Livestock and Climate Change

© Lyle Rosbotham

What if the key actors in climate change are…

Duncan Rawlinson

cows, pigs, and chickens?

Philip MacKenzie

by Robert Goodland and Jeff Anhang

Whenever the causes of climate change are discussed, fossil fuels top the list. Oil, natural gas, and especially coal are indeed major sources of human-caused emissions of carbon dioxide (CO_2) and other greenhouse gases (GHGs). But we believe that the life cycle and supply chain of domesticated animals raised for food have been vastly underestimated as a source of GHGs, and in fact account for at least half of all human-caused GHGs. If this argument is right, it implies that replacing livestock products with better alternatives would be the best strategy for reversing climate change. In fact, this approach would have far more rapid effects on GHG emissions and their atmospheric concentrations—and thus on the rate the climate is warming—than actions to replace fossil fuels with renewable energy.

Livestock are already well-known to contribute to GHG emissions. *Livestock's Long Shadow,* the widely-cited 2006 report by the United Nations Food and Agriculture Organization (FAO), estimates that 7,516 million metric tons per year of CO_2 equivalents (CO_2e), or 18 percent of annual worldwide GHG emissions, are attributable to cattle, buffalo, sheep, goats, camels, horses, pigs, and poultry. That amount would easily qualify livestock for a hard look indeed in the search for ways to address climate change. But our analysis shows that livestock and their byproducts actually account for *at least* 32,564 million tons of CO_2e per year, or 51 percent of annual worldwide GHG emissions.

This is a strong claim that requires strong evidence, so we will thoroughly review the direct and indirect sources of GHG emissions from livestock. Some of these are obvious but underestimated, some are simply overlooked, and some are emissions sources that are already counted but have been assigned to the wrong sectors. Data on livestock vary from place to place and are affected by unavoidable imprecision; where it was impossible to avoid imprecision in estimating any sum of GHGs, we strove to minimize the sum so our overall estimate could be understood as conservative.

The Big Picture

The table to the right summarizes the categories of livestock-based emissions and our estimates of their size. We begin with the FAO's 7,516 million tons of CO_2e per year attributable to livestock, an amount established by adding up GHG emissions involved in clearing land to graze livestock and grow feed, keeping livestock alive, and processing and transporting the end products. We show that 25,048 million tons of CO_2e attributable to livestock have been undercounted or overlooked; of that subtotal, 3,000 million tons are misallocated and 22,048 million tons are entirely uncounted. When uncounted tons are added to the global inventory of atmospheric GHGs, that inventory rises from 41,755 million tons to 63,803 million tons. FAO's 7,516 million tons of CO_2e attributable to livestock then decline from 18 percent of worldwide GHGs to 11.8 percent. Let's look at each category of uncounted or misallocated GHGs:

Breathing. The FAO excludes livestock respiration from its estimate, per the following argument:

> Respiration by livestock is not a net source of CO_2.... Emissions from livestock respiration are part of a rapidly cycling biological system, where the plant matter consumed was itself created through the conversion of atmospheric CO_2 into organic compounds. Since the emitted and absorbed quantities are considered to be equivalent, livestock respiration is not considered to be a net source under the Kyoto Protocol. Indeed, since part of the carbon consumed is stored in the live tissue of the growing animal, a growing global herd could even be considered a carbon sink. The standing stock livestock biomass increased significantly over the last decades.... This continuing growth...could be considered as a carbon sequestration process (roughly estimated at 1 or 2 million tons carbon per year).

But this is a flawed way to look at the matter. Examining the sequestration claim first: Sequestration properly refers to extraction of CO_2 from the atmosphere and its burial in a vault or a stable compound from which it cannot escape over a long period of time. Even if one considers the standing mass of livestock as a carbon sink, by the FAO's own estimate the amount of carbon stored in livestock is trivial compared to the

Uncounted, Overlooked, and Misallocated Livestock-related GHG Emissions

	Annual GHG emissions (CO_2e)	Percentage of worldwide total
	million tons	
FAO estimate	7,516	11.8
Uncounted in current GHG inventories:		
1. Overlooked respiration by livestock	8,769	13.7
2. Overlooked land use	≥2,672	≥4.2
3. Undercounted methane	5,047	7.9
4. Other four categories (see text)	≥5,560	≥8.7
Subtotal	≥22,048	≥34.5
Misallocated in current GHG inventories:		
5. Three categories (see text)	≥3,000	≥4.7
Total GHGs attributable to livestock products	≥32,564	≥51.0

Beatrice Murch

Cows respire on a cold morning at a cattle market in Buenos Aires, Argentina.

amount stored in forest cleared to create space for growing feed and grazing livestock.

