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Gigaton Analysis of the Livestock Industry

The Case for Adoption of a Moderate Intensification Model

The Carbon War Room

The Gigaton Throwdown Initiative

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Executive Summary

Emissions from Livestock Production

Global emissions from livestock production account for 7.5 gigatons (Gt) of carbon dioxide equivalent (CO_2e) per year, representing 18 percent of manmade greenhouse gas (GHG) emissions.[1]

The main sources and types of greenhouse gases from livestock systems are CO_2 from land use and its changes (feed production, deforestation), which accounts for 32 percent of emissions from livestock; nitrous oxide (N_2O) from manure and slurry management, which accounts for 31 percent; and methane (CH_4) production from ruminants, which accounts for 25 percent of emissions and is a GHG that is 21 times more potent than CO_2.[2]

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For countries with growing livestock production industries that rely heavily on the clearing of forests for increasing grazing land, a moderate intensification of livestock production (raising more cattle on the same amount of land) has enormous potential to prevent an increase of several billion metric tons of CO_2e without falling short of production targets.

Strategies for Reducing Emissions from Livestock Production

There are several mature and proven methods for reducing emissions from livestock production, including adoption of improved pastures, diet intensification options, land use options, and changing breeds. One-hundred percent adoption of these strategies yields a reduction in emissions of 20.8 megatons (Mt) of CO_2e per year, and the potential for an optimistic but plausible adoption scenario, of 23 to 30 percent adoption, is 10.7 Mt CO_2e per year.[3]

The total mitigation potential of all options at a plausible implementation rate (23–30 percent) would result in a 214 Mt CO_2e reduction of emissions by 2030, and a maximum implementation rate (100 percent) would result in a 417 Mt CO_2e reduction of emissions by 2030.

For countries with growing livestock production industries that rely heavily on the clearing of forests for increasing grazing land, a moderate intensification of livestock production (raising more cattle on the same amount of land) has enormous potential to prevent an increase of several billion metric tons of CO_2e without falling short of production targets. Implementing a moderate intensification system, which includes improving pastures and changing breeds, has the potential to accomplish this goal and also increase revenues for livestock farmers and generate wealth for those that invest in these solutions.

Deforestation in Brazil Presents the Greatest Threat and Opportunity

Over the next decade and beyond, Brazil will rely heavily on the clearing of tropical forests for the expansion of livestock rangeland. Brazil's total carbon emissions are estimated at 5 Gt CO_2e annually, with 70 percent coming from deforestation and agriculture – an estimated 55 percent (or 1.4 Gt) from deforestation alone.[4] Annual deforestation in Brazil is estimated at over 3 million hectares (ha). Cattle ranching represents 80% of deforestation in the Amazon.

Brazil, as the largest exporter of beef and leather, has an estimated $5 billion annual market that has shown enormous growth over the last decade with exports increasing by a factor of four.[5] Brazil has set a national goal to double exports by 2018, increasing the number of cows raised in Brazil to 100 million.

This dramatic increase in cattle production stands to increase deforestation and drive up the associated environmental degradation. The primary cause of this is the current cattle management practice in Brazil, which suggests one cow per ha. Therefore, in an effort to obtain more useable land through deforestation, the impact of doubling cattle exports would be to double the CO_2e emissions from Brazil by 2018.[6] The deforestation component of cattle ranching in the Amazon produces 10 times more CO_2e per kg of meat than the industrial intensive, concentrated animal feeding operations used in the United States.

[1] Steinfeld *et al.* 2006
[2] Thornton & Herrerob 2009
[3] ibid
[4] McKinsey 2009
[5] Walker *et al.* 2010
[6] ibid

However, there are options to deter this increase in deforestation and green house gas emissions. For instance, agricultural residues and silage can be included in cattle diets, and grazing densities can be increased to up to six animals per ha. The land area of cattle ranching is so vast in the Brazilian Amazon that with just a moderate level of intensification, whereby cattle densities increase to just over two cows per ha, an area the size of California could be saved from future deforestation. This could provide a total annual mitigation potential of 0.9 Gt CO_2e/year, or a total mitigation potential of 6.5 Gt CO_2e by 2018. To accomplish this, an estimated $21.5 billion dollars of capital is required. The period of return on investment is approximately four and a half years, due to increased meat production.

Barriers to Implementation

Major barriers to implementation of moderate intensification in Brazil include lack of capital and legal enforcement. On the other hand, market pressure for zero-deforestation beef is one of the strongest forces that will ensure future deforestation does not continue. Some legal enforcement and market pressure elements are already in place in Brazil such as trade agreements and the public demand for sustainability from major purchasers of leather as well as satellite monitoring of the Amazon, but these measures alone have not put a stop to deforestation from livestock production. Legal enforcement and market pressure for zero deforestation will be critical components of the successful implementation of this livestock intensification model and they should be shown to be effective before implementing a moderate intensification plan.

