

# “Environmental Risk and Opportunity for China and the World”

## Keynote speech for

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#### Introduction

I'd like to talk with you about environmental risk in our world. In particular, I'd like to talk with you about a grave, largely overlooked risk to our environment – which very quickly becomes a grave risk to China and to the Chinese people. It is not an academic risk, but a very real one. And a precisely parallel area of opportunity complements it.

I'll start by setting out some basic facts on climate change, and some common misconceptions. Next I'll provide some risk analysis, describe some pragmatic opportunity for reversing climate change, and finish with some brief conclusions.

In December 2010, world leaders convened in Cancun to agree on a new international treaty to stop global warming – but they failed. A similar summit in December 2009 Copenhagen also failed. Since then, China has experienced its worst climate disruption ever. Last summer, temperatures hit new highs in seventeen countries. The previous record was in 2007, with new highs in fourteen countries. So the trend is in the wrong direction. Worst of all, most climate experts estimate that few years remain before climate change becomes irreversibly catastrophic.

Yet China has been a leader in acting to address the world's climate crisis.<sup>2</sup> For example, while the world strains each year to accommodate about 80 million more people along with new greenhouse gas (GHG) emissions for which they are inevitably responsible, China leads the world in taking measures to stabilize population. Were other countries to follow China's example in offering family planning and choice, the world's climate crisis would be greatly eased.

China's new Five-Year Plan promises to accelerate China's “green transition,” which will be critical in enabling China to implement its target of a 40 to 45 percent reduction in GHG-intensity by 2020. Most commendably, this Five-Year Plan proposes a carbon tax, which will provide a mix of economic incentives and rewards for industries and individuals to address climate priorities. Such a tax promises to accelerate the phase-out of coal over the long term.

China will continue to be a world leader if it successfully acts on its goals. But even if it does, it will be insufficient to prevent climate disruption. And unfortunately, while climate disruption is predicted to cause grave harm to all countries, the country predicted to endure the most harm is China, at least according to one recent comprehensive study.<sup>3</sup>

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<sup>2</sup> Ng, 2011.

<sup>3</sup> Wheeler, 2011.

Now I'll briefly list a few common beliefs that are actually misconceptions. It is commonly believed that the only way to stop global warming is for the world to set as its highest short-term priority the replacement of fossil fuel usage with renewable energy and energy efficiency – even though this path has been pursued for twenty years with little success. This has led to another misconception – which is that world is now locked into climate catastrophe, which destines the Chinese people to be victims of GHG emissions attributable largely to rampant Western consumerism. I'll describe several other misconceptions in the course of this presentation.

## **Risk Analysis**

A frightening risk of climate warming is that a one degree Celsius rise in temperature above optimum in a growing season is said to cause a 10% decline in grain yields.<sup>4</sup> This is already happening in some regions. Yet some eminent experts are warning of a catastrophic four degree Celsius rise in global temperature this century.<sup>5</sup> Preventing this is a priority for the world, in part because of the decline in grain yields that such rise in temperature would deliver.

Developing sufficient levels of renewable energy and energy efficiency to keep temperatures from rising more than two degrees Celsius is projected to cost eighteen trillion dollars and take decades to install<sup>6</sup> – long past the several years that most climate experts estimate remain before the tipping point for climate catastrophe. Even an increase of two degrees Celsius in the world's average temperature is projected to cause grave harm. So it is unlikely that China – or the rest of the world – can stop climate catastrophe by focusing only on renewable energy and energy efficiency.

The most commonly-used snapshot of the world's anthropogenic GHG emissions shows that shorter-lived ones account for only about 15 percent of total anthropogenic greenhouse gas emissions, when all gases are measured on a 100 year timeframe.<sup>7</sup> The figure for shorter-lived gases is significantly higher when each one is measured on a timeframe that more closely matches its half-life – which, for example, is about 10 years for methane. This fact is sometimes interpreted as raising the importance of addressing shorter-lived gases. However, such an interpretation does not account for a dramatic factor that is missed when one considers only the commonly-used snapshot of GHG emissions.

One reason why a dramatic factor in GHG emissions gets overlooked is that people examining GHGs tend to focus on individual gases instead of patterns and systems. In another field – that is, the field of nutrition and public health – a parallel misconception was detected by the internationally respected Dr. Junshi Chen, now senior research professor at the Chinese Center for Disease Control and Prevention, in his work with Dr. T. Colin Campbell. Drs. Chen and Campbell are the lead authors of the well-known China-Oxford-Cornell diet and health project, partly funded by the Government of China, and popularly called the China Study.<sup>8</sup> Before undertaking that project, Drs. Chen and Campbell saw that most studies of nutrition and public health focused on individual nutrients. Yet often, some studies of one individual nutrient would reach very different conclusions than other studies of the same nutrient, so sound results were difficult to discern.

