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# HSI Fact Sheet: The Impact of Animal Agriculture on the Environment and Climate Change in Brazil

Humane Society International

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## HSI Fact Sheet

# **The Impact of Animal Agriculture on the Environment and Climate Change in Brazil**

The intensification of farm animal production in industrialized agricultural systems, or factory farms, compromises animal welfare<sup>1</sup> and degrades the environment.<sup>2</sup> Animal agriculture inefficiently consumes natural resources,<sup>3</sup> contributes to deforestation,<sup>4</sup> and produces immense quantities of animal waste, threatening water and air quality<sup>5</sup> and contributing to climate change.<sup>6</sup> The Food and Agriculture Organization (FAO) of the United Nations estimated in 2006 that animal agriculture was responsible for 18% of global, anthropogenic, or human-induced, greenhouse gas emissions<sup>7</sup> and was “by far the single largest anthropogenic user of land.”<sup>8</sup>

## **Factory Farming in Brazil**

Over 67 billion land animals were raised globally for human consumption in 2008,<sup>9</sup> and global meat and milk production are projected to approximately double between 1999 and 2050.<sup>10</sup> Brazil is the world’s largest meat exporter<sup>11</sup> and 2009 statistics show that its cattle herd is the largest in the world at over 200 million animals.<sup>12</sup> Per capita meat consumption nearly doubled in Brazil between 1980 and 2005,<sup>13</sup> and Brazilian beef production and exports were expected to rise by 3% in 2010 compared to 2009.<sup>14</sup>

Farm animal operations are industrializing in developing nations,<sup>15</sup> with rapidly increasing demand for meat and milk driving this industry transformation.<sup>16</sup> Unlike pasture-based or mixed farming systems, today’s concentrated farm animal production facilities, or **factory farms**, often confine tens of thousands of animals in factory-like facilities.<sup>17</sup> These operations are becoming more widespread throughout the world, and can bring along devastating environmental consequences.<sup>18</sup> According to the FAO, industrial systems now produce approximately two-thirds of the world’s poultry meat and eggs, and more than half of all pork.<sup>19</sup> In fact, “[i]n recent years industrial livestock production has grown at twice the rate of more traditional mixed farming systems and at more than six times the rate of production based on grazing.”<sup>20</sup>

At the same time, there is increasing standardization and consolidation of production in developing countries through vertical integration, in which the retailer contracts with suppliers and/or processors, as well as full integration, in which all units in the food chain are owned by one company.<sup>21</sup> This evolution includes the animal agriculture sector<sup>22</sup> and is present in Latin America, where there is a trend towards vertical integration. For example, 40% of Brazil’s market for broiler chickens is supplied by just four integrators.<sup>23</sup> In Brazil’s dairy industry, the number of milk producers fell by approximately 23% between 2000 and 2002, while maintaining the same volume of milk production.<sup>24</sup> This consolidation may have deleterious effects on rural farmers, as it often “eliminates open market competition and drives down prices paid to growers.”<sup>25</sup> Small farmers that try to directly compete with large animal agribusiness are at risk of being pushed out of the market because they lack the political and economic power of the larger companies, or the ability to exploit economies of scale.<sup>26</sup>

Not only is farm animal production becoming consolidated in developing countries, the facilities themselves are becoming more geographically clustered.<sup>27</sup> In Brazil, these high levels of geographical concentration can be seen in the pork and poultry industries. For example, in 1992, 78% of Brazil’s hen population resided in only 5% of the country’s area; in 2001, this number grew to 85%, while occupying the same total land area.<sup>28</sup> Over the same time period, Brazil’s pig population rose from 45% to 56% on only 5% of the country’s area.<sup>29</sup> This geographical concentration of farm animal production can cause significant air and water pollution.<sup>30</sup>

## **The Environmental Threat of Animal Agriculture**

In 2006, the FAO published “Livestock’s Long Shadow: Environmental Issues and Options,” its landmark report assessing the impacts of animal agriculture. The FAO concluded that “the livestock sector emerges as one of the top two or three most significant contributors to the most serious environmental problems, at every scale from local to global.”<sup>31</sup> With global meat and milk production expected to approximately double within the next 50 years, the FAO cautions that the “environmental impact per unit of livestock production must be cut by half, just to avoid increasing the level of damage beyond its present level.”<sup>32</sup>

