking more than 4,600 passenger cars off the road (Urbanchuk *et al.*, 2009).

Enogen corn is approved for food and feed purposes, the same as conventional corn. But because its value is in the ethanol-production process, it will be cultivated in a closed system. Ethanol-production plants will contract directly with growers in their immediate areas for their supply. Growers, in turn, will need to abide by strict stewardship requirements, and agree to provide their Enogen corn only to the contracting plant.

It's important to understand that what I'm calling "crop capabilities" encompass multiple technologies that deliver compound benefits when used together and systematically. For instance, no- or low-till farming improves soil's ability to absorb water, reduces moisture loss, erosion and run-off into lakes and streams and enhances carbon sequestration. Herbicides that control weeds lower the need for tillage, making no-till or low-till farming more feasible, hence enabling no-/low-till farming and all its environmental benefits.

Another example are seed treatments that protect plants during early growth to help more seeds germinate with less crop loss right from the start. In addition, certain seed treatments also help emerging plants develop robust roots. Superior root structures help plants better use available soil moisture or irrigation water, as well as soil nutrients. That

can mean less water and nitrogen applied to fields, reducing the potential for both run-off and nitrification, which results in the release of nitrous oxide, which is 300 times more potent as a greenhouse gas than carbon dioxide.

In another example, a plant growth regulator, like Syngenta UK MODDUS™ for application to wheat and barley, can be used to reduce crop height. This is desirable for lodging control and yield protection. Root lodging will occur where the plant is insufficiently anchored, however, even in the absence of lodging, the regulator's effects on root structure benefit water and nutrient use, enabling the related environmental benefits.

The “big bang” benefits for agricultural productivity and sustainability come when all these technologies and more are integrated. In Brazil, for instance, Syngenta is pioneering an entirely new way to plant, grow and harvest sugar cane, which meets 70% of global sugar needs and is the most cost-effective feedstock for plant-derived ethanol. Traditionally, however, this crop attracted little technology investment and yields were far below potential. Even so, production is under pressure as demand outstrips the capacity of what has been a largely manual planting and cultivation process. Syngenta has developed a solution that simplifies operations, improves output and ensures sustainability. Our PLENE™ technology integrates multiple technologies including:

- A treatment for sugar-cane cuttings that protects against insects and disease;
- Shorter cuttings—4 cm compared with the conventional 40 cm—that enable mechanized planting with lighter equipment for less soil compaction and less fuel consumption;
- Insecticides that control sucking and chewing pests and deliver an additional vigor effect that results in a 10% yield advantage;
- Our MODDUS plant-growth regulator in Brazil allows growers to schedule harvesting to achieve maximum sugar yield;
- A solution for termite control that does not persist in the environment or harm beneficial insects that help break down cane residues after harvest; and
- A fungicide to prevent orange rust in sugar cane.

Clearly, technology and innovation are firmly on the side of enabling further improvements in sustainability through agricultural productivity and environmental quality. Our PLENE system for sugar cane means greatly enhanced yield, lower water usage and better carbon sequestration—in short, a more productive and sustainable crop enabled by sustainable intensification.

Market Power

A third way the developed world can help propagate sustainable practices is by harnessing market power to create appropriate incentives all along the farm-to-fork supply chain. One of the organizations leading the way in this regard is the Consumer Goods Forum (CGF), a global industry network that brings together the CEOs and senior management of more than 650 retailers, manufacturers, service providers and other stakeholders across seventy countries. It was created in June 2009 by the merger of the Food Business Forum, the Global Commerce Initiative and the Global CEO Forum.

Last November, the Forum announced two climate-change initiatives, one aimed at ending deforestation, and the other focused on phasing out the use of refrigerant gases with high global-warming potential. The Forum pledged to mobilize its collective resources to help achieve, by 2020, zero net deforestation, which currently accounts for 17% of greenhouse-gas production. In announcing the zero net deforestation initiative, Forum leaders said:

We believe that our industry has a responsibility to purchase commodities in a way which encourages producers not to expand into forested areas. Our task is to develop specific action plans for the different challenges of sourcing commodities like soya, palm oil, beef, paper and board sustainably.