Conversely, Drs. Chen and Campbell used an epidemiological method in their China Study, focusing on dietary patterns rather than individual nutrients. This led them to uncover a significant result that had

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<sup>4</sup> Brown, 2011.

<sup>5</sup> New et al., 2011.

<sup>6</sup> International Energy Agency, 2010.

<sup>7</sup> See the chart at <http://www.wri.org/chart/world-greenhouse-gas-emissions-2000>

<sup>8</sup> Chen J. et al., 1990.

been largely overlooked – namely, a strong correlation between consumption of livestock products (that is, meat and byproducts) and chronic degenerative diseases such as coronary heart disease and cancers. They attributed a low level of such diseases in rural China mainly to the traditional Chinese diet followed in those regions. By calories, this diet contains about 20% animal-based foods to 80% plant-based foods, compared to a ratio of about 50 to 50 in a typical American diet. The traditional Chinese diet contains about 1 percent of its calories in the form of animal protein versus about 10 percent in a typical American diet.

When I served as lead environmental advisor at the World Bank Group, my colleague Jeff Anhang and I invited Drs. Chen and Campbell to present the results of their China Study to World Bank Group staff, in 1997. The China Study inspired Jeff Anhang and me to think that it provided a rationale for looking at patterns and systems in the environmental impacts of livestock, rather than focusing on individual species or sites, as do most environmental studies of livestock.

While Drs. Chen and Campbell used epidemiology as their methodology, we used somewhat parallel methods in the environmental world – namely, sectoral assessment and lifecycle assessment. We started with a sectoral assessment of the environmental impacts of livestock,<sup>9</sup> which we first circulated within the World Bank Group, complemented by a series of speakers including Drs. Chen and Campbell. At the end of our speakers' series, the World Bank published a new livestock strategy, which for the first time recommended that institutions "avoid funding large-scale commercial, grain-fed feedlot systems and industrial milk, pork, and poultry production."<sup>10</sup>

We then moved on to a lifecycle assessment of the greenhouse gas emissions attributable to livestock. There, as in our sectoral assessment, and similar to the findings of Drs. Chen and Campbell, we found that livestock products had dramatic impacts that had been widely overlooked. We wrote up the results of our lifecycle assessment in a *World Watch* article – in which we estimate that livestock are responsible for at least half of all human-caused greenhouse gas emissions.<sup>11</sup>

Our article has become quite popular. For example, we have learned that it has been posted on the official climate change website of the Government of China.<sup>12</sup> Elsewhere, UNESCO has reported: "Goodland and Anhang [have] explained... what may be a large-scale paradigm shift in the approaches to mitigating climate change."<sup>13</sup> Though our article critiques the UN Food and Agriculture Organization (FAO), it invited us to deliver presentations in Rome and Berlin.<sup>14</sup> Chris Mentzel, CEO of Clean Energy Maui LLC, has written that our analysis persuaded him that a one percent reduction in meat production would have the same climatic effect as three trillion dollars of solar energy financing.<sup>15</sup>

In 1999, the International Food Policy Research Institute (IFPRI) started reporting on a "Livestock Revolution," in which demand for cereals would increase by 39 percent between 1995 and 2020, while

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<sup>9</sup> Goodland, 1999.

<sup>10</sup> De Haan et al., 2002.

<sup>11</sup> Goodland and Anhang, 2009.

<sup>12</sup> A Chinese friend wrote: "I am very excited to tell you that your article has been posted on the Chinese Government's official Climate Change Website (<http://www.ccchina.gov.cn/cn/NewsInfo.asp?NewsId=20278>)... This is a huge honor, because only high-level Chinese policymakers' articles or speeches are allowed on the website. The website attracts millions of eyeballs every day."

<sup>13</sup> UNESCO, 2010, pp. 14-15.

<sup>14</sup> These presentations can be seen at <http://awellfedworld.org/sites/awellfedworld.org/files/pdf/FAOConsult12-09.pdf> and <http://awellfedworld.org/sites/awellfedworld.org/files/pdf/GoodlandFoodIndustryBerlinJan2010.pdf>.