### **Farm Animal Waste**

Much of the environmental damage caused by factory farms, in which each farm may confine up to hundreds of thousands of animals,<sup>33</sup> is due to the volume and content of animal waste, and the consequent challenges of storage and disposal.<sup>34</sup> In fact, “[o]ne animal facility with a large population of animals can easily equal a small city in terms of waste production.”<sup>35</sup>

Mixed farming systems connect the animal agriculture activity to the crops.<sup>36</sup> On these systems farmers balance the number of animals with the land’s ability to absorb the nutrients in their manure. Factory farms confine large numbers of animals on a disproportionately small land area, breaking this link between crop production and animal husbandry.<sup>37,38</sup> In particularly high production areas, this has resulted in factory farms producing more manure than can be assimilated by available land,<sup>39</sup> causing environmental damage.<sup>40</sup>

Factory farm animal waste, which is stored in lagoons or pits,<sup>41</sup> contains chemical contaminants as well as numerous pathogens.<sup>42</sup> Potentially contaminating water, soil, and air, factory farms typically spray minimally treated or untreated waste on fields.<sup>43</sup> Manure storage lagoons can also overflow.<sup>44</sup> Pathogens from the manure may end up in surface water, and nutrients such as nitrogen and phosphorous can leach into groundwater and run off of fields.<sup>45</sup> Waste storage and application also emit carbon dioxide, hydrogen sulfide, ammonia, methane, and particulates into the atmosphere.<sup>46</sup> Nitrogen can also volatilize into ammonia emissions<sup>47</sup> that are then redeposited into waterways.<sup>48</sup> In fact, according to the FAO, “[t]he livestock sector... is probably the largest sectoral source of water pollution, contributing to eutrophication, ‘dead’ zones in coastal areas, degradation of coral reefs, human health problems, emergence of antibiotic resistance and many others.”<sup>49</sup>

In part to promote growth, farm animals are given large amounts of antibiotics and other drugs,<sup>50</sup> and consequently, produce manure that includes these drug residues.<sup>51,52</sup> Because the animal’s digestion does not degrade all of the drugs, antibiotic and other drug residues are excreted into the environment and have been found to contaminate ground, surface, and tap water.<sup>53</sup> According to the World Health Organization, “[a] growing body of evidence establishes a link between the use of antimicrobials in food-producing animals and the emergence of resistance among common pathogens.”<sup>54</sup>

In addition to antibiotics and other drugs, heavy metals are added to animal feed.<sup>55</sup> Animals are capable of absorbing only 5 to 15% of these toxic metals,<sup>56</sup> and increased feed conversion efficiency results in manure and slurry with an even higher concentration of metals than the enriched feed.<sup>57</sup> Applying factory farm manure degrades the environment because the metals can accumulate in the soil, and potentially poison plants and animals.<sup>58</sup>

### **Deforestation**

Nearly one-third (31%) of the earth’s land is covered by forests,<sup>59</sup> which act as net carbon sinks, releasing less carbon than they store.<sup>60</sup> In fact, the world’s forests retain about 289 billion tonnes of carbon.<sup>61</sup> Deforestation causes approximately 17% of the world’s human-induced GHG emissions, by releasing stored carbon into the atmosphere.<sup>62</sup>

Pasture expansion for livestock is a key driver of deforestation, especially in Latin America, and it is estimated that “some 70 percent of previously forested land in the Amazon is used as pasture, and feed crops cover a large part of the remainder.”<sup>63</sup> Since the 1970s, Brazil, in particular, has suffered extensive deforestation in its Amazon region for cattle ranching.<sup>64</sup> The FAO estimates that 16.9 million hectares of the Legal Amazon were deforested from 2000 through 2008.<sup>65</sup> Between 1990 and 2002, Brazil’s cattle population located in the Amazon expanded from approximately 18% to 31%, which represents 80% of Brazil’s total cattle herd growth during this period.<sup>66</sup> A World Bank paper found that in 2004 “[c]attle ranching enterprises...[occupied] nearly 75 percent of the deforested areas of Amazonia.”<sup>67</sup> With this in mind, it is no surprise that cattle ranching is the main contributor to deforestation in the Brazilian Amazon.<sup>68</sup>