More to the point, livestock (like automobiles) are a human invention and convenience, not part of pre-human times, and a molecule of CO_2 exhaled by livestock is no more natural than one from an auto tailpipe. Moreover, while over time an equilibrium of CO_2 may exist between the amount respired by animals and the amount photosynthesized by plants, that equilibrium has never been static. Today, tens of billions more livestock are exhaling CO_2 than in pre-industrial days, while Earth's photosynthetic capacity (its capacity to keep carbon out of the atmosphere by absorbing it in plant mass) has declined sharply as forest has been cleared. (Meanwhile, of course, we add more carbon to the air by burning fossil fuels, further overwhelming the carbon-absorption system.)

The FAO asserts that livestock respiration is not listed as a recognized source of GHGs under the Kyoto Protocol, although in fact the Protocol does list CO_2 with no exception, and "other" is included as a catchall category. For clarity, it should be listed separately in whatever protocol replaces Kyoto.

It is tempting to exclude one or another anthropogenic source of emissions from carbon accounting—according to one's own interests—on the grounds that it is offset by photosynthesis. But if it is legitimate to count as GHG sources fossil-fuel-driven automobiles, which hundreds of millions of people do not drive, then it is equally legitimate to count livestock respiration. Little or no livestock product is consumed by hundreds of millions of humans, and no livestock respiration (unlike human respiration) is needed for human survival. By keeping GHGs attributable to livestock respiration off GHG balance sheets, it is predictable that they will not be managed and their amount will increase—as in fact is happening.

Carbon dioxide from livestock respiration accounts for 21 percent of anthropogenic GHGs worldwide, according to a 2005 estimate by British physicist Alan Calverd. He did not provide the weight of this CO_2, but it works out to about 8,769 million tons. Calverd's estimate is the only original estimate of its type, but because it involves only one variable (the total mass of all livestock, as all but cold-blooded farmed fish exhale roughly the same amount of CO_2 per kilogram), all calculations of CO_2 from the respiration of a given weight of livestock would be about the same.

Calverd's estimate did not account for the fact that CO_2 from livestock respiration is excluded from global GHG inventories. It also did not account for the GHGs newly attributed to livestock in our analysis. After adding all relevant GHGs to global GHG inventories, the percentage of GHGs attributable to livestock respiration drops from 21 percent to 13.7 percent.

Land. As there is now a global shortage of grassland, practically the only way more livestock and feed can be produced

USDA/NRCS, Jeff Vanuga

A Kansas feedlot operation with waste management lagoon in the foreground.

is by destroying natural forest. Growth in markets for livestock products is greatest in developing countries, where rainforest normally stores at least 200 tons of carbon per hectare. Where forest is replaced by moderately degraded grassland, the tonnage of carbon stored per hectare is reduced to 8.

On average, each hectare of grazing land supports no more than one head of cattle, whose carbon content is a fraction of a ton. In comparison, over 200 tons of carbon per hectare may be released within a short time after forest and other vegetation are cut, burned, or chewed. From the soil beneath, another 200 tons per hectare may be released, with yet more GHGs from livestock respiration and excretions. Thus, livestock of all types provide minuscule carbon "piggybanks" to replace huge carbon stores in soils and forests. But if the production of livestock or crops is ended, then forest will often regenerate. The main focus in efforts to mitigate GHGs has been on reducing emissions, while—despite its ability to mitigate GHGs quickly and cheaply—vast amounts of potential carbon absorption by trees has been foregone.