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Livestock Emissions Profile

Livestock is a global resource that provides substantial benefits to society in the form of food, income, soil nutrients, employment, a means of insurance and risk spreading, traction, and clothing. However, in the process, livestock consume large amounts of natural resources. For example, livestock systems occupy approximately 30 percent of the planet's ice-free terrestrial surface area and account for 8 percent of the total use of fresh water.[7] The demand for livestock products in developing countries will nearly double by 2050 as a result of human population increases, urbanization, and growing economic prosperity.

By some estimates, livestock contribute to 18 percent of green house gas (GHG) emissions and for 80 percent of total anthropogenic land use annually.[8] The climate impact of raising livestock includes direct emissions as well as land use change emissions. Cattle release methane (CH_4) during digestion, which is a GHG 21 times more potent than carbon dioxide (CO_2).The main sources and types of greenhouse gases from livestock systems are: CO_2 from land use and its changes (feed production, deforestation), which accounts for 32 percent of emissions from livestock; nitrous oxide (N_2O) from manure and slurry management, which accounts for 31 percent; and methane (CH_4) production from ruminants, which accounts for 25 percent of emissions.[9]

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Diet improvements through increases in the quality of the feed or through supplementation are common strategies for intensifying the diets of livestock.

Sector Specific Solutions: Existing Literature on Potential Reductions

Four general sector-specific solutions are examined: adoption of improved pastures in Latin America, diet intensification options, land use options, and changing breeds of ruminants; there are summarized in Appendix I.

Adoption of Improved Pastures in Latin America

Adoption of improved pastures (*Bracharia*) can result in a net reduction in CH_4 emissions from livestock production. For instance, although CH_4 emissions per animal[10] consuming *Brachiaria* pastures compared to animals eating natural grasslands is higher (38.7 compared to 31.2 kg CH_4 per year), milk production and liveweight gain per animal per day are three times higher.

As a result, the number of animals required to satisfy demand is reduced under the improved pastures option, resulting in a significant reduction in CH_4 per unit of milk and meat produced and in total CH_4 produced. Adoption of improved deep-rooted pastures has the additional advantage of sequestering 29.5 t CO_2 per ha than natural rangeland vegetation.[11] The direct and indirect impacts of this strategy and a plausible adoption rate (30 percent) represent a mitigation potential of 29.8 Mt CO_2e. This could translate into more CO_2 savings from deforestation that was prevented than what has already been considered in the study, as fewer animals are needed to satisfy demand.

Diet Intensification Options

Diet improvements through increases in the quality of the feed or through supplementation are common strategies for intensifying the diets of livestock. Stover from crops is widely used as a feed resource and can represent up to 50 percent of the livestock diet.[12] Stover from different varieties of the same crop species has a wide range of digestibilities, and these differences are exploited by crop breeders to create dual-purpose crops with higher quality residues.

[8] ibid
[9] Thornton & Herrerob 2009
[10] Expressed as one tropical livestock unit, equivalent to a body weight of 250 kg
[11] Fisher *et al.* 1992
[12] Hererro *et al.* 2008

Implementing alternate diets with higher-quality components allow livestock farmers to reach a target quantity of animal product at lower CH_4 emissions and usually with fewer animals. Improving the digestibility of crop residues produces less milk (3.6 compared to 4.9 kg milk per day) and more CH_4 (33.0 compared to 31.7 kg CH_4 per year) than supplementing the same basal diet with grain concentrates. However, both produce more milk and meat than the control diet and can offset CH_4 production by a significant reduction in the numbers of animals needed to satisfy demand. The total mitigation potential of crop residue digestibility improvements is higher than grain supplementation owing to its broader applicability.

This option is applicable across most rain-fed and irrigated mixed systems where large concentrations of animals exist and numbers are projected to increase. Therefore, significant reductions in the numbers of animals to meet demand can occur, whereas feeding grain concentrates is an option that is most appropriate to the humid and temperate mixed systems.

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Agroforestry practices have dual mitigation benefits. Agroforestry species usually have a high nutritive value and can help to intensify diets of ruminants while they can also sequester carbon.

Land Use Options

Carbon sequestration through restoration of degraded rangelands in tropical Central and South America (CSA) and Sub-Saharan Africa (SSA), and the use of agroforestry practices in mixed crop – livestock systems in humid and tropical highland areas of the developing world are two options commonly believed to have a high mitigation potential. Despite lower potential rates of carbon sequestration in SSA rangelands than in CSA (190 compared to 691 kg C per ha per year),[13] a higher proportion of degraded lands and a greater rangeland area can lead to a higher (almost double) mitigation potential for SSA rangelands than in CSA.

Agroforestry practices have dual mitigation benefits. Agroforestry species usually have a high nutritive value and can help to intensify diets of ruminants while they can also sequester carbon. In this example, replacing some concentrates and part of the basal diet with leaves of *Leucaena leucocephala* also intensifies diets so that animal numbers can be reduced to meet livestock product demand. Approximately 28 percent of the plausible mitigation potential of 32.9 Mt CO_2e for this option comes from the reduction in possible livestock numbers, compared to 72 percent contributed from the carbon sequestration effects.