<sup>15</sup> Mentzel, 2010.

demand for meat would increase by 58 percent. However, in 2011, IFRPI started reporting a scenario of up to 19.2% lower global meat consumption by 2030.<sup>16</sup>

Some people have trouble believing that eating meat can cause the climate to change, let alone imperil humanity. But they may not know that the world's population of land-based livestock has grown six fold since 1960, so close to sixty billion will be raised in 2010 – and that:

- One quarter of land worldwide is now used for grazing livestock;
- One third of all farmable land is used for growing feed;
- One fifth of the Amazon rainforest has been destroyed, five times the area of England, mainly for livestock and feed production; and
- When rainforest is burned, not only are GHGs increasingly emitted, but also the world's largest carbon sink is steadily shrunk.

The largest factor in our analysis is completely uncoun­ted in commonly-used estimates of GHG emissions. It is the direct impact of livestock's respiration – or its reflection in carbon absorption foregone in land set aside for livestock and feed production. This perspective is supported by an eminent team of scientists published in the journal *Science*, stating: "If... crops displace forest or grassland, the carbon released from soils and vegetation, plus lost future sequestration, generates carbon debt, which counts against the carbon the crops absorb."<sup>17</sup>

In our assessment, either carbon dioxide in livestock's breath or carbon absorption foregone because of land set aside for livestock and feed production must be counted. That's because reality no longer reflects the old model of the Carbon Cycle, in which photosynthesis was said to balance respiration perfectly. That made sense when there were roughly constant levels of respiration and photosynthesis on Earth. But respiration has increased exponentially with livestock – while raising these animals has caused a dramatic decline in the earth's photosynthetic capacity, along with large and accelerating increases in volatilization of carbon in soil. This reality seems evident in a table published by the FAO, showing that today's atmospheric carbon from the respiration of all organisms – along with oxidation and erosion of soil organic matter – exceeds the capacity of photosynthesis to absorb such carbon.<sup>18</sup>

The second-largest factor in our analysis is the effect of methane – which is much greater than commonly considered when it is measured on a timeframe that matches its half-life. Its half-life in the atmosphere is only about 10 years, as compared with at least 100 years for carbon dioxide. Therefore, measured over a 20-year timeframe, methane has a global warming potential 72 times that of carbon dioxide. This perspective is supported by four current and former scientists employed by Agriculture and Agri-Foods Canada, a Canadian Government department, who have stated: "The 20-year accounting period may be a better reflection of the time scale for the GWP [global warming potential] of CH<sub>4</sub> [methane] because of the growing urgency of global warming."<sup>19</sup> Yet the powerful influence of methane is often misunderstood.

For example, some experts say that methane is the largest climate risk in livestock, and they prioritize measures for technical mitigation of methane attributable to livestock – while overlooking more

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<sup>16</sup> Rosegrant and Msangi, 2011.

<sup>17</sup> Searchinger et al., 2009.

<sup>18</sup> FAO, 2006, Table 3.2.

<sup>19</sup> Dyer et al., 2011.

important risks in livestock. They neglect the fact that technology to mitigate methane emissions from livestock can normally achieve only about a 10 percent reduction in methane emissions, and that this technology is too expensive and impractical for most livestock.

Some experts say that levels of methane attributable to cattle show that sustainable livestock production can be achieved simply by allowing the present trend of decrease in cattle production worldwide to continue, while industry replaces that cattle production with pork and chicken production, whose growth need not be limited.<sup>20</sup> However, this argument does not take into account carbon dioxide in the respiration of pigs and chickens or its reflection in carbon absorption foregone in land set aside for the production of feed for pigs and chickens.

The importance of livestock respiration is seen in the broadly consistent metabolic rate of cattle, pigs, and chickens alike. Each animal dissipates about two watts per kilogram to stay alive.<sup>21</sup> To reflect that, a roughly constant amount of carbon dioxide per unit of weight of livestock is respired, regardless of species.

Transportation fuels accounted for about 6 billion tons of carbon dioxide in 2009. In comparison, carbon dioxide from the breath of livestock raised in 2009 accounted for about 10 billion tons of carbon dioxide. Not only are the approximately 10 billion tons of carbon dioxide from the breath of livestock in 2009 invariable regardless of animal type, but there are also billions more tons of GHGs that are more or less invariable from these aspects of livestock production:

- GHGs from transporting each kg of livestock product;
- GHGs from solid and liquid waste from livestock and their products;
- GHGs from the substantially higher amount of refrigerating, cooking, and packaging of meat versus alternatives; and
- GHGs attributable to carbon-intensive medical treatment of millions of cases worldwide each year of zoonotic illnesses (such as swine flu) and chronic degenerative illnesses (such as coronary heart disease, cancers and diabetes) are linked to the consumption of livestock products – but not to alternatives.<sup>22</sup>

Accordingly, about half the GHGs attributable to the lifecycle of livestock products are more or less invariable, regardless of the type of livestock. Therefore, while significantly more GHGs are attributable to beef than to other meats because of cattle's grazing, feed, enteric fermentation, and manure management, that significance is much smaller than commonly thought – and no particular meat product is likely to have a GHG footprint more than 25 percent lower than any other.

