It doesn't have to be industrial farms versus small, organic ones. There's another way.

A Five-Step Plan to Feed the World

By Jonathan Foley
Photographs by George Steinmetz and Jim Richardson
When we think about threats to the environment, we tend to picture cars and smokestacks, not dinner. But the truth is, our need for food poses one of the biggest dangers to the planet.

Agriculture is among the greatest contributors to global warming, emitting more greenhouse gases than all our cars, trucks, trains, and airplanes combined—largely from methane released by cattle and rice farms, nitrous oxide from fertilized fields, and carbon dioxide from the cutting of rain forests to grow crops or raise livestock. Farming is the thirstiest user of our precious water supplies and a major polluter, as runoff from fertilizers and manure disrupts fragile lakes, rivers, and coastal ecosystems across the globe. Agriculture also accelerates the loss of biodiversity. As we’ve cleared areas of grassland and forest for farms, we’ve lost crucial habitat, making agriculture a major driver of wildlife extinction.

The environmental challenges posed by agriculture are huge, and they’ll only become more pressing as we try to meet the growing need for food worldwide. We’ll likely have two billion more mouths to feed by mid-century—more than nine billion people. But sheer population growth isn’t the only reason we’ll need more food. The spread of prosperity across the world, especially in China and India, is driving an increased demand for meat, eggs, and dairy, boosting pressure to grow more corn and soybeans to feed more cattle, pigs, and chickens. If these trends continue, the double whammy of population growth and richer diets will require us to roughly double the amount of crops we grow by 2050.

Unfortunately the debate over how to address the global food challenge has become polarized, pitting conventional agriculture and global commerce against local food systems and organic farms. The arguments can be fierce, and like our politics, we seem to be getting more divided rather than finding common ground. Those who favor conventional agriculture talk about how
Agriculture’s Footprint

Farming of both livestock and crops is the largest human endeavor on Earth, using more than 38 percent of ice-free land. Our next largest impact: erosion caused by agriculture, building, logging, and mining.

modern mechanization, irrigation, fertilizers, and improved genetics can increase yields to help meet demand. And they’re right. Meanwhile proponents of local and organic farms counter that the world’s small farmers could increase yields plenty—and help themselves out of poverty—by adopting techniques that improve fertility without synthetic fertilizers and pesticides. They’re right too.

But it needn’t be an either-or proposition. Both approaches offer badly needed solutions; neither one alone gets us there. We would be wise to explore all of the good ideas, whether from organic and local farms or high-tech and conventional farms, and blend the best of both.

I was fortunate to lead a team of scientists who confronted this simple question: How can the world double the availability of food while simultaneously cutting the environmental harm caused by agriculture? After analyzing reams of data on agriculture and the environment, we proposed five steps that could solve the world’s food dilemma.

**STEP ONE: Freeze agriculture’s footprint**

For most of history, whenever we’ve needed to produce more food, we’ve simply cut down forests or plowed grasslands to make more farms. We’ve already cleared an area roughly the size of South America to grow crops. To raise livestock, we’ve taken over even more land, an area roughly the size of Africa. Agriculture’s footprint has caused the loss of whole ecosystems around the globe, including the prairies of North America and the Atlantic forest of Brazil, and tropical forests continue to be cleared at alarming rates. But we can no longer afford to increase food production through agricultural expansion. Trading tropical forest for farmland is one of the most destructive things we do to the environment, and it is rarely done to benefit the 850 million people in the world who are still hungry. Most of the land cleared for agriculture in the tropics does not contribute much to the world’s food security but is instead used to produce cattle, soybeans for livestock, timber, and palm oil. Avoiding further deforestation must be a top priority.

**STEP TWO: Grow more on farms we’ve got**

Starting in the 1960s, the green revolution increased yields in Asia and Latin America using better crop varieties and more fertilizer, irrigation, and machines—but with major environmental costs. The world can now turn its attention to increasing yields on less productive farmlands—especially in Africa, Latin America, and eastern Europe—where there are “yield gaps” between current production levels and those possible with improved farming practices. Using high-tech precision farming systems, as well as approaches borrowed from organic farming, we could boost yields in these places several times over.

**STEP THREE: Use resources more efficiently**

We already have ways to achieve high yields while also dramatically reducing the environmental impacts of conventional farming. The green revolution relied on the intensive—and unsustainable—use of water and fossil-fuel-based chemicals. But commercial farming has started to make huge strides, finding innovative ways to better target the application of fertilizers and pesticides by using computerized tractors equipped with advanced sensors and GPS. Many growers apply customized blends of fertilizer tailored to their exact soil conditions, which helps minimize the runoff of chemicals into nearby waterways.

Organic farming can also greatly reduce the use of water and chemicals—by incorporating cover crops, mulches, and compost to improve soil quality, conserve water, and build up nutrients. Many farmers have also gotten smarter about water, replacing inefficient irrigation systems with more precise methods, like subsurface drip irrigation. Advances in both conventional

Jonathan Foley directs the Institute on the Environment at the University of Minnesota. Jim Richardson's portraits of farmers are the latest in his body of work documenting agriculture. George Steinmetz's big picture approach reveals the landscapes of industrial food.
A World Demanding More

By 2050 the world's population will likely increase by about 35 percent.