Improved Breed Adoption

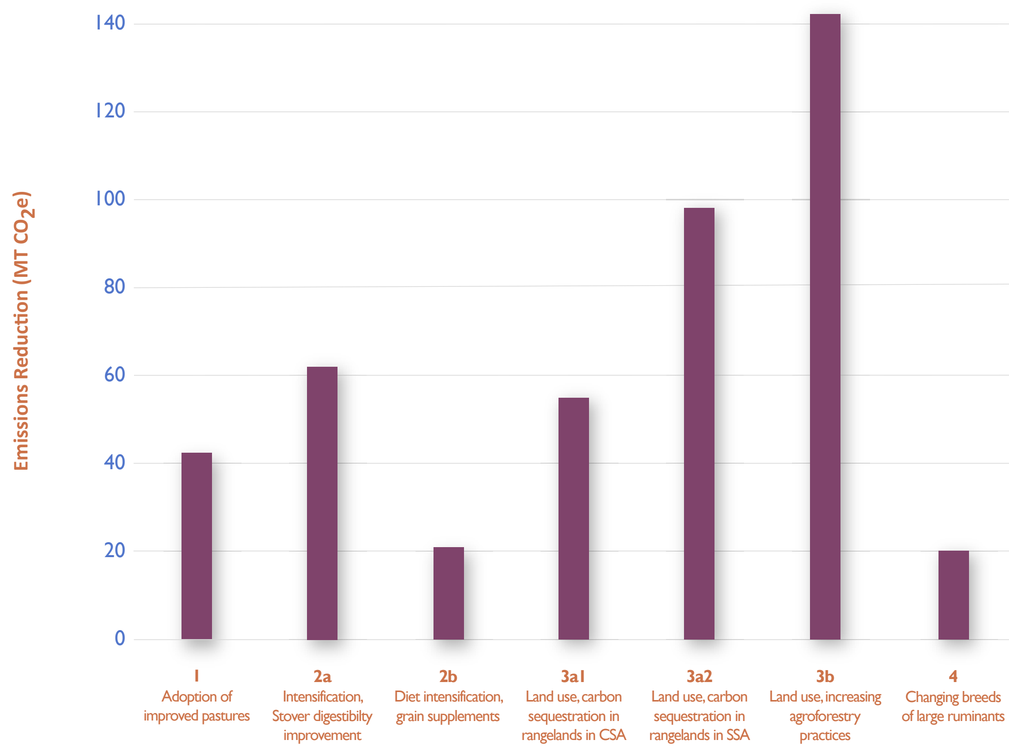
At the current adoption rates of using improved breeds with higher milk production potential and higher body weights, only modest reductions in the amount of CH_4 produced per ton of milk can be obtained. This option potentially could be applied to many animals and across large areas, but the maximum mitigation potential is estimated to be a relatively modest 19 Mt CO_2e by 2030.

[13] Conant & Paustian 2002

Comparisons Between the Different Options

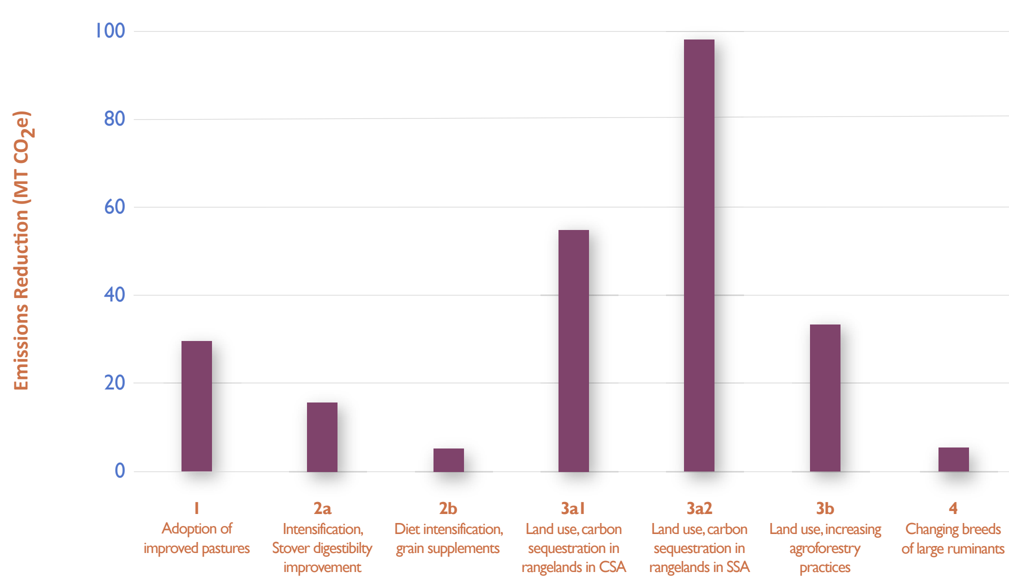
Comparison of options at observed or plausible adoption rates (Fig. 1, Fig. 2, and Table 2 Appendix I) suggest that restoration of degraded rangelands in SSA and CSA has the highest mitigation potential, owing to the magnitude of land degradation and the total area of rangeland in use, although there may well be issues associated with its implementation. The agroforestry option, which sequesters carbon and intensifies diet quality to reduce animal numbers, has the second greatest potential.

