Food, Agriculture & the Environment: Can We Feed the World & Save the Earth?

David Tilman & Michael Clark

Abstract: Secure and nutritious food supplies are the foundation of human health and development, and of stable societies. Yet food production also poses significant threats to the environment through greenhouse gas emissions, pollution from fertilizers and pesticides, and the loss of biodiversity and ecosystem services from the conversion of vast amounts of natural ecosystems into croplands and pastures. Global agricultural production is on a trajectory to double by 2050 because of both increases in the global population and the dietary changes associated with growing incomes. Here we examine the environmental problems that would result from these dietary shifts toward greater meat and calorie consumption and from the increase in agricultural production needed to provide this food. Several solutions, all of which are possible with current knowledge and technology, could substantially reduce agriculture's environmental impacts on greenhouse gas emissions, land clearing, and threats to biodiversity. In particular, the adoption of healthier diets and investment in increasing crop yields in developing nations would greatly reduce the environmental impacts of agriculture, lead to greater global health, and provide a path toward a secure and nutritious food supply for developing nations.

DAVID TILMAN, a Fellow of the American Academy since 1995, is Regents Professor and McKnight Presidential Chair in the College of Biological Sciences and Director of the Cedar Creek Ecosystem Science Reserve at the University of Minnesota.

MICHAEL CLARK is a Graduate Student in the Department of Ecology, Evolution, and Behavior at the University of Minnesota.

*(*See endnotes for complete contributor biographies.)*

The importance of food is undeniable. Stable societies require adequate and predictable supplies of food.[1] Modern industrial societies require that most of their members have differentiated and specialized skills, which is only possible when high-yielding crops allow a few people to feed the many. Societies also depend on a multitude of services provided by ecosystems, including the production of pure drinking water, the decomposition of wastes, the creation of fertile soils, the removal and storage of much of the greenhouse gasses released by society, the amelioration of flooding provided by intact ecosystems, and the support of a multitude of other species that provide food, crop pollination, timber, fiber, medicines, and the functioning of Earth's ecosystems.[2]

Agriculture – as currently practiced – poses major threats to the environment. Agriculture and food production are responsible for more than 25 percent of total global greenhouse gas (GHG) emissions to

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the atmosphere. Each year, global agriculture is responsible for the application of fertilizer possessing more nitrogen and phosphorus than is supplied by the natural processes of all terrestrial ecosystems.[3] In many cases, crops do not take up the majority of these nutrients; rather, they leach out of farmed fields and pollute aquifers, lakes, and rivers in a process called *eutrophication*.[4] When these excess nutrients enter the ocean, they can create low-oxygen "dead zones" that devastate local aquatic ecosystems and the fisheries on which we rely.[5] Agricultural nutrients can also be transported through the atmosphere and deposited on terrestrial ecosystems, where they can reduce biodiversity and harm the functioning of these ecosystems. Many agricultural herbicides, insecticides, and fungicides are long-lived and enter terrestrial and aquatic ecosystems where they can negatively impact ecological and human health.[6]

An equally great environmental impact of agriculture comes from the immense amount of Earth's land area devoted to agriculture. Earth has approximately nine billion hectares of ice-free, nondesert land generally suitable for human life. Global croplands and pasturelands already occupy five billion hectares.[7] Habitat destruction and fragmentation resulting from the conversion of native ecosystems into croplands and pasturelands is a major reason why so many plant and animal species are now threatened with extinction. The loss of Earth's biodiversity is irreversible, forever foreclosing on societies' ability to benefit from any future value that this "natural capital" might have provided.[8] In addition, many of the simplified low-diversity agroecosystems created by farming are less able to provide society with valued ecosystem services.[9] Finally, habitat destruction and fragmentation by agriculture can harm nearby natural ecosystems by causing them to lose biodiversity.[10]

A secure supply of nutritious food and a livable environment are of central importance to humanity, but are increasingly in conflict.[11] Because global demand for food and animal feed is expected to approximately double in the coming forty to fifty years, the environmental harm caused by agriculture expansion in the coming decades could be considerable.[12] In this essay, we 1) analyze the drivers behind what might be a doubling of global food demand during the next half century; 2) review the environmental impacts associated with the last doubling of global food; 3) project the potential environmental impacts of the anticipated doubling of food; and 4) propose several potential solutions that could plausibly allow us to greatly reduce harm to the global environment while feeding a world of eleven billion people.