As a result, replacing beef with chicken and pork would not result in any appreciable slowing of climate change. This point merits emphasis. In recent years, China has allowed multinational food corporations to increase pork and chicken products in China on a large scale. This generates grave risk. While it may be difficult for people to comprehend the climate risk, they may find it easier to understand that the amount of grain required for producing any amount of food from livestock is much higher than the amount needed to feed people directly. This seems to contradict the thrifty aspects of traditional

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<sup>20</sup> Steinfeld and Gerber, 2010.

<sup>21</sup> Calverd, 2005.

<sup>22</sup> Russell, 2010.

Chinese culture. While the world has managed to produce enough grain to feed both people directly as well as livestock, the world's capacity to do so is predicted to decline as climate warming intensifies.

China now imports about 80 percent of its soy beans – about 60 percent of the world's soy bean production – mainly for livestock feed. Much of it is sourced from land in the Amazon and other forest regions, deforested specifically to create pasture for growing crops.

The grave risks in deforesting the Amazon have apparently inspired the restaurant chain McDonald's to announce recently that it would stop sourcing beef, as well as soy feed for its chicken products, from the Amazon forest region.<sup>23</sup> This is a beneficial first step, but does not go nearly far enough. In a press release, McDonald's refers to "sustainable beef" – implying that by sourcing livestock and feed outside the Amazon forest region, they become sustainable, so consumers can feel comfortable eating even more livestock products than they do already. But nothing is said in such marketing about the high GHG footprint of livestock products, or the much lower climate risk of alternatives.

## **Opportunity**

In our *World Watch* article, Jeff Anhang and I explain that almost the entire goal of recent climate treaty negotiations can be achieved by replacing one quarter of today's products deriving from livestock (e.g., cows, pigs, and chickens) with alternatives. This would allow forest to regenerate on the vast areas of land now set aside for cattle grazing and feed production for livestock. Regeneration of forest is the only known way to create new, large-scale capacity to sequester today's atmospheric carbon. If it is not sequestered, then it will take at least a century to dissipate. As a result, our case may be the only pragmatic one available to stop global warming in the 5-10 years that many climate experts believe remain before irreversible climate disruption.

China has commendably become a world leader in halting deforestation within its borders. Climate risk would be lowered if other countries were to follow China's lead in this area.<sup>24</sup> However, GHG emissions and climate change are transboundary, meaning that they do not respect borders.

As long as countries such as Brazil continue not to stop and reverse deforestation, there is a need for countries – where possible – to go beyond just acting to halt deforestation within their own borders. Accordingly, there is an urgent need for the Government of China to phase out its imports of livestock products and feed from countries where livestock and feed production are responsible for significant amounts of deforestation – and where continued production does not allow for forest to regenerate (as in Brazil).

Multinational food corporations act as if they do not know that China's traditional diet is possibly the best in the world – considering its environmental, social, and economic sustainability, as well as its taste. If the world followed China's traditional diet, its climate problems would be largely addressed, at least in the short term. Further, if the world followed China's traditional diet, there would probably be no problem in feeding the world's 9-10 billion people expected by 2050.

Instead, many of the world's population who are not already eating diets intensive in livestock products are moving in that direction. Reversing the present trend could be the key to addressing climate change in the next 5-10 years. It could also be the key to addressing health and economic risks – as consumption of livestock products and associated illnesses have gone beyond their former association

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<sup>23</sup> McDonald's press release, 2011.

<sup>24</sup> Cf. Stern, 2009.

with affluence to become now also associated with poverty, in a phenomenon dubbed by some “the New World Syndrome.”<sup>25</sup>

Where people don’t know of China’s traditional diet, or they know of it but anyway have formed habits around eating meat and dairy products, they can replace those products with substitutes such as seitan-based “chicken,” soy-based “beef,” nut-based milks, and coconut-based ice cream. These are the types of products that companies such as McDonald’s should be marketing as sustainable foods, rather than beef and chicken products.

People may not recognize it, but their habits tend to be induced by fiscal measures and marketing, which strenuously promote meat and dairy products. Fiscal measures and marketing can promote alternatives instead. And trying tasty new foods is normally considered desirable. A carbon tax properly applied to livestock products would help to encourage better diets, while discouraging deforestation for livestock and feed production.<sup>26</sup>

Meat and dairy substitutes can be promoted like digital technology. Within a decade, manufacturers have switched almost entirely from analog televisions and telephones to digital versions – propelled by savings in materials and energy use, along with other improvements. Like digital technology, meat and dairy substitutes can deliver better quality at lower cost, while fulfilling the world’s priority of preventing climate disruption.

