CLIMATE SCIENCE FORUM

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Diet, Health, and Climate Change

Excerpts from this issue:

Healthful Diets for People are Better for the Planet

Diets have shifted in all nations toward including more meat, refined sugars and processed foods. On reviewing evidence in the medical literature, Tilman and Clark show[1] that this shift links to increasing obesity, diabetes, heart disease and other illnesses.

Modern diets require more land, water, energy and resources per person, which ratchet up the levels of climate-warming greenhouse gases. Already, food production is responsible for 25% of all emissions of these gases. Three types of alternative diets, that reduce the health risks mentioned, can meet the future demand for food with little need to clear more land and with no additional threat to the climate.

According to earlier work by Tilman[2], the world can meet demand for food calories and protein by transferring techniques for boosting crop yields from the developed world to the least developed nations, instead of continuing current practices in each nation. Developing nations could avoid clearing new lands for agriculture by acquiring techniques for boosting soil fertility. The developed world could deliver more fertilizers or technologies to nations that most need it (*See the full story, "Feed the World" at left*).

Another way to feed everybody in 2050 is to have people choose healthful diets that reduce the burden of diet-related maladies mentioned above. These diets have more fruits and vegetables, less meat, and fewer 'empty' calories from foods having little nutritional value, like sugar and alcohol. Tilman and Clark compiled results[1] from 18 publications in which rates of type 2 diabetes, death from heart disease, some cancers, and mortality in general were lower among those who ate one of three alternative diets.

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Feed the World with Smart Farming, not with more CO_2

Demand for calories in food and feed will likely double by 2050. Under current practices, rich nations would meet the demand with more pressure on resources and more greenhouse gas emissions; the poorest nations would clear large areas of land for cultivation. By transferring techniques that have led to high-yield agriculture from the wealthy nations to the poorest, the future demand can be met without much clearing of land, and without more greenhouse gas impacts from agriculture.

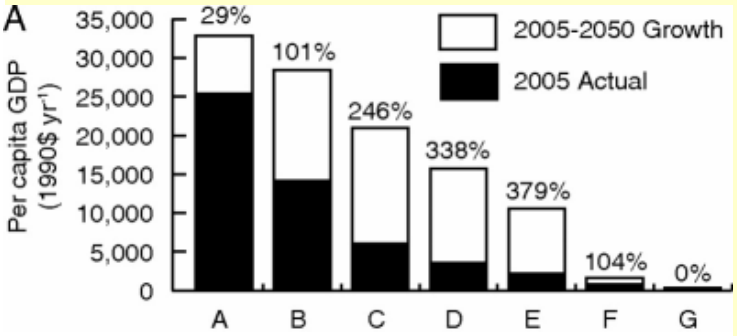

Figure A : *Gross Domestic Product (GDP) per person, in dollars ($) per year in 2005 (black), and increase expected to 2050 (white), with % increase above bar. Countries are grouped in seven categories of wealth [FROM: Tilman et al., 2011 [ref. 1 below].*

Diet and national income. Economic development permitted people in most nations to adopt diets offering more calories and protein over the last 50 years. The demand for crops (measured by calories and protein per person) in a nation's economy depends on that nation's per-capita income: David Tilman demonstrated this[1] three years ago. In one of his graphs (Figure A, above) the black bars make obvious a gap in per-capita income between the rich (group A)

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and poor nations (groups F and G). Wealthier nations also have a higher demand for "crop Calories" than poor nations do. Tilman uses the term "crop Calories"[2] to combine animal feed and human foods into one category representing the total demand for Calories in a nation's agricultural and food industries. Demand for crop Calories in seven income groups is strongly related to per-capita income: see Figure B which combines both relationships. In poor nations (purple dots), each person gets by on 2000—3000 crop Calories per day; while the highly developed nations (red dots) demanded from 6500 Calories/person fifty years ago, to 8500 Calories/person as recently as 2005.