Figure 1 • Mitigation Potential by 2030 at 100 Percent Adoption Rate



Source Thornton & Herrerob 2009

Figure 2 • Mitigation Potential by 2030 at 23-30 Percent Adoption Rate



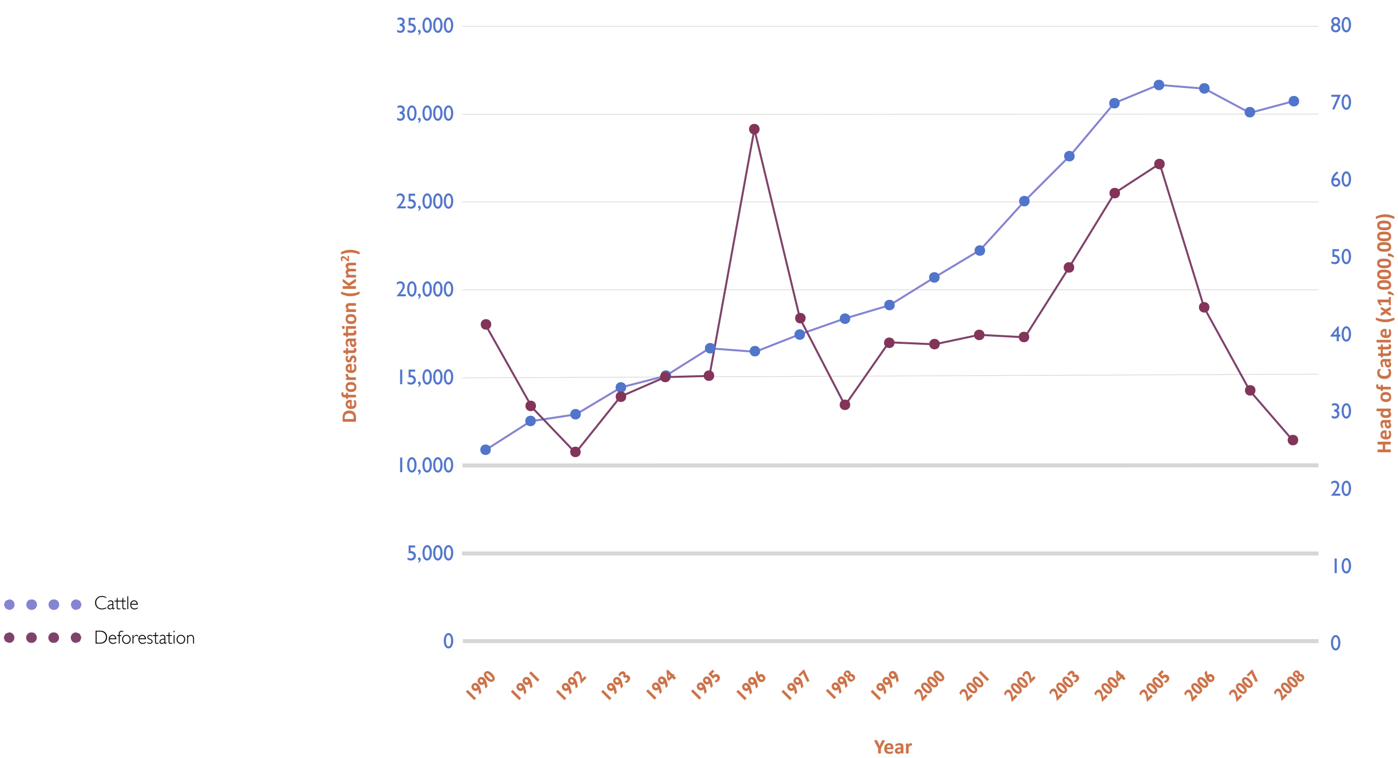
Source Thornton & Herrerob 2009

The total mitigation potential of all options at a plausible 23 to 30 percent implementation rate would result in a 214 Mt CO_2e reduction of emissions. The total mitigation potential of all options at a 100 percent implementation rate would result in a 417 Mt CO_2e reduction of emissions.