Most land used for livestock and feed production can regenerate forest. In woody vegetation and the soil beneath, much more carbon can be sequestered than in grasslands now set aside for grazing and feed – as much as the increase in atmospheric carbon since 1980, according to James Hansen, the US government’s top climate scientist.

Some argue that millions of poor people have no alternative to raising livestock for their livelihoods. But tens of millions of poor people’s livestock have died recently due to climate disasters. Replacing them would risk a similar fate for the new animals. Supporting new livelihoods for those whose livestock die in climate disasters would be less risky. Microfinance, mobile banking, computers, and off-grid electricity have generated dramatic growth in many poor rural communities.

Agriculture is outdoors to a unique degree, exposing it to greater risk from livestock-related emissions than any other industry’s risk from the same emissions. So food industry leaders have a compelling commercial incentive to reduce these emissions. Meat and dairy substitutes require no subsidies or offsets. Consumers can buy more of them tomorrow.

## **Conclusions**

According to Lester Brown, founder of the Worldwatch Institute, the environmental think tank that published our livestock-climate analysis, worldwide anthropogenic GHGs can and should be cut by 80 percent by 2020. To do so, practically all means will be needed simultaneously: (a) revenue-neutral carbon or GHG emissions taxes applied domestically and to imports, including livestock products and feed; (b) prompt phase out of coal (unless its GHG emissions are sequestered); (c) prompt repeal of subsidies for agrifuel from oilseeds and grain; (d) population stability; (e) vigorous transition to renewable energy; and (f) large-scale regeneration of forests together with tree planting. Among these

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<sup>25</sup> Shell, 2001.

<sup>26</sup> The world average meat consumption was about 40 kg/cap/year in 2000, with USA’s at 120 kg, OECD countries at about 80 kg, while China’s is now rising above 50 kg. According to one estimate, a tax on meat equivalent to 60€/ton of carbon dioxide (far less than half the current petrol/gasoline taxes in many European countries) would reduce beef consumption by about 15 percent (Wirsenius et al., 2011).

measures, only regeneration of forests and tree planting could actually increase absorption of atmospheric carbon on a large scale as is desperately needed. Probably the only way this can occur is by replacing a significant amount of livestock products with alternatives.

In addition, our recommendation of a 25 percent replacement of livestock products with alternatives could liberate as much as 40 percent of current world grain production. This would be enough to provide adequate calories and nutrients for more than 3 billion people, an important objective if the projection of a worldwide population of 9-10 billion by 2050 is fulfilled. It would also make possible significant reductions in GHG emissions from forest fires and concomitant biomass decay, which inevitably accompany expansion of livestock and feed production. It would also result in less livestock-related methane from manure and from ruminants' enteric anaerobic digestion.<sup>27</sup> Given the relatively short half-life of methane and its high global warming potential, this would add to the short-term reduction in atmospheric carbon available from regeneration of forest on land set aside for livestock and feed production.

Renewable energy must still be increased on a large scale to keep emissions and atmospheric carbon down over the long term. But in the near term, China can become an even greater leader on climate change than it is today by implementing carbon or GHG taxes properly applicable to livestock products; by phasing out its imports of livestock products and livestock feed; and by vigorously revitalizing its traditional diet, possibly adding some new meat and dairy substitutes as a modern twist. After all, as described in this presentation, replacing livestock products with substitutes is the only way for governments, industry, and the general public collaboratively to take a single, powerful action to reduce climate change quickly.

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### References Cited and Guide to Further Information

Audsley, E, Brander, M & Chatterton, J, 2009. *How low can we go? An assessment of greenhouse gas emissions from the UK food system and the scope to reduce them by 2050*. FCRN-WWF-UK.

Brown, L, 2011. *World on the edge: How to prevent environmental and economic collapse*. New York, W.W. Norton & Co 240 p.

Calverd, A, July 2005. "A radical approach to Kyoto." *Physics World*, 56.

Campbell, T Colin and Campbell, T M, 2005. *The China study: the most comprehensive study of nutrition ever conducted and the startling implications for diet, weight loss and long-term health*. Dallas TX., BenBella Books, 417 p.

Chen J, Campbell TC, Li J, Peto R, 1990. *Diet, lifestyle and mortality in China*. Oxford University Press, Oxford, Cornell University Press, Ithaca, and People's Publishing House, Beijing, 1990

De Haan, C *et al*, 2002. *Livestock Development: Implications for Rural Poverty, the Environment and Global Food Security*. Washington, D.C.: The World Bank, Directions in Development Series, [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2001/12/11/000094946\\_01112104010387/Rendered/PDF/multi0page.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2001/12/11/000094946_01112104010387/Rendered/PDF/multi0page.pdf).