The FAO counts emissions attributable to changes in land use due to the introduction of livestock, but only the relatively small amount of GHGs from changes each year. Strangely, it does not count the much larger amount of annual GHG reductions from photosynthesis that are foregone by using 26 percent of land worldwide for grazing livestock and 33 percent of arable land for growing feed, rather than allowing it to regenerate forest. By itself, leaving a significant amount of tropical land used for grazing livestock and growing feed to regenerate as forest could potentially mitigate *as much as half (or even more) of all anthropogenic GHGs.* A key reason why this is not happening is that reclaiming land used for grazing livestock and growing feed is not yet a priority; on the contrary, feed production and grazing have been fast expanding into forest.

Or suppose that land used for grazing livestock and growing feed were used instead for growing crops to be converted more directly to food for humans and to biofuels. Those fuels could replace one-half of the coal used worldwide, which is responsible for about 3,340 million tons of CO_2e emissions every year. That tonnage represents 8 percent of GHGs in worldwide GHG inventories that omit the additional GHGs assessed by this article, or 5.6 percent of GHGs worldwide when the GHGs assessed in this article are included. If biomass feedstocks are chosen and processed carefully, then biofuels can yield 80 percent less GHGs per unit of energy than coal. Therefore, the extra emissions resulting from using land for livestock and feed can be estimated to be 2,672 million tons of CO_2e, or 4.2 percent of annual GHG emissions worldwide.

Considering these two plausible scenarios, at least 4.2 percent of worldwide GHGs should be counted as emissions attributable to GHG reductions foregone by using land to graze livestock and grow feed.

Methane. According to the FAO, 37 percent of human-induced methane comes from livestock. Although methane warms the atmosphere much more strongly than does CO_2, its half-life in the atmosphere is only about 8 years, versus at least 100 years for CO_2. As a result, a significant reduction in livestock raised worldwide would reduce GHGs relatively quickly compared with measures involving renewable energy and energy efficiency.

The capacity of greenhouse gases to trap heat in the atmosphere is described in terms of their global warming potential (GWP), which compares their warming potency to that of CO_2 (with a GWP set at 1). The new widely accepted figure for the GWP of methane is 25 using a 100-year timeframe—but it is 72 using a 20-year timeframe, which is more appropriate because of both the large effect that methane reductions can have within 20 years and the serious climate disruption expected within 20 years if no significant reduction of GHGs is achieved. The Intergovernmental Panel on Climate Change supports using a 20-year timeframe for methane.

The FAO estimates that livestock accounted for 103 million tons of methane emissions in 2004 through enteric fermentation and manure management, equivalent to 2,369 million tons of CO2e. This is 3.7 percent of worldwide GHGs using, as FAO does, the outdated GWP of 23. Using a GWP of 72, livestock methane is responsible for 7,416 million tons of CO_2e or 11.6 percent of worldwide GHGs. So using

the appropriate timeframe of 20 years instead of 100 years for methane raises the total amount of GHGs attributable to livestock products by 5,047 million tons of CO_2e or 7.9 percentage points. (Further work is needed to recalibrate methane emissions other than those attributable to livestock products using a 20-year timeframe.)

Other sources. Four additional categories of GHGs adding up to at least 5,560 million tons of CO_2e (8.7 percent of GHGs emissions) have been overlooked or undercounted by the FAO and uncounted in the existing inventory of worldwide GHGs:

First, *Livestock's Long Shadow* cites 2002 FAO statistics as the key source for its 18-percent estimate. From 2002 to 2009, the tonnage of livestock products worldwide increased by 12 percent, which must yield a proportional increase in GHG emissions. Through extrapolation from the FAO's estimate as well as our own, we calculate that the increase in livestock products worldwide from 2002 to 2009 accounts for about 2,560 million tons of CO_2e, or 4.0 percent of GHG emissions.

Second, the FAO and others have documented frequent undercounting in official statistics of both pastoral and industrial livestock. *Livestock's Long Shadow* not only uses no correction factor for such undercounting, but in some sections actually uses lower numbers than appear in FAO statistics and elsewhere. For example, *Livestock's Long Shadow* reports that 33.0 million tons of poultry were produced worldwide in 2002, while FAO's *Food Outlook* of April 2003 reports that 72.9 million tons of poultry were produced worldwide in 2002. The report also states that 21.7 billion head of livestock were raised worldwide in 2002, while many nongovernmental organizations report that about 50 billion head of livestock were raised each year in the early 2000s. If the true number is closer to 50 billion than to 21.7 billion, then the percentage of GHGs worldwide attributable to undercounting in official livestock statistics would likely be over 10 percent.