The twentieth century introduced an era of unprecedented human population growth, primarily resulting from falling mortality rates associated with advances in sanitation and medicine.[13] The global population doubled from 1900 to 1957, and doubled again by 1995, only thirty-eight years later. The UN forecasts that the global population will increase from 7.3 billion people in 2015 to 9.6 billion people by 2050, and then peak at about 10.9 billion people by 2100.[14] At this point, from a human perspective, we will have reached a "full Earth." If agricultural practices were to stay the same and per capita food demand did not increase, population expansion alone would increase demand for agricultural production by 30 percent by 2050 and 50 percent by 2100.

Per capita incomes, which are rising around the world, are a strong driver of human dietary choices.[15] The net effect of income on diet is that demand for agricultural crops is increasing at a much faster rate than global population. Indeed, a recent analysis forecasts that global food demand in 2050 will be double that of 2005, with income-driven dietary shifts responsible for about 70 percent of this increase and the growing global population responsible for the remaining 30 percent.[16]

There are two major ways in which increases in income affects diets. First, as incomes increase, people tend to consume more animal products like meat, dairy, and eggs (Figure 1).[17] Second, diets also shift toward increased caloric consumption, and in particular toward more sugars, oils, fats, and alcohols, which are commonly referred to as "empty calories."

For a typical citizen of one of the fifteen richest nations, daily food demand – measured as food that enters the household per person – is about 3,500 calories.[18] Up to 25 percent of this food is wasted after it reaches the household. About 20 percent of daily calories consumed in these wealthy nations come from meat, milk, and eggs; 38 percent of daily calories are from empty calories; and the rest come from other plant-based foods. In comparison, the average person's daily food demand in the twenty or so poorest economies is about 2,000 calories, much less of which is wasted, with only 3 percent of the total coming from meat, milk, and eggs, and 12 percent from empty calories. One effect of this income-dependent disparity in caloric demand and consumption is that 2.1 billion people are overweight or obese globally because of excess consumption while, at the same time, another eight hundred million of the world's poorest people suffer from malnutrition or undernourishment related to a lack of access to adequate and appropriate food.[19]

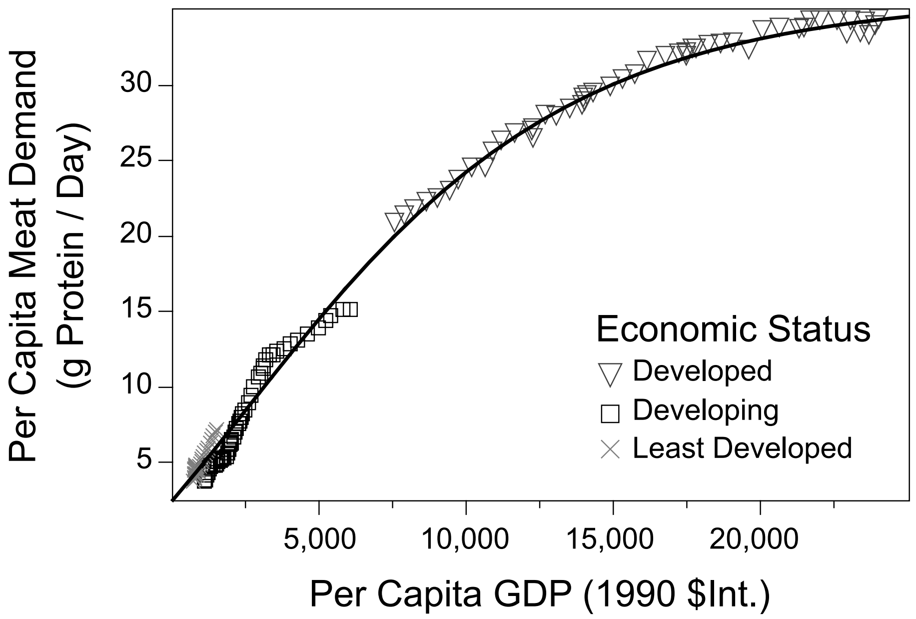
The shift toward greater per capita consumption of animal products has a major impact on societal demand for agricultural crops. In richer nations, about 8,000 calories per day of agricultural crop production are required to provide the 3,500 calories of food brought into the household by the average person.[20] The 4,500 calorie difference between the caloric content of the crops that must be grown and the caloric content of food brought into the household mainly represents the calories fed to the animals used to produce animal-based foods.