D'Silva, J and Webster, J. 2010. *The meat crisis: Developing more sustainable production and consumption*. London: Earthscan 305 p. [www.netLibrary.com/urlapi.asp?action=summary&v=1&bookid=339081](http://www.netLibrary.com/urlapi.asp?action=summary&v=1&bookid=339081).

European Parliament, 2009. "Less meat = less heat." Sir Paul McCartney and Dr Rajendra K. Pachauri. [www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+IM-PRESS+2009.1201.PR65710+0+DOC+XML+V0//EN](http://www.europarl.europa.eu/sides/getDoc.do?pubRef=-//EP//TEXT+IM-PRESS+2009.1201.PR65710+0+DOC+XML+V0//EN).

Dyer, JA, Vergé, X P C, Desjardins, R L and Worth, D E, 2010. "The Protein-based GHG Emission Intensity for Livestock Products in Canada," *Journal of Sustainable Agriculture*, 34: 6, 618 — 629, <http://dx.doi.org/10.1080/10440046.2010.493376>.

FAO, 2006. *Livestock's long shadow: Environmental issues and options*. Steinfeld, H., Gerber P., Wassenaar, T., Castel, V.,

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<sup>27</sup> The global livestock chain is commonly said to be responsible for 65 per cent of the nitrous oxide (mainly from manure), 37 per cent of the methane, 64 per cent of the ammonia, and nearly 80 per cent of all agriculture-related emissions. However, the amount of methane commonly attributable to livestock has been reported as undercounted by as much as 65 percent; e.g., see *Science Daily*, 2010.