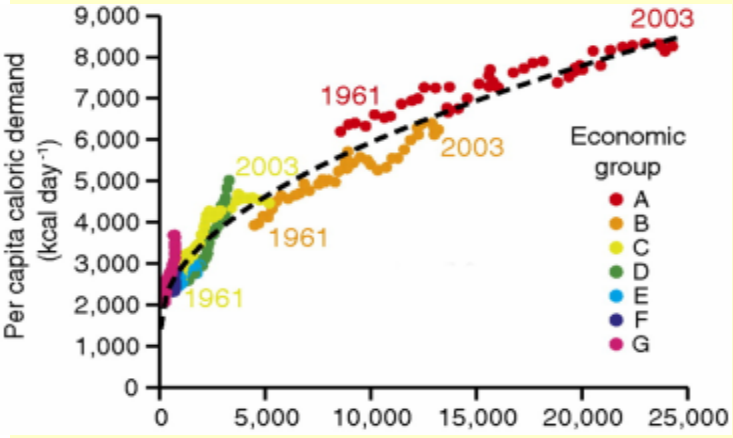

Figure B: *Per capita demand for crop Calories per day (left), which depends on per capita GDP ($, bottom) in each economic group A–G in figure A. [FROM: Tilman et al., 2011; ref. 1].*

Economic development has also permitted people to consume more meats, oils, refined sugars and processed foods. These foods need more resources (land, water, fertilizer, and energy) per serving. The dietary shift put pressure on resources, which led to more releases of greenhouse gases (GHG) per person and overall.

Tilman's goal was to forecast the environmental impact of agriculture in the year 2050, by taking stock of trends in population and economic growth, and the shift to modern diets that demand more resources. The authors then discuss ways to meet the total demand for crop Calories 35 years into the future. Some alternatives impact the Earth much less than when we "stay the course" by producing food much as we now do.

Glancing again at Figure A, we see not only huge differences in per-capita income between groups of nations (black bars), but also their projected growth to 2050 (white bars). It is not in the wealthiest nations (A), but rather in the middle-income groups B, C, D, and E, where income per person is expected to grow the most. In the poorest nations (G), income is not expected to grow at all!

Tilman estimated how a nation's yield of Calories from crops depends on its per-capita income (in groups A to G), the amount of nitrogen fertilizers applied to crops, the year, the precipitation, and more. Some 80% of the variation depends on the first four factors alone.

Demand for Calories in food and feed is expected to double by 2050; and demand for protein to more than double. The world's population is expected to go up 36% from 2009 to 2050. One billion hectares of uncultivated land would be cleared for agriculture, mainly in the less developed world. *(One hectare equals 2.5 acres.)* Because of changing diets, greenhouse gas releases would go up by 32% per person. Altogether, growing, processing, and delivering the global food basket would release 80% more greenhouse gases to the atmosphere than it now does.

The authors forecast not only the impacts if current trends continue, but how alternative strategies can meet the future food demand with less land clearing and environmental impacts.

If current trends continue in agriculture, the poorest nations will meet the need for food by clear-cutting more land to put it under cultivation. The wealthiest nations will likely follow pathways of improving fertility on existing lands and boosting yields through advances in technology, as they have done up to now.

We examine here alternatives to meet the world's demand for crops in 2050, without considering changes in dietary practices. In group A nations, yields are up to three times higher per hectare of land than in the poor nations of groups F and G. Clearly, one solution is to transfer technologies and practices that yield more food from the same land to the poor nations. That reduces pressure to clear wild land, with its many impacts on the environment.

More intense application of nitrogen fertilizers can also improve future yields without depending on better technologies. But by maintaining fertilizer application at the same intensity as now, or even less, yields would still increase 50% or more by 2050 through continuing improvements in technology, or better, transfers of technology to poorer nations.

If the world chooses a policy of avoiding the clearing of new land, yields can increase more than 50% through ambitious transfers of farming technologies and practices. In that scenario, it is possible to get the same yields even if 3 to 5 times less land were cleared, if less developed nations adopt the practices that led to high yields in the developed nations.

Climate impact. Clearing land for agriculture, cultivating it, and making and using fertilizer all release greenhouse gases, especially CO2. Tilman and Clark assert that boosting the application of nitrogen fertilizers in less developed nations will reduce, not increase, the emission of such gases, contrary to what we expect. This is because the pressure to clear new land would be dramatically scaled back. They predict lower GHG emissions from agriculture in 2050 than actually occurred in 2005, if production of nitrogen fertilizers is maintained at the current level.

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Feed the World (concludes)

Avoiding deforestation would reduce the GHG emissions by three times more than the GHG increases that result from more intense fertilizer use.

Conclusion. The future demand for Calories can best be met by ambitiously transferring techniques for boosting crop yields from wealthy nations to the least developed nations, rather than to continue current agricultural trends distinctive to each group of nations. By adopting the techniques for boosting soil fertility from the wealthy nations, developing nations would not need to clear new lands for planting. The developed world would not apply nitrogen fertilizers ever more intensively on their own farmland, as they now do, but rather deliver more fertilizers or more technology and know-how to the nations that need it most. In some scenarios, global emission of greenhouse gases from the production of food could actually decrease.