1 billion people

To feed that population, crop production will need to double.

1 billion tons

Why? Production will have to far outpace population growth as the developing world grows prosperous enough to eat more meat.

Increase in daily protein demand

Per capita by 2050

SOURCE: DAVID TILMAN, UNIVERSITY OF MINNESOTA

and organic farming can give us more "crop per drop" from our water and nutrients.

STEP FOUR Shift diets

It would be far easier to feed nine billion people by 2050 if more of the crops we grow ended up in human stomachs. Today only 55 percent of the world's crop calories feed people directly, the rest are fed to livestock (about 36 percent) or turned into biofuels and industrial products (roughly 9 percent). Though many of us consume meat, dairy, and eggs from animals raised on feedlots, only a fraction of the calories in feed given to livestock make their way into the meat and milk that we consume. For every 100 calories of grain we feed animals, we get only about 40 new calories of milk, 22 calories of eggs, 12 of chicken, 10 of pork, or 3 of beef. Finding more efficient ways to grow meat and shifting to less meat-intensive diets—even just switching from grain-fed beef to meats like chicken, pork, or pasture-raised beef—could free up substantial amounts of food across the world. Because people in developing countries are unlikely to eat less meat in the near future, given their newfound prosperity, we can first focus on countries that already have meat-rich diets. Curtailing the use of food crops for biofuels could also go a long way toward enhancing food availability.

STEP FIVE Reduce waste

An estimated 25 percent of the world's food calories and up to 50 percent of total food weight are lost or wasted before they can be consumed. In rich countries most of that waste occurs in homes, restaurants, or supermarkets. In poor
countries food is often lost between the farmer and the market, due to unreliable storage and transportation. Consumers in the developed world could reduce waste by taking such simple steps as serving smaller portions, eating leftovers, and encouraging cafeterias, restaurants, and supermarkets to develop waste-reducing measures. Of all of the options for boosting food availability, tackling waste would be one of the most effective.

TAKEN TOGETHER, these five steps could more than double the world's food supplies and dramatically cut the environmental impact of agriculture worldwide. But it won't be easy. These solutions require a big shift in thinking. For most of our history we have been blinded by the overzealous imperative of more, more, more in agriculture—clearing more land, growing more crops, using more resources. We need to find a balance between producing more food and sustaining the planet for future generations.

This is a pivotal moment when we face unprecedented challenges to food security and the preservation of our global environment. The good news is that we already know what we have to do; we just need to figure out how to do it. Addressing our global food challenges demands that all of us become more thoughtful about the food we put on our plates. We need to make connections between our food and the farmers who grow it, and between our food and the land, watersheds, and climate that sustain us. As we steer our grocery carts down the aisles of our supermarkets, the choices we make will help decide the future.

The Future of Food

Food Versus Feed and Fuel

Percentages on the map show whether most of the calories in a region's crops go directly to human consumption (green) or go to animal feed and biofuels (purple). Only 55 percent of the world's food-crop calories directly nourish people. We get another 4 percent indirectly by eating meat, dairy, or eggs from animals raised on feed.

China
The second largest corn producer, China feeds 77 percent of its corn to animals. Humanity consumes 50 percent of the rice crop calories.

India
Vegetable consumption, though rising, is lower in India than in much of the world. Most crops still directly feed humans.

89% Asia (without China)
Most crops, mainly rice, are grown to feed people, though some are used for cooking and other food products but also for cosmetics instead.

75% Brazil
Brazil is the world's largest soy producer. The soybeans are diverted to feed livestock.

72% Africa
Small farmers grow crops mostly for human consumption. Some calories, meats, and oilseeds are diverted to feed livestock.

73% U.S.
U.S. soybean production has jumped from 7 percent of the supply in 2000 to almost 40 percent today.

32% U.S. Midwest
Europe

The map shows the rising food security crisis, which is most acute in the developing world, where governments and consumers are demanding more food faster than the food system can produce it. The map highlights the growing global imbalance between food production and food consumption.

31% Europe

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100% calories

FEED and FUEL

For animals and industry:

100% calories

Food:

100% calories

FEED

for animals and industry

FUEL

Food

100% calories

Where the calories are produced

50%

FOOD

45%

FEED

55%

FUEL

How global crop calories are used

100% calories

The numbers in the map reflect the percentage of calories fed to livestock, used in the production of biofuels, or consumed directly by humans around the world. The map shows that the world's food crops are increasingly being diverted away from human food consumption to feed livestock and produce biofuels.

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*Includes biofuels and other ethanol products

SOURCE: GLOBAI DEVELOPMENT NETWORK, WORLDWIDE FUTURE OF FOOD PROJECT, UNIVERSITY OF MINNESOTA.
Beyond Delicious

You might say the apple fell from grace in the 1920s and '30s, with the advent of refrigerated long-distance shipping. Thanks to supermarket Darwinism, thousands of heirloom varieties, like many of those at right, went commercially extinct. Produce bins featured Delicious, Jonathan, and Rome—selected for durability and beauty, but boring in taste. "People switched off their taste buds," says Diane Miller, an apple geneticist at Ohio State University. Apple consciousness-raising, says Miller, came with the release of the aptly named Honeycrisp hybrid in 1991. Now breeders create dozens of flavorful new hybrids a year and heirlooms are back in style.