- Rosales, M. and Haan, C. Rome: UN Food and Agriculture Organization. 390 p.
- Friel, S, Dangour, A, Garnett, T, Lock, K, Chalabi, Z, Roberts, I, Butler, A, Butler, C, Waage, J, McMichael, AJ, and Haines, A, 2009. "Public health benefits of strategies to reduce greenhouse-gas emissions: food and agriculture." *The Lancet* 374 (9706): 2016 – 2025. doi:10.1016/S0140-6736(09)61753-0.
- Goodland, R and Pimentel, D, 1999. "Livestock sector environmental assessment" in Hardtlein, M., Kaltschmitt, M., Lewandowski, I. and Wurl, H. (eds.) *Nachhaltigkeit in der Landwirtschaft: Landwirtschaft in Spannungsfeld zwischen Ökologie, Ökonomie und Sozialwissenschaften*. Berlin, E. Schmidt Verlag [for] Umwelt Stiftung: Deutsche Bundesstiftung Umwelt, p. 239-261.
- Goodland, R and Anhang, J, 2009. "Livestock and Climate Change: What if the key actors in climate change are... cows, pigs, and chickens?" *World Watch*, Oct/Nov, 10 p., [www.worldwatch.org/node/6294](http://www.worldwatch.org/node/6294); sources and resources at <http://www.worldwatch.org/ww/livestock>; update at [www.weblogtheworld.com/countries/africa-africa/replace-25-of-livestock-products-to-reduce-global-warming/](http://www.weblogtheworld.com/countries/africa-africa/replace-25-of-livestock-products-to-reduce-global-warming/); responses to readers at <http://awellfedworld.org/sites/awellfedworld.org/files/pdf/WWMLivestock-ClimateResponses.pdf>
- Goodland, R, 2009. "Forests, Fisheries, Agriculture: A Vision for Sustainability," prepared by invitation of the FAO for its expert consultation in Rome, Italy, 2- 4 December 2009, at <http://awellfedworld.org/sites/awellfedworld.org/files/pdf/FAOConsult12-09.pdf>.
- Goodland, R, 2010. "How the Food Industry Can Reverse Climate Change Quickly and Profitably," prepared by invitation of the FAO for the Global Forum for Food and Agriculture, International Green Week, Berlin, 14-16 January 2010, at <http://awellfedworld.org/sites/awellfedworld.org/files/pdf/GoodlandFoodIndustryBerlinJan2010.pdf>.
- Goodland, R, 2010. "The overlooked climate solution: Joint action by governments, industry, and consumers." *J. Human Security* 6(3):50-60.
- Guardian, 2009. "UN says eat less meat to curb global warming." [www.guardian.co.uk/journalismcompetition/professional-climate-changeconflicts](http://www.guardian.co.uk/journalismcompetition/professional-climate-changeconflicts). [www.guardian.co.uk/environment/2008/sep/07/food.foodanddrink](http://www.guardian.co.uk/environment/2008/sep/07/food.foodanddrink).
- Hansen, J, 2010. Top international climatologist: "...the things that individuals can do are helpful, and one of the most helpful is actually a vegetarian diet, produces much less greenhouse gasses than a meat diet," at [www.whirledpeas.com.au/this-i-get-hansens-climate-logic-and-the-vegetarian-diet](http://www.whirledpeas.com.au/this-i-get-hansens-climate-logic-and-the-vegetarian-diet).
- Hansen, J, Sako, M, Ruedy, R, Lacis, A and Oinas, V, 2000. "Global warming in the twenty-first century: An alternative scenario." *PNAS* 97: 9875-9880. [www.pnas.org/content/97/18/9875.full](http://www.pnas.org/content/97/18/9875.full).
- International Energy Agency, 2010. Presentation by Nobuo Tanaka, Executive Director, at [www.iea.org/speech/2010/Tanaka/IEA\\_press\\_conf\\_cop16.pdf](http://www.iea.org/speech/2010/Tanaka/IEA_press_conf_cop16.pdf).
- Koffman, N, (Ed.) 2010. *Meat the truth: Essays on livestock production, sustainability and climate change*. Amsterdam, Nicolaas Pierson Foundation 240p
- McDonald's press release, 2011. "McDonald's Announces Commitment to Certified Sustainable Sources; Releases 2010 Corporate Responsibility Report," at <http://www.marketwire.com/press-release/McDonalds-Announces-Commitment-Certified-Sustainable-Sources-Releases-2010-Corporate-NYSE-MCD-1408785.htm>
- McMichael, AJ, Neira, M, Bertollini, R, Campbell-Lendrum, D and Hales, S, 2009. "Climate change: A time of need and opportunity for the health sector." *Lancet* 374: 2123-2125.
- McMichael, AJ, Powles, J, Butler, CD. and Uauy, R, 2007. "Food, livestock production, energy, climate change and health." *Lancet* 370: 1253-1263. [www.thelancet.com/journals/lancet/article/PIIS0140673607612562/fulltext](http://www.thelancet.com/journals/lancet/article/PIIS0140673607612562/fulltext).
- "Meat: The facts. Mitigating climate change through food policy," 2009. [meatthefacts.org/download/mitigating\\_climate\\_change\\_through\\_food\\_policy.pdf](http://meatthefacts.org/download/mitigating_climate_change_through_food_policy.pdf): 26 p
- Mentzel, C, 2010. "The Copenhagen Fools." *Maui Weekly*, [www.mauiweekly.com/page/content.detail/id/500866/The-Copenhagen-Fools.html](http://www.mauiweekly.com/page/content.detail/id/500866/The-Copenhagen-Fools.html).
- Moore, FC and MacCracken, MC, 2009. "Lifetime-leveraging: An approach to achieving international agreement and effective climate protection using mitigation of short-lived greenhouse gases," *International Journal of Climate Change Strategies and Management* 1 (1): 42 – 62.
- New, MG, Liverman, DM, Betts, RA, Anderson, KL, and West, CC, 2011. *Four degrees and beyond: the potential for a global temperature change of four degrees and its implications*, at [http://rsta.royalsocietypublishing.org/site/2011/four\\_degrees.xhtml](http://rsta.royalsocietypublishing.org/site/2011/four_degrees.xhtml)
- Ng, SW, 2011. "China's challenge to Europe" at <http://www.chinadialogue.net/article/show/single/en/4145>.
- Pachauri, Rajendra K., 2009. "One of the most cost efficient and easiest ways to reduce GHG emissions is to reduce meat consumption. In terms of immediacy of action and the feasibility of bringing about reductions in a short period of time, it clearly is

the most attractive opportunity. Give up meat for one day [a week] initially, and decrease it from there,” at [www.care2.com/causes/global-warming/blog/reduce-meat-consumption-to-reduce-greenhouse-gas-emissions/](http://www.care2.com/causes/global-warming/blog/reduce-meat-consumption-to-reduce-greenhouse-gas-emissions/).

Pimentel, D. and Pimentel, M., 2003. “Sustainability of meat-based and plant-based diets and the environment.” *American Journal of Clinical Nutrition* 78 (suppl): 660S-3S. [www.ajcn.org/cgi/content/full/78/3/660S-663S](http://www.ajcn.org/cgi/content/full/78/3/660S-663S).