The reason that increased demand for meat, milk, and eggs results in large increases in agricultural production is directly related to the inefficiency with which various animals convert feed crops into edible animal-based foods. For example, for cattle to create one kilogram of edible beef protein they must eat twenty kilograms of plant protein, for a ratio of 1:20. The ratio is 1:5.7 for pork; 1:4.7 for poultry; 1:4.4 to 1:4.8 for aquaculture production of halibut, salmon, cod, and arctic char; 1:3.9 for milk; and 1:2.6 for eggs.[21] In total, more than half of all agricultural crop production and land use in richer nations feeds livestock, rather than producing crops for direct human consumption.[22] Animal production is not only calorie-intensive, but is also land-intensive: approximately 80 percent of global agricultural land is used to graze livestock and a significant portion of cropland is for animal feeds.[23]

In summary, the major reason why a world with about 30 percent more people in 2050 would demand about 100 percent more production of agricultural crops is because of the feed necessary to meet increased demand for animal-based foods resulting from the rising incomes of billions of people in the developing world.[24] Increased demand for empty calories directly consumed by people, often in the form of sugars, fats, oils, and alcohols, also contributes to this demand, though to a lesser extent.

These dietary shifts also have major implications for human health. The global trend toward consuming more total calories, more empty calories, and more meats and dairy is called the *global nutrition tran-*

Figure 1
The Dependence of Meat Consumption on Income



Results for the one hundred most populous nations of the world are based on averages calculated by grouping nations by their economic status (developed, developing, least developed). The average for each group is shown for each year from 1961 – 2007. Figure is based on analyses of data from Food and Agriculture Organization of the United Nations. See David Tilman, Christian Balzer, Jason Hill, and Belinda L. Befort, "Global Food Demand and the Sustainable Intensification of Agriculture," *Proceedings of the National Academy of Sciences* 108 (50) (2011): 20260 – 20264; and David Tilman and Michael Clark, "Global Diets Link Environmental Sustainability and Human Health," *Nature* 515 (2014): 518 – 522.

sition.[25] Driven by increases in income and urbanization, the global nutrition transition results in increased rates of obesity, diabetes, heart disease, and other diet-related chronic noncommunicable diseases in both developing and developed countries.[26] For instance, as China industrialized from 1980 to 2008, the incidence of diabetes increased from less than 1 percent of its population to more than 10 percent, and is still increasing.[27] Even when viewed at a global level, the increased incidences of noncommunicable diseases are large. For instance, the age-adjusted global incidence of diabetes increased 45 percent from 1990 to 2013.[28] The incidences of all noncommunicable diseases are increasing so rapidly that such diet and lifestyle-dependent diseases are projected to become the major burden of disease for the world by 2030.[29]

The "green revolution" began when the agronomist Norman Borlaug bred new strains of wheat capable of much greater yields (defined as crop production per unit of area) than local varieties if provided with fertilizer and, if needed, water. Yield increases in wheat were followed by work that led to similar increases in rice production. When this technology was adopted rapidly, as it was for wheat production by both Pakistan and India between 1965 and 1970, yields almost doubled. On the global scale, production of cereal grains doubled from 1960 to 1995 mainly because of green-revolution technologies (but also because of land being cleared to create new cropland), even though such technologies had not been adopted by most African nations. This rapid increase in the global food supply helped meet the demands of a rapidly growing global population, thus averting what had been anticipated to be global episodes of mass starvation.[30] The benefits of the green revolution were immense; but to illuminate the potential impacts driven by the anticipated doubling of global crop production over the next forty to fifty years, it is necessary to consider some of the green revolution's harmful impacts on human health and the environment.