Livestock Production in Brazil

As the nation with the most commercial cattle herds and the top exporter of beef, Brazil is in the position to deliver a massive impact to emissions mitigation.[14] The conversion of forests to cattle ranches is the biggest cause of deforestation in the Brazilian Amazon. Seventy percent of deforestation in the Brazilian Amazon is due to expansion of medium to large sized cattle ranches, and around 80 percent of the total deforested land is used for cattle grazing.[15] The recent drop in deforestation has been attributed to falling meat and soy prices, which, considered together, correlate well with deforestation rates.[16]

Figure 3 • Deforestation and Cattle Herd in the Legal Amazon, 1990-2007



Source Instituto Nacional de Pesquisas Espaciais (INPE) 2010 (deforestation); Instituto Brasileiro de Geografia e Estatística (IBGE) 2010 (cattle numbers), adopted from: *Walker et al.* 2010

[14] USDA FAS 2009

[15] Fearnside 2005; Amigos da Terra – Amazônia Brasileira 2009; Greenpeace 2009a2

[16] Barreto *et al.* 2008a; Greenpeace 2009a

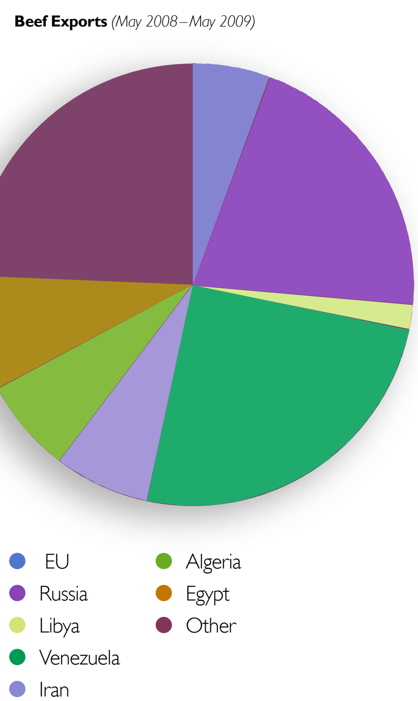
Market Overview

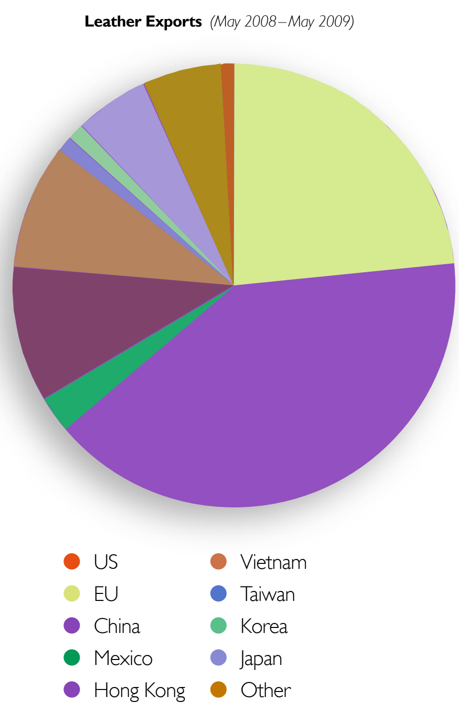
Beef production for export is relatively new to the Amazon. Until the mid-1990s, ranchers raised cattle for domestic markets, or simply to occupy the land for speculative purposes. However, an increasing domestic demand, the eradication of hoof-and-mouth disease, the rise of mad cow disease outside of Brazil, and the currency devaluation have contributed to a seven-fold increase in Brazilian beef exports between 1990 and 2008.[17] Therefore, the growing external demand for beef is a serious threat to the forests of the Brazilian Amazon. Exports currently account for over one fifth of beef production and the biggest export markets for beef are the European Union, Russia, and Venezuela (Fig. 4a).[18]

Leather exports also provide significant revenues. The European Union (particularly Italy), China, and Vietnam are the biggest importers of leather originating in the Brazilian Amazon (Fig. 4a). Approximately 44 percent of all Amazon leather exports from 2008 through May 2009 were sent to China, where such leather is used to make a variety of products, including footwear. Eighty-eight percent of U.S. footwear imports come from China.[19] Brazil is also a major producer and exporter of footwear. In 2010, the United States imported 26 million pairs of shoes from Brazil.[20]

The majority of Brazilian cattle ranching operations are publicly funded through the Brazilian National Bank of Economic and Social Development (BNDES), which has focused its lending on expansion and acquisition projects, while dedicating only 6 percent of its funds toward restoring pastureland. Cattle ranching in the Brazilian Amazon is carried out with an average grazing density of only 1.08 animals per hectare (ha).[21] Improvements in the production system potentially provide scope to greatly increase cattle production without the need for any additional land. For example, agricultural residues and silage can be included in cattle diets, and grazing densities can be increased to up to six animals per ha.[22] The land area of cattle ranching is so vast in the Brazilian Amazon that with just a moderate level of intensification, whereby cattle densities increase to just over two cows per hectare, an area of the Amazon Rainforest the size of California could be saved from deforestation by 2018.

Figure 4b • Exports of Beef and Leather from Three Largest Brazilian Amazon Export States (Mato Grosso, Pará and Tocantins) to Largest Importers by value.