CITATIONS:

1. "Global food demand and the sustainable intensification of agriculture", by David Tilman, C. Balzer, J. Hill, and B. Befort (2011). *Proceedings of Nat. Academy of Sciences,* v. 108, 20260--20264, Dec. 13, 2011.

2. In the United States the Calorie (with capital C), commonly used in nutrition, equals 1000 calories (with small c) used in science. A Calorie is also called a kilocalorie. We follow the American usage here.

Healthful Diets are Better (continues)

The three diets are illustrated in Figure C (below): Mediterranean (rich in fish, seafood, and nuts, and containing some meats); pescetarian (fish and seafood, fruits and vegetables, but almost no meat); and vegetarian (fruits, vegetables, dairy products and eggs, but no meat nor fish). These were compared to a 'reference' diet which was a global-average, omnivorous diet in 2009. The authors used relationships between income and diet in each nation-group to calculate a global, *income-dependent diet,* as the reference for 2050.

Tilman and Clark[1] report that emissions of greenhouse gases per person will go up 32% by 2050 if this global dietary shift continues. Overall emissions for the globe go up by 80%. If alternative diets are widely chosen in the future, what are the consequences for the environment?

Food production already has a large impact on the Earth, according to Tilman, who wrote, "Dietary composition strongly influences GHG (greenhouse gas) emissions." Growing, processing and hauling food and feed is responsible for 25% of current emissions. To produce this food and feed, farms and pastures now require **one-half of the land on Earth** that is free of ice.

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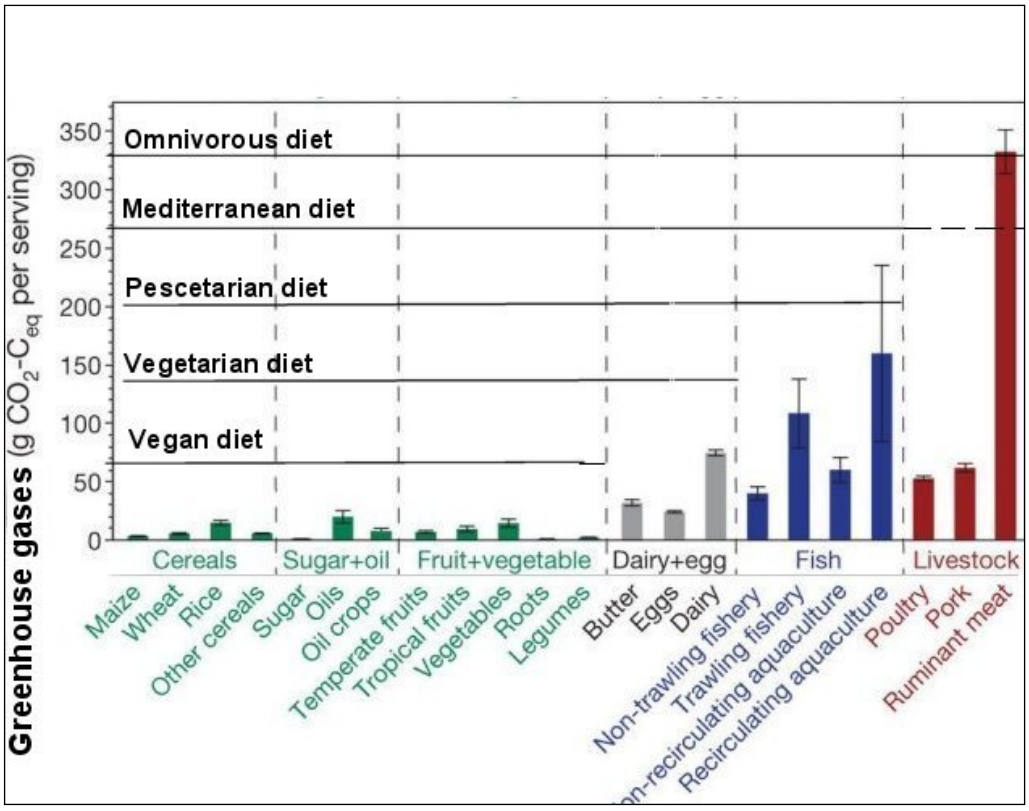

Figure C: *Emissions of Greenhouse Gases (GHG) per serving*, over the life cycle of growing and producing 22 food types. *Defined by the US Dept. of Agriculture. [FROM: Tilman and Clark., 2014 [ref. 1 below]].*

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Under "business as usual," global demand for crop Calories will double by 2050, and demand for protein will more than double. They reviewed an impressive 120 published studies from which they garnered 555 "Life Cycle Analyses" of food, feed, livestock, fisheries, and aquaculture enterprises, and their greenhouse gas emissions[3]. Some 82 foods were in their "basket."