Use of nitrogen fertilizer, phosphorus fertilizer, and irrigated water increased greatly during the green revolution. From 1960 to 1995, the annual global application of nitrogen fertilizer on agricultural land increased from ten million to seventy million metric tons. Phosphorus fertilization tripled and irrigation doubled.[31] The doubling of food production thus increased nitrogen application seven-fold, tripled phosphorus application, and doubled irrigation. The global use of these inputs has continued to increase: more than one hundred million metric tons of nitrogen fertilizer were applied in 2010, a rate comparable to all natural inputs of biologically available nitrogen into ecosystems.[32]

Because of agriculture, humans are now the dominant force controlling the terrestrial dynamics of the global nitrogen and phosphorus cycles.[33] Although crops capture about half of these fertilizers, the nitrogen and phosphorus not incorporated into plants can be carried by erosion or leach into aquifers, rivers, and lakes, or enter the atmosphere. The net effect is nutrient pollution of terrestrial and aquatic ecosystems. In lakes, these agricultural pollutants can, in extreme cases, ruin freshwater fisheries and cause blooms of blue-green algal species that can make the water toxic for livestock and human drinking.[34] Where large rivers drain agricultural runoff into oceans, these nutrients create massive blooms of algae and subsequent oxygen-free dead zones where fish cannot survive.[35] Moreover, irrigation of croplands accounts for about 75 percent of humanity's consumptive use of freshwater.[36] Some of the world's larger rivers have so much water removed for human use that there are years when the rivers no longer flow into their receiving oceans. In the United States, for example, the Colorado River reached the Sea of Cortez just once in the last sixteen years (in 2014).

Global use of herbicides, insecticides, and other pesticides expanded equally dramatically during the green revolution. Applications of these chemicals increased six-fold over a span of thirty-five years, from about one-half million metric tons per year in 1960 to more than three million metric tons per year by 1995.[37] Some localized pesticides are redistributed globally, both in water supplies and in the atmosphere, causing health impacts in humans, fish, birds, and mammals.

The green-revolution doubling of global food production required the clearing of one hundred fifty million hectares of cropland, which is about the size of Alaska. At the same time, about three hundred million hectares of pastureland were cleared, which is one-third the area of the United States.[38] This conversion of forests, savannas, and grasslands to agriculture destroyed high-diversity native ecosystems and replaced them with frequently disturbed systems planted with one or a few crop or pasture species. Such habitat destruction is a major threat to global biodiversity, with the risk of extinctions escalating as more land is cleared.[39]

What we eat may have a greater impact on greenhouse gas emissions than what form of transportation we use. On a global scale, agriculture accounts for more than 25 percent of total greenhouse gas emissions.[40] In contrast, all forms of transportation, including automobiles, airplanes, trains, trucks, and ships, account for only 14 percent of global emissions.[41] In terms of warming potential, expressed as the number of gigatonnes (billion tonnes) of carbon released as carbon dioxide, total agricultural emissions were about four gigatonnes in 2010, while transportation emissions were about two gigatonnes.[42]

What are the major sources of agricultural greenhouse gas emissions? The three greatest sources are methane (1.7 gigatonnes per year), nitrous oxide (1.6 gigatonnes per year), and land clearing (0.9 gigatonnes per year). Methane emissions are largely from livestock production, especially cattle and sheep. Nitrous oxide emissions mainly result from nitrogen fertilization. Land clearing releases carbon dioxide to the atmosphere when vegetation is burned or decomposed and when soil organic matter is decomposed when tilled. Additional, but smaller, emissions come from agricultural combustion of fossil fuels.