This kind of commitment is spreading. In an essay for the *New York Times*, the World Wildlife Fund's Jason Clay (2011) pointed out that major food brands are demanding greater sustainability from their supply-chain partners through increased productivity, efficiency and the elimination of waste. In a TED Conference¹ presentation, Jason Clay (2010) had kind words for work that Cargill, Coke and Mars are already doing in this regard. He pointed out the huge opportunity that still exists, noting that a hundred companies control about 25% of the trade in all fifteen of the most significant agricultural commodities. He made a compelling case for the sustainability gains that could be wrung from the purposeful application of that market power, contending that mega-buyers of agricultural commodities can push producers toward sustainable practices faster than consumers can. Clay's point is straightforward: If mega buyers decide they want to source a commodity produced in a certain way, then producers will get in line to fulfill that demand, as long as doing so makes economic sense. When buyers are incented by self-interest to source agricultural commodities sustainably, then producers' self-interests should be well served by fulfilling that demand for sustainably produced commodities. In short, get the market forces and incentives aligned and the seeds for a self-reinforcing virtuous cycle are planted.

DEVELOPING WORLD

Three ground rules govern the discussion of the developing-world perspective on agricultural productivity, sustainability and food security. The first is to accept the premise that long-term food security in the developing world cannot be accomplished solely via philanthropy or technology.

I am not dismissing the important work being done by numerous foundations and NGOs in this regard, but food aid and hunger relief, as valuable as they are, cannot be the enduring fix for the problem. An Oxfam study cited in the *New York Times* in May, 2011, stated the case clearly (Rosenberg, 2011). It costs much less to prevent a famine than to save lives after one has struck. Oxfam estimates that it costs seven times more to provide emergency food relief than it does to prevent a food-security disaster. Similarly, simply providing new technologies to the developing world will not solve the food-security challenge.

¹TED Conference, "Ideas Worth Spreading": <http://www.ted.com/>.

Hence, the second ground rule is to accept that there will be no global food security without productivity increases among smallholders. By United Nations' and other estimates, there are some 450 million farms of less than 5 acres in non-OECD² countries. The owners of these very small farms are providing—or trying to provide—sustenance for two billion people. Improved productivity on these small farms will be essential to sustainable food security.

The third ground rule is basically a corollary to the second: closing the yield gap between what is possible in the developed world and what is realized in the developing world without encouraging resource waste is the imperative.

The path to the levels of productivity required will involve sustainable intensification. In the developing world, this means creating the means for smallholders to progressively evolve from subsistence farming, to semi-commercial farming to commercial operators to advanced farmers.

If this sounds more aspirational than realistic, it is important to realize that it's been done before. From the 1960s to the 1980s, productivity improvement in Asia and Latin America resulted in a doubling of food production, which saved millions of lives and laid foundations for economic growth in countries like India and China.

More to the point, it is being done now. Private foundations, public entities, private-public partnerships and NGOs are all helping create the capacity required to enable smallholder farmers to pursue sustainable intensification. What's required is access to improved genetics, crop protection, fertilizer, soil and water management, agronomic and extension services, financial services, markets, infrastructure, *etc.* Furthermore, the provision of these resources needs to be combined with the provision of education and training that enables smallholders to use them wisely and effectively. That's one reason why Syngenta trains millions of farmers annually—4.3 million last year and more than 10 million over the last three years.

As an example of the essential linkage of provision of improved resources with provision of required education, consider what can happen when smallholder farmers are provided with elite corn hybrids. The temptation in subsistence and pre-commercial operations will be to save seed from those hybrids for the next season's planting. Of course doing so ultimately defeats the purpose of providing the improved technology. Instead, smallholder growers need the education and support to understand that the increased yield from the elite hybrids is worth more than the saved seed. And they, of course, need supporting technology and services to realize that increased yield.