The GHG emissions per serving (Figure C, previous page) vary tremendously among food types. Plant-based foods (in green) have much lower emissions than animal-based foods. Ruminant livestock (beef cattle and lamb) can digest grass and very fibrous plant foods in their many stomachs, but ruminants need to eat more feed to put on a pound of meat than other animals. Many ruminants also expel methane, a potent greenhouse gas, from their digestive tract.

What is less well known is that producing beef or lamb (tall red bar) yields twice the GHG emissions per serving as harvesting and producing fish does (blue bars), and many times more than pork or poultry (three red bars). Servings of dairy or eggs produce fewer emissions than a plate of fish.

How fish are caught has a large effect on GHG emissions. Catching fish in nets trawled across the seafloor produces three times more GHG than catching free-swimming fish in other ways. Among cereal grains, a serving of wheat produces 60% less GHG emissions than a serving of rice.

More people can be fed on less land and with less resources if they eat alternative diets. If for health reasons, people around the world adopt a global diet that is the average of the three alternative diets described, no additional emissions of GHG would occur (Figure D). There would be other benefits to the planet: the amount of land cleared for future cultivation would be substantially lower or even nil (Figure E).

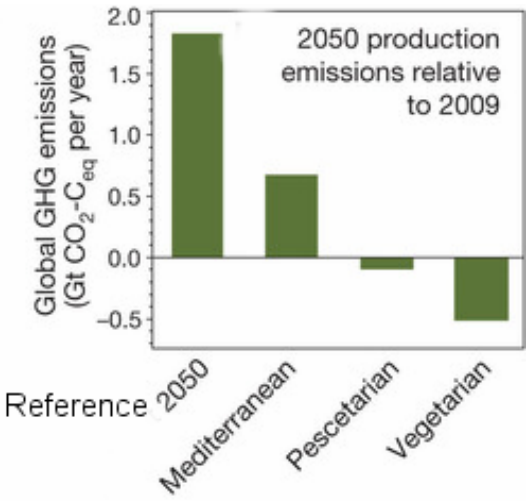

***Figure D**: Change in global GHG emissions from food production after year 2009.*
[Figures D and E from Tilman and Clark, 2014 [ref. 1].

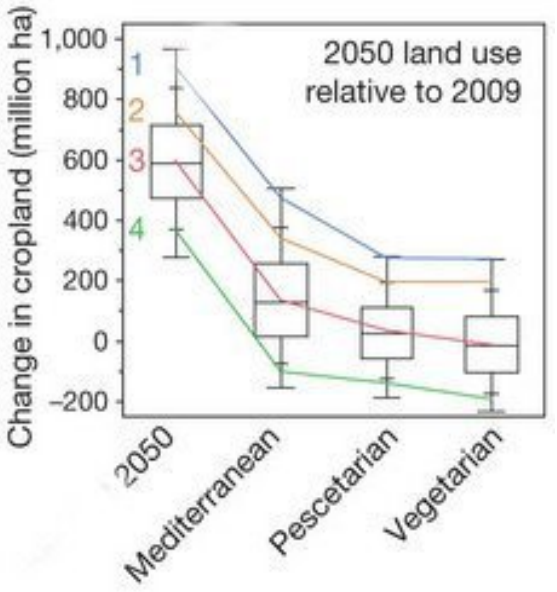

***Figure E**: Change in area of crop land needed for each diet, relative to year 2009.*

CITATIONS:

1. "Global Diets link environmental sustainability and human health"- by David Tilman and M. Clark (2014), *Nature,* 27 Dec. 2014, v. 515, 518-522, doi:10.1038/nature13959.

2. "Global food demand and the sustainable intensification of agriculture", by David Tilman, C. Balzer, J. Hill, and B. Befort (2011). *Proceedings of Nat. Academy of Sciences,* v. 108, 20260--20264, Dec. 13, 2011.

3. Greenhouse gases other than carbon dioxide (CO2) were expressed in CO2-equivalent units, abbreviated as g CO2-Ceq.