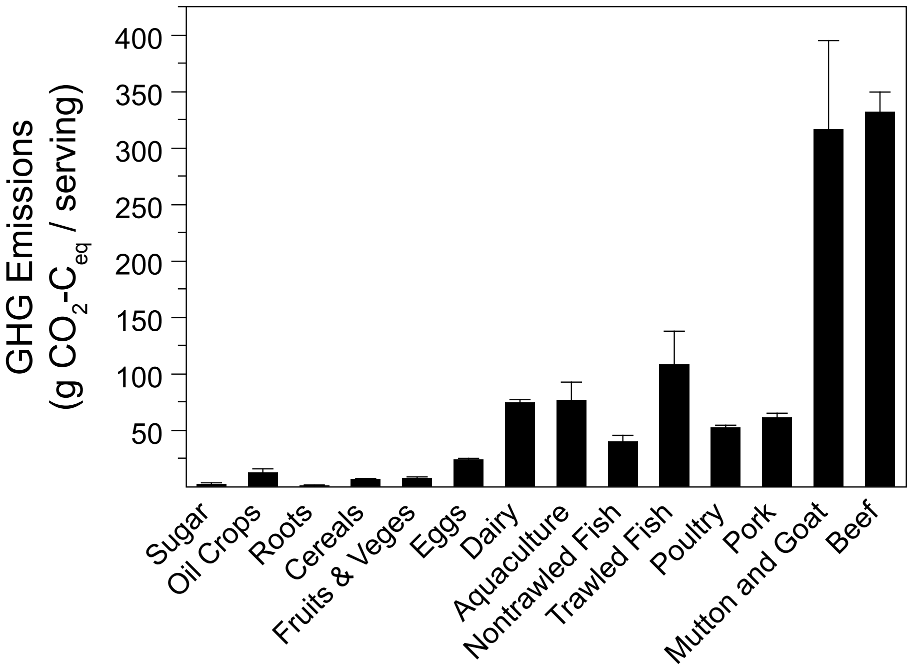
Foods differ greatly in their greenhouse gas emissions, whether these are measured per calorie, per gram of protein, or per serving.[43] Plant-based foods generally have the lowest emissions, followed by eggs, then nontrawled marine fish, then poultry, pork, dairy, and aquaculture, then trawled fish, and finally ruminant meats, including lamb, goat, and beef (Figure 2).

Contrary to popular perception, fossil fuel emissions associated with food transportation are a minor component of total agricultural greenhouse gas emissions.[44] Rather, agricultural emissions are overwhelmingly from beef and lamb production, nitrogen fertilization, and land clearing.[45] Minimizing beef and lamb consumption, eating moderate amounts of other meats and low-fat animal products, eating crops grown with moderate fertilization, and minimizing food waste are effective ways for individuals to decrease their dietary greenhouse gas emissions.

The environmental impacts of the green revolution suggest that a second doubling of global crop production might cause substantial increases in global land clearing, fertilizer use, pesticide use, and greenhouse gas emissions.[46] Analyses based on past trends, relationships, and methods and practices estimated that a 170 percent increase in nitrogen fertilization, a 140 percent increase in phosphorus fertilization, a 190 percent increase in irrigation, and a 170 percent increase in pesticide use might be required to double global food production by 2050.[47] Because these greater inputs are associated with increased yields, only a 23 percent increase in cropland and a 16 percent increase in pastureland were forecast.[48]

Doubling global crop production is also predicted to increase global agricultural greenhouse gas emissions by an amount equal to current emissions from all forms of transportation combined.[49] These increased emissions would come from methane emissions from increased production of cattle, sheep, and rice; nitrous oxide emissions from increased nitrogen fertilizer application; and increases in agricultural fossil fuel combustion. If global agriculture were to continue on its current trajectory, we have estimated that global agricultural greenhouse gas emissions from food production in 2050 would be about six gigatonnes per year: a 50 percent increase from current levels.[50]

Figure 2
Lifecycle Greenhouse Gas Emissions per USDA-Defined Serving Associated with the Production of Various Types of Crops or Animal/Livestock-Based Foods



Source: Figure uses results of hundreds of lifecycle analyses, as summarized by David Tilman and Michael Clark, "Global Diets Link Environmental Sustainability and Human Health," *Nature* 515 (2014): 518–522.

Although global agriculture seems capable of feeding ten billion people by 2050, the resulting environmental impacts – if agriculture grew along established global trajectories – would be great.[51] Moreover, the global health impacts of the nutrition transition are also serious.[52] There are, however, several major ways to reduce the environmental impacts of agriculture while still providing a fully populated Earth with healthy and nutritious diets. These include increasing crop yields, avoiding or reversing the shift to less healthy and more environmentally harmful diets, reducing crop and food waste, and using fertilizers and irrigation water more efficiently.