Third, the FAO uses citations for various aspects of GHGs attributable to livestock dating back to such years as 1964, 1982, 1993, 1999, and 2001. Emissions today would be much higher.

Fourth, the FAO cites Minnesota as a rich source of data. But if these data are generalized to the world then they understate true values, as operations in Minnesota are more efficient than operations in most developing countries where the livestock sector is growing fastest.

Finally, we believe that FAO has overlooked some emissions that have been counted under sectors other than livestock. These emissions add up to at least 3,000 million tons of CO_2e, or 4.7 percent of GHG emissions worldwide.

USDA/NRCS, Bob Nichols

Adding more to the carbon footprint: large fans keep pigs cool in North Carolina.

First, the FAO states that "livestock-related deforestation as reported from, for example, Argentina is excluded" from its GHG accounting. Second, the FAO omits farmed fish from its definition of livestock and so fails to count GHGs from their life cycle and supply chain. It also omits GHG emissions from portions of the construction and operation of marine and land-based industries dedicated to handling marine organisms destined to feed livestock (up to half the annual catch of marine organisms).

Lastly, the FAO leaves uncounted the substantially higher amount of GHGs attributable to each of the following aspects of livestock products versus alternatives to livestock products:

- Fluorocarbons (needed for cooling livestock products much more than alternatives), which have a global warming potential up to several thousand times higher than that of CO_2.
- Cooking, which typically entails higher temperatures and longer periods for meat than alternatives, and in developing countries entails large amounts of charcoal (which reduces carbon absorption by consuming trees) and kerosene, each of which emits high levels of GHGs.
- Disposal of inevitably large amounts of liquid waste from livestock, and waste livestock products in the form of bone, fat, and spoiled products, all of which emit high amounts of GHGs when disposed in landfills, incinerators, and waterways.
- Production, distribution, and disposal of byproducts, such as leather, feathers, skin, and fur, and their packaging.
- Production, distribution, and disposal of packaging used for livestock products, which for sanitary reasons is much