Soybean production for animal feed is another emerging cause of rainforest destruction.<sup>69,70</sup> According to a 2006 FAO report, the cultivation of soybean and corn for animal feed contributes to the clearing of forests in Brazil and Latin America.<sup>71</sup> Over 97% of global soymeal production is fed to animals used in agriculture, and during the last four decades of the 20th century, over 60% of the corn and barley crop were also fed to these animals.<sup>72</sup> Globally, soybean production increased rapidly in recent decades, and expanding production is currently due to demand for animal feed.<sup>73</sup> A 2010 study of Amazonian deforestation during the years 2000–2006 concluded that “even if the proximate cause of deforestation was mainly ranching, it is likely that soy cultivation is a major underlying cause.”<sup>74</sup>

Deforestation contributes to environmental degradation, including loss of biodiversity, soil degradation, and water pollution.<sup>75</sup> In Brazil, Amazon deforestation emits more CO<sub>2</sub> than any other source.<sup>76</sup>

## **Greenhouse Gas Emissions (GHGs) and Climate Change**

The FAO estimated in 2006 that animal agriculture is responsible for 18% of global, anthropogenic GHGs.<sup>77</sup> The animal agriculture sector is one of the most important sectors for policies aimed at immediate and swift reductions in humans’ climate impacts.<sup>78</sup>

Essentially every part of the animal production chain pollutes the air or contributes to climate change.<sup>79</sup> The sector emits significant amounts of three of the most important GHGs: carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O).<sup>80</sup> In fact, globally the farm animal sector accounts for:

- 9% of human-induced CO<sub>2</sub> emissions<sup>81</sup>
- 35–40% of human-induced CH<sub>4</sub> emissions,<sup>82</sup> which has 25 times the global warming potential (GWP), or power, of CO<sub>2</sub> over 100 years,<sup>83</sup> and
- 65% of human-induced N<sub>2</sub>O emissions,<sup>84</sup> which has about 300 times the GWP of CO<sub>2</sub>.<sup>85</sup>

**CO<sub>2</sub>:** Carbon dioxide emissions from this sector are produced through nitrogen fertilizer production for feed, on-farm fossil fuel use, deforestation to make way for grazing and animal feed production (~2.4 billion tonnes), and pasture desertification,<sup>86</sup> which can result from overgrazing by farm animals.<sup>87</sup> An estimated 41 million tonnes of CO<sub>2</sub> are emitted from fertilizer production for feed crops each year.<sup>88</sup> Brazil, alone, emits 1.69 million tonnes of CO<sub>2</sub> per year from fossil fuel use in the production of nitrogen fertilizer for feed.<sup>89</sup>

**CH<sub>4</sub>:** Enteric fermentation and manure management are the key causes of animal agriculture’s methane emissions.<sup>90</sup> Enteric fermentation, which is microbial fermentation that takes place in the digestive systems of ruminant animals, such as cattle, sheep, and buffalo,<sup>91</sup> accounted for 63.2% of Brazil’s methane emissions in 2005.<sup>92</sup> Globally, this process accounts for 25% of animal agriculture’s total GHG emissions.<sup>93</sup> Manure is responsible for the remaining portion of methane emissions from farm animals<sup>94</sup> and accounts for approximately 5% of animal agriculture’s GHG emissions.<sup>95</sup>

**N<sub>2</sub>O:** The farm animal sector also is responsible for the majority of the world’s human-induced nitrous oxide emissions.<sup>96</sup> Nitrous oxide emissions from animal agriculture originate primarily from manure and fertilizer for feed crops,<sup>97</sup> and contribute approximately 31% of animal agriculture’s GHG emissions.<sup>98</sup>

## Conclusion

Mitigating the animal agriculture sector's significant yet underappreciated role in climate change and environmental problems is vital for the health and sustainability of the planet, and its human and nonhuman inhabitants. As “the single largest anthropogenic user of land”<sup>99</sup> and responsible for an estimated 18% of human-induced GHG emissions,<sup>100</sup> the farm animal production sector must be held accountable for its many deleterious impacts, and changes in animal agricultural practices must be achieved. Individually, incorporating environmentally sound and animal welfare-friendly practices into daily life, including a reduction in meat, milk, and egg consumption, can reduce our environmental impact.

### Humane Society International (HSI) calls for critical actions each of us can and should take:

**Reduce:** A shift towards plant-based foods can achieve GHG reductions. By making flexitarian, vegetarian, and vegan lifestyle choices, each of us can reduce our environmental impact.<sup>101,102</sup>

**Refine:** Refining the diet by switching to higher-welfare animal products helps diminish animal suffering and protect the environment.