Source Ministério do Desenvolvimento Indústria e Comércio Exterior (MDIC) 2009, adopted from: Walker *et al.* 2010

[17] Kaimowitz *et al.* 2004; USDA FAS 2010
[18] MDIC 2009
[19] American Apparel & Footwear Association 2010
[20] ibid
[21] Amigos da Terra – Amazônia Brasileira 2009
[22] Nepstad *et al.* 2008

Cattle Emissions in Brazil Versus the United States

In the United States, it is common for beef cattle to be raised in Concentrated Animal Feeding Operations (CAFOs) and fed mainly a corn and soy diet. The total GHG footprint of beef production in the United States is 4.5 to 5.4 metric tons of CO_2e per head of cattle or 22kg CO_2e emissions per kg of meat. [23]

In the Brazilian Amazon, cattle are raised in an extensive management system of low density pasture grazing and the average cow weighs 450 kg, as compared to the United States where the average cow weights 607 kg.[24] Enteric fermentation emissions from grazing herds are roughly double those of CAFOs.[25] However, over 50 percent of enteric fermentation emissions of CAFO animals come from N_2O emissions as a result of manure management and feedcrop fertilization.[26] In Brazilian pasture management systems, these emission levels could be lower than 10 percent of those in the United States and therefore the total emissions per kg of meat or per head of cattle, considering only these emissions, would not be very different. A large differentiator of emissions in the Brazilian Amazon versus the United States is direct land use change. As stated above, around 80 percent of deforestation in the Brazilian Amazon is driven by land use conversion to cattle pasture, which equates to 560 million metric tons of CO_2e/year. [27] When taking into account emissions from deforestation related to pasture expansion, beef raised in the Brazilian Amazon produces 300 kg CO_2e per kg of meat.[28]

Therefore, the deforestation component of cattle ranching in the Amazon results in 10 times more CO_2e per kg of meat than the industrial intensive CAFO. As the livestock sector is expected to double by 2050, this level of cattle production will not be sustainable from a land use or climate perspective without significant changes.[29]

Therefore, the deforestation component of cattle ranching in the Amazon results in 10 times more CO_2e per kg of meat than the industrial intensive CAFO.

Cattle Ranching Intensification in the Brazilian Amazon

Brazil has set a national goal to double beef and leather exports by 2018, increasing the number of cows raised nationally from 50 million to 100 million. Under an inefficient business-as-usual scenario of one cow per ha, the addition of 50 million head will drive the deforestation of 50 million ha, which equates to about 6 percent of the total land area of Brazil.

Through intensification of livestock – namely, increasing the number of cows per hectare – it might be possible for Brazil to attain its export goal (100 million cows, 2018) without additional deforestation and at the same time reduce methane emissions per gross production output. The agricultural research agency of Brazil, Embrapa, has developed a moderate intensification model for cattle ranching that more than doubles the head of cattle per ha, from the current model of one cow per ha to an estimated two to two and one-half cows per ha. Components of the intensification model include the following:

- Innovative mixtures on native and nonnative grasses and legumes to reduce enteric fermentation (CH_4)
- Improved animal husbandry and breeding using European breeds to reduce time to reach slaughter weight
- Active rotation using small, fenced paddocks to eliminate need for deforestation.

[23] Johnson *et al.* 2003
[24] Evans 2006; USDA 2008
[25] Steinfeld *et al.* 2006
[26] Johnson *et al.* 2003
[27] McAlpine *et al.* 2009
[28] Bustamente *et al.* 2009
[29] Steinfeld *et al.* 2006

Gigaton Opportunity

A moderate intensification model for Brazil presents an opportunity to reduce CO_2e emissions by several gigatons. Under business-as-usual, Brazil's emissions could rise by half a gigaton or more a year by 2018, driven mostly by deforestation. Implementing this model would provide a total annual mitigation potential of 0.9 Gt CO_2e per year, or a total project mitigation potential of 6.5 Gt CO_2e by 2018.

Implementing Solutions in Brazil: Investment Opportunities

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In order to achieve a reduction of 6.5 Gt CO_2e by 2018 in Brazil through implementation of moderate intensification systems for livestock, representing an 85 percent reduction over projections based on the business-as-usual scenario, an estimated investment of $21.5 billion dollars is required, or $541.51 dollars per ha.

In order to achieve a reduction of 6.5 Gt CO_2e by 2018 in Brazil through implementation of moderate intensification systems for livestock, representing an 85 percent reduction over projections based on the business-as-usual scenario, an estimated investment of $21.5 billion dollars is required, or $541.51 dollars per ha.

Operational expenses for additional ranch hands, purchase of sperm, maintenance (fences, etc.), and nutritional supplementing animals are estimated at $46 per cow per year.[30]

Table I • Labor Costs Associated with Changing Grass Species

Capital Expenditures	Costs (R$/ha)	Costs (US$/ha)
Cutting of Vegetation	5.4*	3.2*
Planting	163.62*	98.4*
Manual Weeding	27.27*	16.4*
Fence Construction/Animal Breeding	703.71	423.51
Total	900§	541.51§

*Values are from Embrapa presentation: Increasing Productivity of Cattle Production Systems and Reducing Deforestation and Greenhouse Gas Emissions in the Amazon. These assume 2.42 bushels/ha. Conversion to US dollars is based on 1.00 R$ = 0.60168 USD.

§ Value estimate from Nathalie Walker, National Wildlife Federation.