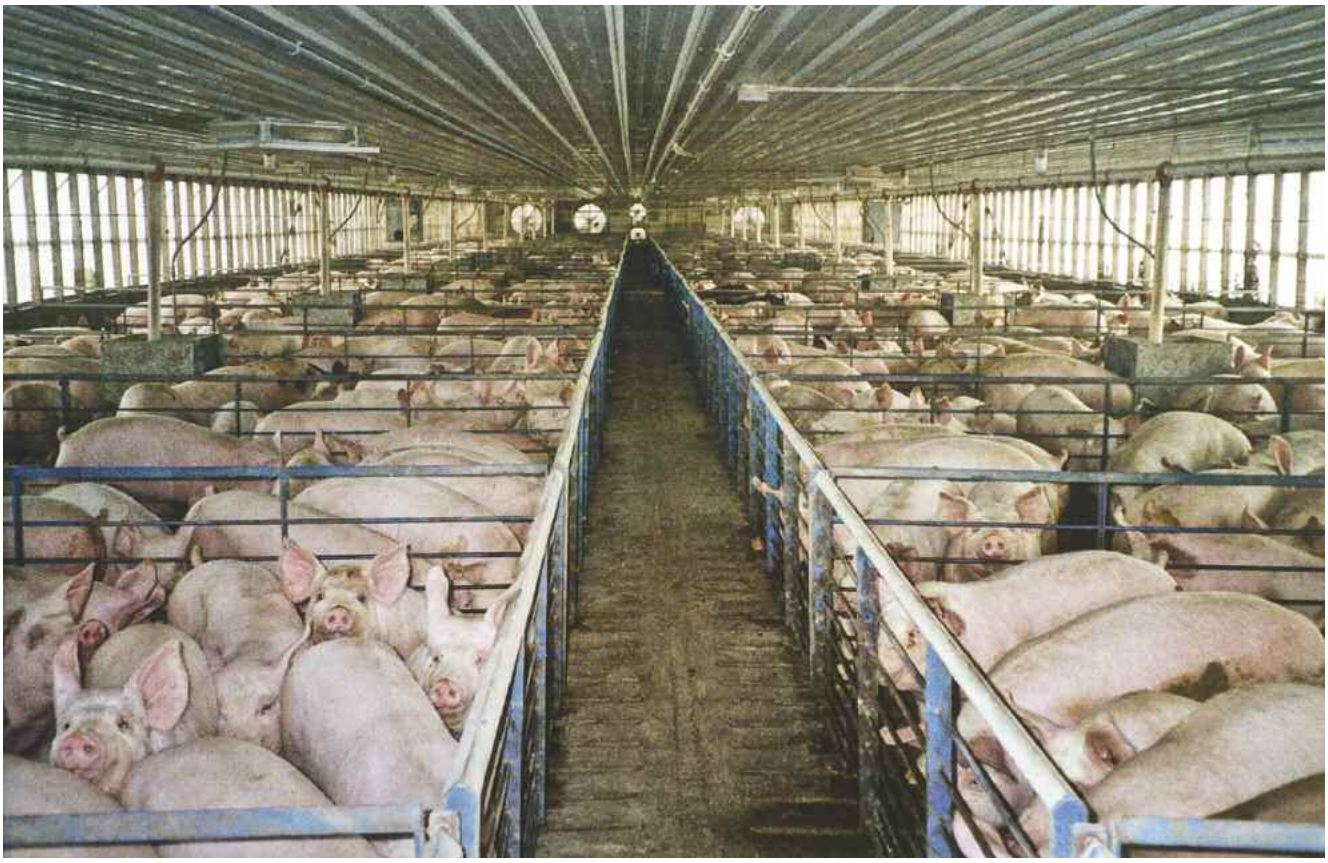

Photo courtesy Farm Sanctuary

Scene on the factory floor: pigs in production.

more extensive than for alternatives to livestock products.

- Carbon-intensive medical treatment of millions of cases worldwide of zoonotic illnesses (such as swine flu) and chronic degenerative illnesses (such as coronary heart disease, cancers, diabetes, and hypertension leading to strokes) linked to the consumption of livestock products. Full accounting of GHGs attributable to livestock products would cover portions of the construction and operation of pharmaceutical and medical industries used to treat these illnesses.

Mitigation

A key risk factor for climate change is the growth of the human population, projected to be roughly 35 percent between 2006 and 2050. In the same period, the FAO projects that the number of livestock worldwide will double, so livestock-related GHG emissions would also approximately double (or rise slightly less if all the FAO's recommendations were fully implemented), while it is widely expected that GHGs from other industries will drop. This would make the amount of livestock-related emissions even more unacceptable than today's perilous levels. It also means that an effective strategy must involve replacing livestock products with better alternatives, rather than substituting one meat product with another that has a somewhat lower carbon footprint.

A substantial body of theory, beliefs, and even vested interest has been built up around the idea of slowing climate change through renewable energy and energy efficiency. However, after many years of international climate talks and practical efforts, only relatively modest amounts of renewable energy and energy efficiency have been developed (along with more nuclear- and fossil-energy infrastructure). GHG emissions have *increased* since the Kyoto Protocol was signed in 1992 and climate change has accelerated. However desirable, even major progress in displacing nonrenewable energy would not obviate substantial action to reduce the huge amounts of livestock-related GHGs emissions.

Action to replace livestock products not only can achieve quick reductions in atmospheric GHGs, but can also reverse the ongoing world food and water crises. Were the recommendations described below followed, at least a 25-percent reduction in livestock products worldwide could be achieved between now and 2017, the end of the commitment period to be discussed at the United Nations' climate conference in Copenhagen in December 2009. This would yield at minimum a 12.5-percent reduction in global anthropogenic GHGs emissions, which by itself would be almost as much reduction as is generally expected to be negotiated in Copenhagen.