**Replace:** The consequences of replacing animal products with healthy vegetarian options are enormous—not only for farm animals, but for public health and environmental integrity as well.

*Humane Society International (HSI) and its partner organizations together constitute one of the world's largest animal protection organizations — backed by 11 million people. For nearly 20 years, HSI has been fighting for the protection of all animals through advocacy, education, and hands-on programs. Celebrating animals and confronting cruelty worldwide — On the web at [hsi.org](http://hsi.org).*

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<sup>1</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p. 33. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.

<sup>2</sup>Chakravorty U, Fisher DK, Umetsu C. 2007. Environmental effects of intensification of agriculture: livestock production and regulation. *Environmental Economics and Policy Studies* 8:315 -336. p. 325.

<sup>3</sup>Nellemann C, MacDevette M, Manders T, et al. (eds.). 2009. *The Environmental Food Crisis: the environment's role in averting future food crises* (Norway: United Nations Environment Programme, p. 26). [http://www.grida.no/res/site/file/publications/FoodCrisis\\_lores.pdf](http://www.grida.no/res/site/file/publications/FoodCrisis_lores.pdf). Accessed May 18, 2010.

<sup>4</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 12.

<sup>5</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p. 23, 25, 27. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.

<sup>6</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. xxi, 113 Table 3.12.

<sup>7</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 112.

<sup>8</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. xxi.

- 
- <sup>9</sup>Food and Agriculture Organization of the United Nations. 2010. FAOSTAT. <http://faostat.fao.org/>. Accessed May 13, 2010.
- <sup>10</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. xx.
- <sup>11</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 20). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>12</sup>Food and Agriculture Organization of the United Nations. 2010. FAOSTAT. <http://faostat.fao.org/>. Accessed January 21, 2011.
- <sup>13</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 11 Table 1). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>14</sup>U.S. Department of Agriculture Foreign Agricultural Service, Global Agricultural Information Network. 2010. Brazil Livestock and Products Semi-Annual Report 2010, p. 4. [www.apeda.com/TradeJunction/Report/march\\_2010/Brazil\\_livestock\\_report.pdf](http://www.apeda.com/TradeJunction/Report/march_2010/Brazil_livestock_report.pdf). Accessed May 19, 2010.
- <sup>15</sup>Chakravorty U, Fisher DK, Umetsu C. 2007. Environmental effects of intensification of agriculture: livestock production and regulation. *Environmental Economic and Policy Studies* 8: 315 -336. p. 316.
- <sup>16</sup>Costales A, Gerber P, and Steinfeld H. 2006. Underneath the Livestock Revolution. In: McLeod A (ed.), *Livestock Report 2006* (Rome, Italy: Food and Agriculture Organization of the United Nations, p. 24). <ftp://ftp.fao.org/docrep/fao/009/a0255e/a0255e.pdf>. Accessed May 19, 2010.
- <sup>17</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p.6, 9. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.
- <sup>18</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p.6, 9. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.
- <sup>19</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 27). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>20</sup>Vergé XPC, De Kimpe C, and Desjardins RL. 2007. Agricultural production, greenhouse gas emissions, and mitigation potential. *Agricultural and Forest Meteorology* 142:255-269.
- <sup>21</sup>Steinfeld H, Wassenaar T, and Jutzi S. 2006. Livestock production systems in developing countries: status, drivers, trends. *Rev. sci. tech. Off. int. Epiz.* 25(2):505 -516, pp. 511-512. <http://www.oie.int/boutique/extrait/04steinfeld505516.pdf>. Accessed May 19, 2010.
- <sup>22</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 4). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>23</sup>De Haan, C, Van Veen TS, Brandenburg B, et al. 2001. Livestock development: implications for rural poverty, the environment, and global food security (Washington, D.C.: The World Bank, p. 5). [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). Accessed May 19, 2010.