Fence construction and animal breeding costs are assumed to be the difference of total costs minus replanting costs §-*.

Time Table for Returns

The period of return is approximately four and a half years. It takes one year to clear the land and prepare for the new grass mix to be planted ($118/ha), one additional year for this grass to grow, and two years to produce a mature cow. These steps need to be implemented on half of the ranchers land at a time, after which, the cows per ha can be doubled, thus also doubling annual profits.[31]

[30] ibid
[31] Walker 2010

Key Challenges

The viability of implementing and scaling a moderate intensification model for cattle ranching in the Brazilian Amazon is dependent on several factors. In order to attract private finance on a scale necessary to implement the system country wide, there will likely be a need for test cases and a more comprehensive documentation and analysis of the costs and challenges such as leakage.

Perhaps the greatest threat of ecological damage associated with any REDD project to reduce deforestation in the Amazon is the displacement of forest clearing for livestock and grazing land away from high biomass forests into lower biomass ecosystems, a particularly detrimental form of leakage. Another, potentially equally damaging, threat posed by reduced deforestation in one area is the replacement of native ecosystems by monoculture tree plantations.

In the long term, the growing global demand for food, driven in part by both population growth and increasing levels of affluence in emerging economies, will exacerbate the tendency of REDD to displace agricultural expansion into low-biomass ecosystems, demanding a more systemic solution.[32] For example, the intensification (i.e., increase in the yield per area) of agricultural and livestock production on existing cleared lands could allow growing global demands for food, fuels, feeds, and fiber to be met without expansion of the area of cultivation and grazing, although intensification is not without its ecological costs, either.[33]

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The intensification (i.e., increase in the yield per area) of agricultural and livestock production on existing cleared lands could allow growing global demands for food, fuels, feeds, and fiber to be met without expansion of the area of cultivation and grazing, although intensification is not without its ecological costs, either.

A major concern will also be the monitoring and enforcement of protection statutes for forests. While a moderate intensification model for livestock will theoretically reduce the impetus for deforestation due to 70 percent of deforestation being driven by this industry,[34] a moderate intensification model may be viewed as an opportunity to not just double production on existing land, but also as an opportunity to increase production on a much higher magnitude through the expansion of grazing land by deforestation.

A key challenge will be to increase market pressure on livestock producers to provide products guaranteed to be sustainable and to bring in partners from both the government and the NGO space to assist with monitoring and enforcement.

Capital Requirements

Private finance is needed to cover the upfront cost to farmers of introducing new crops, introducing new cattle breeds, and to build fencing and additional infrastructure. Initial sources of capital will likely be provided by government or NGO entities for demonstration cases. A carbon price for reduced deforestation credits under REDD would also be helpful with respect to attracting, and possibly providing, capital to make the investment in the intensification model. Assuming a carbon price of 7.5 $/ton, the intensification model could yield approximately $48.7 billion dollars over a 20 year project life under a REDD project scenario.

Legal Protection of Forests and Enforcement

Legal protection of forests and enforcement is a key requirement for the success of the moderate intensification model. Until only two years ago there was no large-scale enforcement of laws preventing land appropriation or violations of the Forest Code. Globally, to protect forests, there must be strong demand for forest credits matched by strong verification and enforcement of forest protection, which are the goals of REDD.

Brazil currently has systems in place for national-scale monitoring of deforestation (*DeFries et al.,* 2006), which would aid in legal protection, enforcement, and verification. Under threat of prosecution by the Federal Public Prosecutor's Office in Pará state, the major slaughterhouses signed an agreement (Terms of Adjustment of Conduct, known as the TAC) that from February 2010, they would only buy cattle from ranchers registered with the Pará State Rural Environmental Register (Cadastro Ambiental Rural, or CAR).[35] A similar agreement was later signed in Mato Grosso state, the largest cattle producing state in the Amazon. In order to obtain the CAR, ranchers must provide the GPS coordinates of their properties' boundaries. Brazil's state-of-the-art deforestation monitoring system can be used to detect whether there is new deforestation within these ranch boundaries (*Walker et al.* 2010a).

[32] Nepstad *et al.* 2006; Nepstad & Stickler 2008
[33] Steinfeld *et al.* 2006
[34] Fearnside 2005
[35] Barreto & Silva 2010

Training programs for local farmers will also be necessary. The National Wildlife Federation is planning a series of workshops throughout the Amazon with JBS, World Wildlife Fund, and other NGO partners to explain to ranchers the benefits of improved pasture management.

Market Pressure for Zero Deforestation Beef

The global footwear industry, which is a primary consumer of leather products, is highly centralized. For example, Nike enjoys a 16 percent market share of the global footwear industry and the company is expected to increase its market share to 19-21percent in the next six years.[36] Many footwear companies have already expressed a desire to source leather from sustainable producers, based in part of consumer pressure. There is also an opportunity for large companies to meet public expectation by certifying goods and demanding merchandise that is not sourced at the expense of environmental degradation. This is an area for market leverage that, if coupled with NGO pressure on industry, can drive demand for zero deforestation beef, leather, and tallow. Slaughterhouses are also to some extent demanding zero deforestation beef from ranchers, further increasing the pressure for so-called zero deforestation beef.