Because of the urgency of slowing climate change, we believe that recommending change directly to industry will be more effective than recommending policy changes to governments, which may or may not eventually lead to change in

Lyle Rosbotham

Non-meat meat. Alternative ingredients include textured soy protein, soy lecithin, brown rice, ground sunflower seeds, mycoprotein, and wheat gluten.

industry. This is true even though industry and investors normally thrive when they are responsive to customers and shareholders in the short term, while climate seems to pose longterm risks.

Livestock-related GHGs could be managed by governments through the imposition of carbon taxes (despite opposition from the livestock industry), in which case leaders in the food industry and investors would search for opportunities that such carbon taxes would help create. In fact, they might seek to benefit from such opportunities even in the absence of carbon taxes because livestock-related GHG emissions are a grave risk to the food industry itself. Disruptive climate events are forecast to threaten developed markets increasingly, and to result in even more harm to emerging markets, where the food industry is otherwise forecast to achieve its greatest growth.

Opportunity

An individual food company has at least three incentives to respond to the risks and opportunities applicable to the food industry at large. The first incentive is that individual food companies already suffer from disruptive climate events, so a company's self-interest might well be served by acting to slow climate change. In affected areas, disruptive climate events can be expected to degrade not only the food industry's markets, but also its infrastructure and its ability to operate. For example, all these risks played out in the New Orleans area in 2005 following Hurricane Katrina, when Whole Foods Market, Inc. reported US$16.5 million in losses that year due to the closure of its damaged stores in the New Orleans area, loss of sales, and renovations at the damaged stores. Such risks will be aggravated by extreme climate events in the future, which are expected to occur with increasing frequency and intensity worldwide.

A second incentive stems from the likelihood, once the current economic crisis is resolved, that demand for oil will rise to levels impossible to meet because of a terminal decline in production (the "peak oil" phenomenon). Petroleum's price will spike so high as to bring about the collapse of many parts of today's economy. Livestock products would take an extra hit because every gram of biofuel from crops that can possibly be produced to replace conventional fuel likely will be produced—and thereby diverted from livestock—in efforts to stave off disaster. It has been predicted from within both the livestock and financial sectors that peak oil could bring about the collapse of the livestock sector within a few years. To be ahead of the competition in that scenario is another reason for leaders in the food industry to begin replacing livestock products with better alternatives immediately.

A third incentive is that a food company can produce and market alternatives to livestock products that taste similar, but are easier to cook, less expensive, and healthier, and so are better than livestock products. These alternatives are analogs to livestock products such as soy- and seitan (wheat gluten) beef, chicken, and pork; and soy- and rice milk, cheese, and ice cream.

Sales in the United States alone of soy analogs totaled $1.9 billion in 2007, up from $1.7 billion in 2005, according to the

Soyfoods Association of North America. In comparison, sales in the United States of meat products (including poultry) topped $100 billion in 2007. This 1.9 to 100 ratio suggests much room for growth in sales of meat and dairy analogs. Meat and dairy analogs are already sold throughout the developing world, and as in the United States sales have increased in recent years. So efforts to increase sales of these products in developing countries do not have to wait for similar efforts to succeed in the developed world first. Worldwide, the market for meat and dairy analogs is potentially almost as big as the market for livestock products.

Large organic-food companies might find these opportunities especially appealing. Such companies could establish subsidiaries to sell meat and dairy analogs, possibly exclusive of meat or dairy products. They could significantly scale up production and sales of analogs within a few years at a reasonable capital cost and with an attractive return on investment. And because meat and dairy analogs are produced without the GHG-intensive processes used in raising livestock—such as animals' CO_2 and methane emissions, and usage of land for growing feed and grazing livestock—the analogs clearly generate a small fraction of the GHGs attributable to livestock products. So additional revenues might be captured from the sale of carbon credits for the reduction in GHG emissions achieved by analogs versus livestock products.

Analogs are most indistinguishable from meat and dairy products when they are chopped, breaded, sauced, spiced, or otherwise processed, so among the least risky strategies might be for a company subsidiary to build a chain of fast-food outlets featuring soy burgers, soy chicken products, sandwiches made with various meat analog products, and/or soy ice cream. If the chain's growth were rapid, then other food companies would be tempted to copy from the first mover.