Much of the world's croplands produce significantly less food than their potential. The difference between the crop yields that could be obtained on a piece of land by using current technology and management techniques and the yields that are actually obtained is called the *yield gap*.[53] Nations with lower per capita incomes tend to have larger yield gaps. For instance, much of sub-Saharan Africa has maize, wheat, and rice yields that are only 20–25 percent of what could be attained in those nations using improved technologies and practices (yield gaps of 75 percent to 80 percent).[54] These yield gaps suggest that improved agronomic methods could increase the food supplies of these nations by 300–400 percent while using only the existing croplands of these nations. One reason for these immense yield gaps is that the poorest nations currently apply less than five kilograms of nitrogen fertilizer per hectare (and similarly low amounts of other inputs), whereas the richest nations apply thirty times that amount. Similarly, of the one hundred most populous nations, the fifteen nations with incomes nearest the global median income have fertilization rates that are less than half those of the fifteen richest nations, and yields that are one-third of those of the richest nations.[55]

Some analyses suggest that increasing yields in nations with large yield gaps may cause less environmental harm from greenhouse gas emissions and habitat destruction than would the clearing of natural ecosystems to create the new cropland needed to produce this amount of food at current yields.[56] For instance, green-revolution technologies doubled global crop production while only increasing global cropland by 10 percent, thus sparing millions of hectares from clearing.[57] Because of the immense amounts of greenhouse gasses that are released when land is cleared and, for several subsequent decades, tilled, the green-revolution technologies applied to existing croplands lead to lower net greenhouse gas emissions than would result from doubling crop production by simply doubling the land area being farmed.[58]

Closing the global yield gap should be a top global priority.[59] It would increase food supply in the nations that have the most malnourished people, as well as in the nations currently experiencing the most rapid increase in food demand from population growth and dietary shifts.

A recent study found that should all nations achieve yields of 95 percent of their attainable levels (a 5 percent yield gap), no new land would be needed to meet 2050 global food demand.[60] Similarly, shrinking the yield gap by using fertilizer at rates of about 80 percent of those in the richest nations, which would decrease environmental harm from overfertilization, could increase global crop production by 70 percent.[61]

In the 1960s and 1970s, the green revolution approximately doubled the maximum achievable crop yield of several major crops through crop breeding and increased fertilizer use. The rate at which global yields subsequently increased was then mainly dependent on the rate at which green-revolution crop strains and nutrient management techniques were adopted in various nations. Post–green revolution advances in breeding and agronomic techniques have led to continual increases in crop yield maxima.[62] However, the annual yield increases of three major crops – soybeans, rice, and wheat – have consistently shrunk over the past forty years, with their average annual rate of increase for 1990 to 2007 being only 0.8 percent. Moreover, yields of some crops seem to be approaching biophysical yield ceilings.[63] Wheat yields in The Netherlands, the United Kingdom, and France, which are among the highest wheat yields in the world, have not increased over the past ten to fifteen years. Similar yield plateaus were reached for rice in Korea, Indonesia, and California about fifteen to twenty years ago. These plateaus suggest that crop yields have an upper limit. But many other crops that are important elements of diets, including roots, vegetables, fruits, nonmajor cereals, and seed and oil crops, have not undergone intensive breeding programs and likely would greatly benefit from use of new breeding and agronomic techniques.

The nutrition transition is creating a global pandemic of obesity, diabetes, and heart disease that is decreasing the quality of life and increasing mortality rates for multitudes of people around the world.[64]

As per capita caloric consumption, empty calorie consumption, and meat consumption increased, global incidences of obesity, diabetes, and heart disease also increased.[65] Researchers anticipate that global rates of diet-related diseases will continue to increase as diets shift toward increased calorie, empty calorie, and meat consumption, causing noncommunicable diseases to become the world's greatest disease burden.[66]