- 
- <sup>24</sup>Delgado CL, Narrod CA, Tiongco MM, et al. 2008. Determinants and implications of the growing scale of livestock farms in four fast-growing developing countries, p. 24. International Food Policy Research Institute, Research Report 157. <http://www.ifpri.org/sites/default/files/publications/rr157.pdf>. Accessed May 19, 2010.
- <sup>25</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, pp.41-2. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.
- <sup>26</sup>McLeod A, Thieme O, and Mack S.D. 2009, Structural changes in the poultry sector: will there be smallholder poultry development in 2030? World's Poultry Science Journal 65: 191-199. p. 196.
- <sup>27</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 4). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>28</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, pp. 57-58.
- <sup>29</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 58.
- <sup>30</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 262.
- <sup>31</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. xx.
- <sup>32</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. xx.
- <sup>33</sup>US Environmental Protection Agency. 2001. Emissions From Animal Feeding Operations. p. xi. <http://www.epa.gov/ttn/chief/ap42/ch09/draft/draftanimalfeed.pdf>. August 8, 2010.
- <sup>34</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p. 23. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.
- <sup>35</sup>United States Environmental Protection Agency. 2004. Risk Assessment Evaluation for Concentrated Animal Feeding Operations. EPA/600/R-04/042. p. iv. <http://www.epa.gov/nrmrl/pubs/600r04042/600r04042.pdf>.
- <sup>36</sup>Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 26). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>37</sup> Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, pp.13, 23. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed May 18, 2010.
- <sup>38</sup> Food and Agriculture Organization of the United Nations. 2009. The state of food and agriculture: livestock in the balance (Rome, Italy: FAO, p. 30). <http://www.fao.org/docrep/012/i0680e/i0680e.pdf>. Accessed May 19, 2010.
- <sup>39</sup>Kellogg RL, Lander CH, Moffitt DC, and Gollehon N. 2000. Manure nutrients relative to the capacity of cropland and pastureland to assimilate nutrients: spatial and temporal trends for the United States. U.S. Department of Agriculture Natural Resources Conservation Service. p. ii.

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<http://www.nrcs.usda.gov/technical/NRI/pubs/manmr.pdf>. Accessed June 17, 2008.

<sup>40</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 31.

<sup>41</sup>American Public Health Association. 2003. Precautionary Moratorium on New Concentrated Animal Feed Operations. <http://www.apha.org/advocacy/policy/policysearch/default.htm?id=1243>. Accessed January 13, 2011.

<sup>42</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p.11. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed January 12, 2011.

<sup>43</sup>Pew Commission on Industrial Farm Animal Production. 2008. Putting meat on the table: industrial farm animal production in America, p.11. <http://www.ncifap.org/bin/e/j/PCIFAPFin.pdf>. Accessed January 6, 2011.

<sup>44</sup>U.S. Environmental Protection Agency. 2003. National Pollutant Discharge Elimination System permit regulation and effluent limitation guidelines and standards for concentrated animal feeding operations (CAFOs); final rule. February 12. Federal Register 68(29):7181.

<sup>45</sup>Aillery M, Gollehon N, Johansson R, Kaplan J, Key N, and Ribaldo M. 2005. Managing manure to improve air and water quality. U.S. Department of Agriculture Economic Research Service, Report No. ERR-9. pp. 3, 5. [www.ers.usda.gov/publications/ERR9/](http://www.ers.usda.gov/publications/ERR9/).

<sup>46</sup>U.S. Environmental Protection Agency, Office of Water. 2001. Environmental assessment of proposed revisions to the National Pollutant Discharge Elimination System regulation and the effluent guidelines for concentrated animal feeding operations. pp. 3-16. <http://www.epa.gov/waterscience/guide/cafo/pdf/EnvAssessPt1of2.pdf>. Accessed January 24, 2011.

<sup>47</sup>U.S. Environmental Protection Agency Emission Standards Division. 2001. Emissions from animal feeding operations, draft. August 15. pp. 2-6. [www.epa.gov/ttn/chief/ap42/ch09/draft/draftanimalfeed.pdf](http://www.epa.gov/ttn/chief/ap42/ch09/draft/draftanimalfeed.pdf).

<sup>48</sup>U.S. Environmental Protection Agency. 2003. National Pollutant Discharge Elimination System permit regulation and effluent limitation guidelines and standards for concentrated animal feeding operations (CAFOs); final rule. February 12. Federal Register 68(29):7176, 7181.

<sup>49</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. xxii.

<sup>50</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 142.

<sup>51</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 4.

<sup>52</sup>United States Environmental Protection Agency. 2004. Risk Assessment Evaluation for Concentrated Animal Feeding Operations. EPA/600/R-04/042. p. 53. <http://www.epa.gov/nrmrl/pubs/600r04042/600r04042.pdf>.

<sup>53</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 143.