If production of meat and dairy analogs is significantly increased, then their costs will decline—a key advantage for at least as long as the present economic recession in many countries persists. Cost reductions will follow from economies of scale and increased competition among analog producers, as well as because the primary feedstock for biodiesel is soy oil. Meeting the significantly higher forecast demand for biodiesel will yield surpluses of soy meal, which is not only a byproduct of soy oil but a raw material for many meat and dairy analogs. Surpluses in stocks of soy meal may drive down its price significantly.

For consumers who do not like meat and dairy analogs, protein-rich legumes and grains are readily available alternatives. Another option might be artificial meat cultivated in laboratories from cells originating from livestock, sometimes called "in vitro" meat. Some experiments have been done and patents registered, but production and possible commercialization are several years off and it will be awhile before it is known whether in vitro meat might compete with analogs in cost and taste as well as health and environmental impacts.

Marketing

To achieve the growth discussed above will require a significant investment in marketing, especially since meat and dairy analogs will be new to many consumers. A successful campaign would avoid negative themes and stress positive ones. For instance, recommending that meat not be eaten one day per week suggests deprivation. Instead, the campaign should pitch the theme of eating all week long a line of food products that is tasty, easy to prepare, and includes a "superfood," such as soy, that will enrich their lives. When people hear appealing messages about food, they are listening particularly for words that evoke comfort, familiarity, happiness, ease, speed, low price, and popularity. Consequently, several other themes should be tapped to build an effective marketing campaign:

By replacing livestock products with analogs, consumers can take a single powerful action collectively to mitigate most GHGs worldwide. Labeling analogs with certified claims of the amount of GHGs averted can give them a significant edge.

Analogs are less expensive, less wasteful, easier to cook, and healthier than livestock products.

Meat and dairy analogs can be positioned as clearly superior to livestock products, thus appealing to the same consumer urges that drive purchases of other analog products, such as Rolex knockoffs.

In developing countries, where per-capita meat and dairy consumption is lower than in developed countries, consumers often see meat and dairy products as part of a better diet and a better life, and have not yet been informed about their adverse impacts. Yet meat and dairy analogs can yield even better outcomes, particularly if they are marketed with such intent.

As shown by the track record of green businesses, the most appropriate target of the campaign would be environmentalists, on the basis that eating meat and dairy analogs is the best way to combat climate change. They can be expected to spread such messages to other people, and may press for analogs to be served at meetings they attend and for the GHGs thereby avoided to be well publicized.

Probably most susceptible to messages about new foods and fast foods are children, who are prone to act on advertising, having less-ingrained habits than adults, and often seek to catch the wave of a new trend. Parents often join in eating a fast food meal or other food product that their children insist be bought for them. At the same time, children are being increasingly educated on climate change in school, and are searching for activities that allow them to experiment with what they have learned. Yet they are major targets when it comes to marketing livestock products, despite the grievously high climate risk of those products. To correct this, consideration should be given to changing applicable standards for marketing to children. In any event, marketing

Non-dairy dairy: an array of soy milk options.

meat and dairy analogs to children should be a priority.

In addition, food companies can market meat and dairy analogs through strategic alliances with other companies. They can engage with schools, governments, and nongovernmental organizations. Environmentalists with relevant skills can be called upon to conduct ongoing, comprehensive tracking of GHGs attributable to livestock products and analogs. Politicians and celebrities can be enlisted to make public pitches for consumers to choose alternatives to livestock products.

We recommend that when grocers plan displays and set slotting fees (for favorable shelf placement), they consider the benefits of displaying analogs side by side with meat and dairy products. This would expose analogs to many consumers who may not otherwise be exposed to them, and thereby facilitate an increase in their sales. It would permit the achievement of good sales results that normally occur when consumers are shown multiple forms of a product on the same shelf. Where analogs cost less than meat products, displaying one beside the other may have an enhanced benefit for grocers. That is, if consumers find in a side-by-side comparison that analogs are cheaper than livestock products, then side-by-side placement may help grocers keep up their overall sales volumes in an economic downturn.