As that example illustrates, there is a "high touch" component to creating the capacity that will enable sustainable intensification in the developing world. It will be a long and steep climb, but I believe the commitment is there. It's evident in projects being advanced by organizations such as the Bill and Melinda Gates Foundation, the Consumer Goods Forum, numerous NGOs and by companies like Cargill, General Mills, Coca-Cola and Syngenta.

²Organization for Economic Co-operation and Development

Syngenta Foundation for Sustainable Agriculture

At Syngenta, this capacity-building work is being advanced by both the company and by the Syngenta Foundation for Sustainable Agriculture. An example of a corporate initiative is our partnership with the International Maize and Wheat Improvement Center (CIMMYT) in Mexico, announced in April, 2010. As the director of the Center's wheat program pointed out when this partnership was announced, global wheat production is increasing at less than 1% annually whereas demand is increasing at 1.5% or more, creating conditions that foreshadow persistent shortages. The agreement enables Syngenta's genetic-marker technology, advanced traits platform and wheat breeding for the developed world to be combined with the Center's access to diverse wheat genetics, global partners and wheat-breeding programs targeted at the developing world to improve yields.

India

Another corporate-sponsored venture is a "crop health center" in India called Krishi Shakti. The center provides agronomy advice and resources to farmers from surrounding villages. In parallel, Syngenta started operating Krishi Shakti vans to support farmers on their farms. These programs provide crop diagnostics, soil testing, library facilities, training and education, demonstration plots and interactions with scientists to improve crop yields and quality.

Africa

Syngenta, in collaboration with the Syngenta Foundation for Sustainable Agriculture, is also building capacity and capability for sustainable intensive farming among smallholders. In East Africa, for instance, our Scaling up Laikipia Project, begun in June, 2009, aims to reach as many as 30,000 smallholder farmers in an extension-services model with assets and information to help them raise vegetables as cash crops, improve water management, gain access to markets and take advantage of new technologies.

One of the farmer beneficiaries saw her potato crop increase from two bags a year to six, which tripled her income from \$61 to \$186. That \$125 improvement is the difference between living on the edge of starvation, vulnerable to disease, and opening a bank account and buying more land.

Elsewhere in Africa, the Syngenta Foundation runs a program that provides fast-growing, drought-resistant maize to smallholders while offering them a first-of-its-kind crop insurance program that enables growers to enroll via mobile phone and provides payouts when automated weather stations report severe drought rather than requiring the farmer to prove economic loss. This innovative program makes it feasible and affordable for smallholders to take on the risk of planting higher quality seed—a risk too great otherwise.

NOBLE WORK

These examples underscore the point that what may look like unrealistic ambition—improving smallholder productivity through propagation of intensive, but sustainable, practices—is, in fact, achievable. That is why meeting the global food-security challenge, while certainly daunting, is also achievable.

Improved agricultural productivity, in both the developed and developing worlds, is essential to meeting the challenge. In the developed world, it will require sustaining gains in agricultural productivity through continued investment and implementation of advanced technologies, measuring agricultural productivity holistically and harnessing the market power of major players to create farm-to-fork incentives for sustainability.

The most problematic barriers in the developed world will likely continue to be overzealous, under-informed and unsynchronized regulatory strictures.

In the developing world, we should be mindful of a Marshall McLuhan quote, uttered decades ago, but more apt than ever now:

We have moved into an age in which everybody's activities affect everybody else.

Many of the catalysts that can help accelerate the evolution of smallholder, subsistence farmers into viable commercial farmers are likely to come in the form of new hybrids, new traits, new seed treatments and new crop-protection chemistries. The adoption of these new technologies can move ahead rapidly if it is not unnecessarily constrained by unscientific policy or regulation. Consider Brazil, which doubled its soybean production within a decade thanks in part to rapid adoption of new technologies.

The need to solve our global food-security challenges through improvements in sustainable agricultural productivity is certainly among the most urgent and important challenges we'll face in the next few decades. The concerted effort of the public and private sectors, academia, foundations and NGOs will be essential.

This is noble work and it is both gratifying—and humbling—to be engaged in it.

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