Pimentel D., Williamson S., Alexander C.E., Gonzalez-Pagan O., Kontak C., and Mulkey S.E., 2008. “Reducing energy inputs in the US food system.” *Human Ecology* 36(4): 459-471. [www.sciencedaily.com/releases/2008/07/080723094838.htm](http://www.sciencedaily.com/releases/2008/07/080723094838.htm).

Pimentel, D., 2009. “Energy inputs in food crop production in developing and developed nations.” *Energies* 2(1): 1-24. <http://www.mdpi.com/1996-1073/2/1>.

Popkin, BM, 2009. “Reducing meat consumption has multiple benefits for the world's health.” *Archives of Internal Medicine* 169 (6): 543.

Popkin, BM, 2006. “Global nutrition dynamics: the world is shifting rapidly toward a diet linked with noncommunicable diseases.” *The American Journal of Clinical Nutrition* 84 (2): 289.

Rosegrant, M and Msangi, S, 2011. *Feeding the Future's Changing Diets: Implications for Agriculture Markets, Nutrition, and Policy* (Advance Copy), Washington, D.C., IFPRI, <http://www.ifpri.org/sites/default/files/publications/2020anhconfpaper03.pdf>.

Russell, G, 2010. “Of brains, biceps and baloney.” Guest post by Barry Brook at [bravenewclimate.com/2010/10/31/of-brains-biceps-and-baloney/](http://bravenewclimate.com/2010/10/31/of-brains-biceps-and-baloney/) (31 Oct.).

Science Daily, 2010. “Scientists Question EPA and IPCC Estimates of Greenhouse Gas Emissions,” at [http://www.sciencedaily.com/releases/2010/06/100624183017.htm?keepThis=true&TB\\_iframe=true&height=480&width=650](http://www.sciencedaily.com/releases/2010/06/100624183017.htm?keepThis=true&TB_iframe=true&height=480&width=650).

Searchinger, T D, Hamburg, S P, Melillo, J, Chameides, W, Havlik, P, Kammen, DM, Likens, G E, Lubowski, RN, Obersteiner, M, Oppenheimer, M, Robertson, GP, Schlesinger, WH, and Tilman, GD, 2009. “Fixing a Critical Climate Accounting Error.” *Science*, 326 no. 23 527-528, [news.msu.edu/media/documents/2009/10/e945ce1b-c5ae-4d09-945c-541ad502889e.pdf](http://news.msu.edu/media/documents/2009/10/e945ce1b-c5ae-4d09-945c-541ad502889e.pdf).

Shell, ER, 2001. “New World Syndrome.” *The Atlantic Monthly*, [www.theatlantic.com/magazine/archive/2001/06/new-world-syndrome/2248/#](http://www.theatlantic.com/magazine/archive/2001/06/new-world-syndrome/2248/#).

Sinha R, Cross, AJ, Graubard, BI, Leitzmann, MF, and Schatzkin, A, 2009. “Meat intake and mortality: a prospective study of over half a million people.” *Archives of Internal Medicine* 169 (6): 562-571.

Smith, KR, 2009. “Methane first, OK? Reducing carbon dioxide emissions will be vital in the long run, but we should start by tackling methane.” *New Scientist* 202 (2714): 24-25 (27 June).

Smith, KR. 2009. “Methane controls before risky geoengineering, please.” *Commonwealth Health Ministers' Update. New Scientist* (27 June) 2714: 24-25.

Stehfest, E, Bouwman, L, Van Vuuren, DP, Den Elzen, MGJ, Eickhout, B., and Kabat, P, 2009. “Climate benefits of changing diet.” *Climatic Change* 95 (1-2): 83-102. DOI: 10.1007/s10584-008-9534-6. [www.springerlink.com/content/053gx71816jq2648/](http://www.springerlink.com/content/053gx71816jq2648/).

Steinfeld, J and Gerber, P, 2010. “Livestock production and the global environment: Consume less or produce better?” *PNAS*, 107 no. 43 18237-18238.

Stern, N, 2009. *The global deal: How to manage climate change and create a new era of progress and prosperity*. London, Bodley 256 p.

UNESCO, 2010. “Energy Flow, Environment and Ethical Implications for Meat Production” at <http://unesdoc.unesco.org/images/0018/001897/189774e.pdf>.

Wheeler, D, 2011. *Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance*. Washington, DC., Center for Global Development, Working Paper 240: 53 p. [www.cgdev.org/content/publications/detail/1424759](http://www.cgdev.org/content/publications/detail/1424759).

Wirsenius, S, Fredrik, H, and Mohlin, K, 2011. “Greenhouse gas taxes on animal food products: Rationale, tax scheme and climate mitigation effects.” *Climatic Change* DOI 10.1007/s10548-010-9971-x.