Sources of Investment

A company with a sound plan for increasing sales of meat or dairy analogs is likely to find sufficient commercial financing available from investors seeking investment opportunities that promise to help slow climate change. It may also find concessional financing through development finance institutions and "climate funds." But it may need to raise awareness among investors unfamiliar with meat and dairy analogs.

Investors can be shown that it is in their self-interest to avoid new investments in the production of meat and dairy products and to seek investments in analogs instead. Compared with power and transportation projects, analog projects can be implemented quickly, with relatively low levels of incremental investment, larger amounts of GHGs mitigated for the same amount of investment, and faster returns on investment.

Investments in minimizing and mitigating GHGs most often focus on renewable energy in the transportation and power sectors. However, renewable-energy infrastructure has both long and complex product-development cycles and capital-intensive requirements. Converting vehicle fleets and power plants is forecast to cost trillions of dollars, and to require political will and consensus that do not appear close at hand. Even if money and politics were up to the task, such solutions are expected to take more than a decade to implement fully, by which time the tipping point may long since have been passed for irreversible climate disruption.

Most commercial banks, some export-credit agencies, and even some equity funds have adopted the Equator Principles, by which they commit to complying with a set of rigorous environmental and social performance standards for invest-

Scott Robinson

The mighty analog: soybeans await harvest on a Maryland farm.

ment projects in developing countries. If those standards were to frown upon investments in large-scale livestock projects, then a company with a meat or dairy analog project would be well positioned to attract investments.

Benefit Package

Meat and dairy analog projects will not only slow climate change but also help ease the global food crisis, as it takes a much smaller quantity of crops to produce any given number of calories in the form of an analog than a livestock product. Analogs would also alleviate the global water crisis, as the huge amounts of water necessary for livestock production would be freed up. Health and nutritional outcomes among consumers would be better than from livestock products. Analog projects would be more labor intensive than livestock projects, so would create both more jobs and more skilled jobs. They would also avert the harmful labor practices found in the livestock sector (but not in analog production), including slave labor in some areas such as the Amazon forest region. Workers producing livestock products can easily be retrained to produce analogs.

Of course, some livestock will continue to be raised, especially where they are important in mixed farming systems. They may also be important where raising livestock is one of the few ways for poor rural populations to create assets and earn income. However, that is increasingly less common, as the dramatic growth in recent years in the use of computers, mobile communications, mobile banking, microfinance, and off-grid electricity has created a multitude of new opportunities for poor rural communities.

For many years, advocacy of alternatives to livestock products has been based on arguments about nutrition and health, compassion for animals, and environmental issues other than carbon intensity. These arguments have mostly been ignored and the consumption of livestock products worldwide has increased, leading some to believe that such advocacy may never succeed. Even urging governments to mandate reductions in livestock production on grounds of climate change may prove ineffective because of the food industry's own large lobbying capacity. But if the business case for meat and dairy analogs is clear, then those who normally would lobby governments can appeal directly to leaders in the food industry, who may welcome them as champions. The business risks of analog projects would be similar to those in most other food manufacturing projects, but the risks would be mitigated by the fact that much of the necessary infrastructure (such as for growing and processing grains) already exists.

The key change would be a significant reduction in livestock products. Industry-led or supply-led growth has been successful in other industries, such as the computer and mobile-phone industries, which suggests that it can be successful with meat and dairy analogs. Generally, the food industry worldwide has a very sophisticated marketing capacity, making high growth from marketing new food products practically a norm —even before one considers the extra lift that might be achieved from interest in slowing climate change.

The risks of business as usual outweigh the risks of change. The case for change is no longer only a public policy or an ethical case, but is now also a business case. We believe it is the best available business case among all industries to reverse climate change quickly.

Robert Goodland *retired as lead environmental adviser at the World Bank Group after serving there for 23 years. In 2008 he was awarded the first Coolidge Memorial Medal by the IUCN for outstanding contributions to environmental conservation.* Jeff Anhang *is a research officer and environmental specialist at the World Bank Group's International Finance Corporation, which provides private-sector financing and advice in developing countries.*

For more information about issues raised in this story, visit **www.worldwatch.org/ww/livestock**.