<sup>54</sup>World Health Organization. 2001. WHO global strategy for containment of antimicrobial resistance, p.4. [http://www.who.int/drugresistance/WHO\\_Global\\_Strategy\\_English.pdf](http://www.who.int/drugresistance/WHO_Global_Strategy_English.pdf). Accessed January 13, 2011.



- 
- <sup>55</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 143.
- <sup>56</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 144.
- <sup>57</sup>Chakravorty U, Fisher DK, Umetsu C. 2007. Environmental effects of intensification of agriculture: livestock production and regulation. Environmental Economic and Policy Studies (8): 315-336. pp. 326 -327.
- <sup>58</sup>United States Environmental Protection Agency. 2004. Risk Assessment Evaluation for Concentrated Animal Feeding Operations. EPA/600/R-04/042. pp. 45 -46.  
<http://www.epa.gov/nrmrl/pubs/600r04042/600r04042.pdf>.
- <sup>59</sup>Food and Agriculture Organization of the United Nations. 2010. The global forest resource assessment 2010: key findings, p. 3. <http://foris.fao.org/static/data/fra2010/KeyFindings-en.pdf>. Accessed May 19, 2010.
- <sup>60</sup>Gorte RW, and Sheikh PA. 2010. Deforestation and climate change, p. 1. Congressional Research Service. <http://www.fas.org/sgp/crs/misc/R41144.pdf>. Accessed May 19, 2010.
- <sup>61</sup>Food and Agriculture Organization of the United Nations. 2010. The global forest resource assessment 2010: key findings, p. 4. <http://foris.fao.org/static/data/fra2010/KeyFindings-en.pdf>. Accessed May 19, 2010.
- <sup>62</sup>Gorte RW, and Sheikh PA. 2010. Deforestation and climate change, p. 1. Congressional Research Service. <http://www.fas.org/sgp/crs/misc/R41144.pdf>. Accessed May 19, 2010.
- <sup>63</sup>Food and Agriculture Organization of the United Nations. 2006. Livestock Impacts on the Environment. <http://www.fao.org/ag/magazine/0612sp1.htm>. Accessed October 13, 2010.
- <sup>64</sup>Barona E, Ramankutty N, Hyman G, and Coomes OT. 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environmental Research Letters 5:1- -9, p. 8. [http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326\\_5\\_2\\_024002.pdf](http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326_5_2_024002.pdf). Accessed May 20, 2010.
- <sup>65</sup>Food and Agriculture Organization of the United Nations, Forestry Department. 2009. Global forest resources assessment 2010: Brazil country report, p. 15. <http://www.fao.org/forestry/20262-1-206.pdf>. Accessed May 19, 2010.
- <sup>66</sup>Kaimowitz D, Mertens B, Wunder S, and Pacheco P. 2004. Hamburger connection fuels Amazon destruction: cattle ranching and deforestation in Brazil's Amazon. Center for International Forestry Research, pp. 2-3. [http://www.cifor.cgiar.org/publications/pdf\\_files/media/Amazon.pdf](http://www.cifor.cgiar.org/publications/pdf_files/media/Amazon.pdf). Accessed May 20, 2010.
- <sup>67</sup>Margulis S. 2004. World Bank Working paper No. 22: Causes of Deforestation of the Brazilian Amazon, p. xviii. The World Bank. Available at [http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/02/02/000090341\\_20040202130625/Rendered/PDF/277150PAPER0wbwp0no1022.pdf](http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2004/02/02/000090341_20040202130625/Rendered/PDF/277150PAPER0wbwp0no1022.pdf). Accessed May 20, 2010.
- <sup>68</sup>Barona E, Ramankutty N, Hyman G, and Coomes OT. 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environmental Research Letters 5:1 -9, p. 8. [http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326\\_5\\_2\\_024002.pdf](http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326_5_2_024002.pdf). Accessed May 20, 2010.
- <sup>69</sup>Barona E, Ramankutty N, Hyman G, and Coomes OT. 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. Environmental Research Letters 5:1 -9. [http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326\\_5\\_2\\_024002.pdf](http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326_5_2_024002.pdf). Accessed May 20, 2010.