Just as nutrition transition diets are the cause of these health problems, so can alternative diets be their solution. A diet high in vegetables and fruits, nuts and seeds, whole grains, and fish – such as the Mediterranean diet or the DASH (Dietary Approaches to Stop Hypertension) diet[67] – can offer many health benefits when compared to the diets resulting from the global nutrition transition. Consider, for instance, the health benefits of Mediterranean and vegetarian diets. Both diets have a much greater portion of their calories and protein coming from plant, rather than animal, sources. When controlling for a number of potentially confounding factors, and when compared to persons consuming the usual omnivorous diet of a given region, people who consume a Mediterranean or vegetarian diet have between 15 – 40 percent lower incidences of diabetes and 20 – 25 percent lower mortality from coronary heart disease.[68] Pescetarian diets, which basically are vegetarian diets that include seafood in place of some of the dairy and eggs, have similar health benefits.[69]

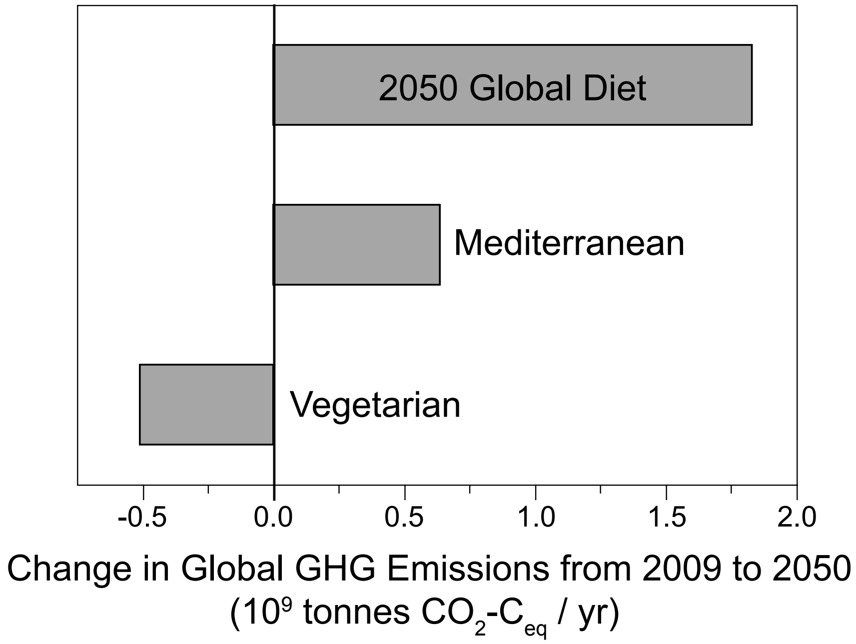
Healthier diets also provide major environmental benefits. Compared to the greenhouse gas emissions forecast to result from the nutrition transition, these alternative diets would lead to significantly lower global emissions (Figure 3) while decreasing global land clearing between now and 2050 by about five hundred million hectares.[70] The major reason for these environmental benefits is that the healthier diets involve lower consumption of empty calories and meat, and greater consumption of vegetables and fruits, thus reversing the trajectory of the nutrition transition.

Approximately one-third of global agriculture production is wasted.[71] The proportion of food waste in society tends to increase alongside its members' incomes. Further, waste tends to shift from primarily agricultural production waste toward more household food waste as incomes increase. Should all food waste be cut in half by 2050, we could reduce 2050 agricultural land use by approximately three hundred million hectares and cut greenhouse gas emissions from crop production by one-fifth.[72]

Reducing food waste in developing and developed economies is feasible. In developing economies, better crop harvesting and storage, as well as increased access to refrigeration, could reduce substantial waste.[73] In developed economies, reducing waste in retail stores and households has great promise. For instance, encouraging the use of abnormally shaped or slightly blemished produce, as is done by the French supermarket Intermarché, or incentivizing sales of foods about to reach "stale dates" can reduce waste, as could selling foods in smaller portion sizes.