- 
- <sup>70</sup>Morton DC, DeFries RS, Shimabukuro YE, et al. 2006. Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Proceedings of the National Academy of Sciences of the United States of America* 103(39):14637 -14641, p. 14638. <http://www.pnas.org/content/103/39/14637.full.pdf+html>. Accessed May 20, 2010.
- <sup>71</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 12.
- <sup>72</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 38 -39, 43.
- <sup>73</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 43 -44.
- <sup>74</sup>Barona E, Ramankutty N, Hyman G, and Coomes OT. 2010. The role of pasture and soybean in deforestation of the Brazilian Amazon. *Environmental Research Letters* 5:1 -9, p. 8. [http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326\\_5\\_2\\_024002.pdf](http://iopscience.iop.org/1748-9326/5/2/024002/pdf/1748-9326_5_2_024002.pdf). Accessed May 20, 2010.
- <sup>75</sup>Food and Agriculture Organization of the United Nations, Livestock Information, Sector Analysis and Policy Branch, Animal Production and Health Division. 2006. *Livestock Policy Brief 03: Cattle ranching and deforestation*, p. 2. <ftp://ftp.fao.org/docrep/fao/010/a0262e/a0262e00.pdf>. Accessed May 20, 2010.
- <sup>76</sup>Morton DC, DeFries RS, Shimabukuro YE, et al. 2006. Cropland expansion changes deforestation dynamics in the southern Brazilian Amazon. *Proceedings of the National Academy of Sciences of the United States of America* 103(39):14637 -14641, p. 14637. <http://www.pnas.org/content/103/39/14637.full.pdf+html>. Accessed May 20, 2010.
- <sup>77</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 112.
- <sup>78</sup>Unger N, Bond TC, Wang JS, et al. 2010. Attribution of climate forcing to economic sectors. *Proceedings of the National Academy of Sciences of the United States of America* 107(8):3382 -3387, pp. 3382 -3383, 3384 Fig. 1, 3386. [http://pubs.giss.nasa.gov/docs/2010/2010\\_Unger\\_et\\_al.pdf](http://pubs.giss.nasa.gov/docs/2010/2010_Unger_et_al.pdf). Accessed May 20, 2010.
- <sup>79</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 79.
- <sup>80</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 82.
- <sup>81</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 112.
- <sup>82</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 112.
- <sup>83</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 82 Table 3.1.
- <sup>84</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 82 Table 3.1.

- 
- <sup>85</sup>Forster P, Ramaswamy V, Artaxo P, et al. 2007. Changes in atmospheric constituents and in radiative forcing. In: Solomon S, Qin D, Manning M, et al (eds.), *Climate change 2007: the physical science basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge, United Kingdom and New York, NY, USA: Cambridge University Press, p. 212 Table 2.14).
- <sup>86</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 86 -93, 113 Table 3.12.
- <sup>87</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 30, 66.
- <sup>88</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 45, 86-88.
- <sup>89</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 88 Table 3.4.
- <sup>90</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 113 Table 3.12.
- <sup>91</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 95 -96.
- <sup>92</sup> Federative Republic of Brazil. 2010. Second national communication of Brazil to the United Nations Framework Convention on Climate Change, p. 202. [http://www.mct.gov.br/upd\\_blob/0214/214078.pdf](http://www.mct.gov.br/upd_blob/0214/214078.pdf). Accessed January 21, 2011.
- <sup>93</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 113 Table 3.12.
- <sup>94</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 113 Table 3.12.
- <sup>95</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 113 Table 3.12.
- <sup>96</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 114.
- <sup>97</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, pp. 104-105, 113 Table 3.12.
- <sup>98</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. 113 Table 3.12.
- <sup>99</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. *Livestock's long shadow: environmental issues and options*. Food and Agriculture Organization of the United Nations, p. xxi.

---

<sup>100</sup>Steinfeld H, Gerber P, Wassenaar T, Castel V, Rosales M, and de Haan C. 2006. Livestock's long shadow: environmental issues and options. Food and Agriculture Organization of the United Nations, p. 112.

<sup>101</sup>Baroni L, Cenci L, Tettamanti M, and Berati M. 2007. Evaluating the environmental impact of various dietary patterns combined with different food production systems. *European Journal of Clinical Nutrition* 61:279 -286, p. 282 -283, Tables 2 -4.

<sup>102</sup>Weber CL and Matthews HS. 2008. Food-miles and the relative climate impacts of food choices in the United States. *Environmental Science & Technology* 42(10):3508 -3513, at pp. 3512 -3513, p. 3512.  
<http://pubs.acs.org/doi/pdf/10.1021/es702969f>. Accessed May 20, 2010.