Numerous studies have shown that yields can be maintained, or even improved, via more efficient use of fertilizers, irrigation, and pesticides.[74] This was demonstrated in the European Union in the 1990s upon adoption of regulations designed to increase water quality by reducing excess application of nitrogen fertilizers. Since then, crop yields in several large EU nations have continued to increase along their established temporal trajectories, but use of nitrogen fertilizer has decreased by 20 – 30 percent. These outcomes (and other studies) suggest that the environmentally detrimental impacts of agricultural fertilization can be significantly decreased without imposing a cost to crop yields.[75]

Figure 3
How Healthier Diets would Impact Future Changes in Greenhouse Gas Emissions from Agricultural Production



Using 2009 production emissions from global agriculture as the baseline (setting 2009 values to zero), emissions from the global diet that may be generated by the nutrition transition (2050 Global Diet) are compared to those if diets shifted to be either a Mediterranean or vegetarian diet. Source : Figure prepared by the authors.

Eating local or organic foods is another idea for limiting the negative environmental and health consequences of agriculture. Local and organic foods are likely to be fresher, better tasting, and biased toward vegetables and fruits. As such, they could encourage adoption of healthier diets. The greenhouse gas emissions from organic and local systems are, in general, no lower than those from conventional systems. However, if adoption of local or organic foods led to lower consumption of meat and empty calories, it could offer both health benefits and reduced greenhouse gas emissions. The extent of any such reduction, though, might be somewhat tempered by the lower yields of some organic crops.[76]

Increasing the proportion of agricultural production consumed by humans would have positive impacts on food security and the environment. Globally, about 60 percent of grain production is used as human food, 35 percent as animal feed, and 5 percent as biofuels.[77] Greater direct consumption of plant-based foods, preferential consumption of low feed-input animal-based foods such as eggs, milk, and poultry meat, and elimination of food-based biofuels would allow current crop production to feed approximately an additional one billion people without increasing agricultural land requirements, and would reduce agricultural greenhouse gas emissions.[78]

Agricultural trade among nations can also be environmentally beneficial. Because of climatic and soil conditions, different nations are better suited to produce different combinations of crops, thereby giving them a comparative advantage in their production. Trade among nations based on such comparative advantages can allow nations to produce the crops for which they have the highest relative yields and trade them internationally to meet their needs for other crops. The net effect of such trade is to increase global yields and thus decrease the amount of land and inputs needed to meet global food demand.

If the anticipated doubling in global crop production were achieved by following the agricultural trajectories of the past forty years, it would impose major environmental harm through global greenhouse gas emissions, excessive fertilizer use in developed nations, and land clearing in developing nations. Moreover, the dietary transition now underway is causing a global pandemic of noncommunicable diseases.[79] The same dietary changes that would prevent this epidemic would also prevent much environmental harm.

Food is essential for life; people will do whatever they can to obtain it. Neither nature reserves nor their fences and guards will do anything more than shift the land being cleared from one location to another. Increasing yields by shrinking or closing yield gaps could, on current cropland, meet 70 percent or more of the food demand anticipated by 2050.[80] It could save global biodiversity by reducing the need for land clearing. Indeed, it is hard to imagine any other means by which biodiversity could be saved except by decreasing the need to destroy ecosystems to grow food. Most important, the peoples of developing nations deserve adequate and nutritious diets and the health that such diets bring. They deserve secure food supply systems that can help assure stable governments and increase access to educational and economic opportunities.[81] The single most important action for meeting all of these goals is to invest in increasing yields in developing nations.

ENDNOTES

* Contributor Biographies: DAVID TILMAN, a Fellow of the American Academy since 1995, is Regents Professor and McKnight Presidential Chair in the College of Biological Sciences and Director of the Cedar Creek Ecosystem Science Reserve at the University of Minnesota. He is also Professor at the Bren School of Environmental Science and Management at the University of California, Santa Barbara. He is the author of *Functional Consequences of Biodiversity: Empirical Progress and Theoretical Extensions* (with Ann P. Kinzig and Stephen Pacala, 2002), *Plant Strategies and the Dynamics and Structure of Plant Communities* (1988), *Resource Competition and Community Structure* (1982), and more than two hundred scientific papers.

MICHAEL CLARK is a Graduate Student in the Department of Ecology, Evolution, and Behavior at the University of Minnesota. He is the author, with David Tilman, of "Global Diets Link Environmental Sustainability and Human Health," which appeared in *Nature* 515 (2014).

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