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There is also an opportunity for large companies to meet public expectation by certifying goods and demanding merchandise that is not sourced at the expense of environmental degradation.

The International Leather Working Group was set up to improve environmental standards in the leather industry, whose members include major leather brands and tanneries such as Adidas, New Balance, Nine West, Puma, and Nike.[37] This year, the Group agreed on new standards in a revised Tannery Auditing Protocol, which calls for improved traceability for leather sourced from Brazil and processed by tanneries that supply its members. The zero deforestation language in the Protocol demonstrates how, for the first time, key players in the leather industry are acting to prioritize Amazon conservation.[38]

On October 5, 2009, Brazil's largest slaughterhouses (JBS-Bertín, Marfrig, and Minerva), signed an agreement with Greenpeace that set a timeline to reach a date where they would only buy from ranches they can show have no deforestation. The slaughterhouses started by obtaining one georeferenced location point from all their direct suppliers and overlaying these points on maps of recent deforestation, protected areas, and indigenous lands. Suppliers found to be located near protected areas or areas of new deforestation were then required to prove that the new deforestation was not on their property or they would be suspended from supplying the slaughterhouse. In July 2010, this process led to the slaughterhouses announcing that they had suspended purchases from 221 suppliers.[39]

This action represents a very small proportion of the tens of thousands of ranches that supply them but shows how in a matter of months, several slaughterhouses were able to eliminate deforestation from their direct suppliers. The next steps are to obtain full GPS boundary coordinates of all the directly supplying ranches (often large fattening farms) and subsequently to address indirect suppliers, which are often small calving ranches. This latter step is likely to present a much greater challenge.

[36] The Street 2010
[37] Leather Working Group 2010
[38] Walker *et al.* 2010a
[39] Amazona Informa 2010

Appendix I. Data From Thornton and Herrerob 2009

Table 2 • Mitigation Options for Livestock Sector

Option	Region	System	Gas affected	Changes evaluated
1. *Adoption of improved pastures*				
	CSA	LGH	CH_4, CO_2	Cerrado vegetation to Brachiaria spp. pasture: digestibility increase, impacts on animal productivity Carbon sequestration (9) Restoration of degraded soils (10) Area adopted: best case from Central America, 1990–2003, 1.3 percent per year (30 percent to 2030); average of five countries, 0.6 percent per year (11)
2. *Diet intensification*				
(a) Stover digestibility improvement	SSA, SA	MRA, MRH, MRT, MIA, MIH, MIT	CH_4	Stover digestibility increase by 10 percent, impacts on animal productivity Adoption rate: 43 percent, maximum observed for genetically improved Adoption rate: 43 percent, maximum observed for genetically improved dual-purpose cowpea in West Africa (12); generally much lower rates (<10 percent) are observed or expected (13); 23 percent to 2030 used here (1 percent per year)
(b) Grain supplements	SSA, SA	MRH, MRT, MIH, MIT	CH_4	Grain supplement: increase from 0.5 to 2.0 kg per head per day, impacts on animal productivity Adoption rate: 23 percent to 2030 assumed (1percent per year). In the absence of data, similar adoption rates to agroforestry-based supplements may be plausible
3. *Land use*				
(a) Carbon sequestration in rangelands	CSA, SSA	LGA, LGH, LGT	CO_2 (CH_4)	Changed carbon sequestration rates (10) (Methane production at intermediate stocking rates: not evaluated here) Complete adoption
(b) Increasing agroforestry practices	CSA, SSA, SA, SEA	MRH, MRT	CH_4, CO_2	*Leucaena* spp supplement of leaves, animal performance: Adoption rate: 1 percent per year, 23 percent to 2030 assumed, plausible for the best case (14) Carbon sequestration per ha: average lower limit for different tropical agroforestry systems (15)

CSA, tropical Central and South America; SA, South Asia; SEA, Southeast Asia; SSA, Sub-Saharan Africa; LG, rangeland-based systems; MI, mixed crop-livestock irrigated systems; MR, mixed crop-livestock rainfed systems; A, arid-semiarid systems (including hyper-arid); H, humid-sub humid systems; T, tropical highland systems.

Table 3 • Mitigation potential of livestock sector specific solutions listed above, Thornton and Herrerob (2009)

	CH_4 production (kg) per t of		No. of bovines (×106) needed to satisfy demand in 2030 for		Mitigation of CH_4 via reduction in bovine nos. (Mt $CO_{2\text{-eq}}$)	C sequestered via restoration of degraded pastures[*] (Mt $CO_{2\text{-eq}}$)	C sequestered via land-use change (Mt $CO_{2\text{-eq}}$)	Total Mitigation (Mt $CO_{2\text{-eq}}$)
Option	**Milk**	**Meat**	**Milk**	**Meat**				
1. Adoption of improved pastures in LGH systems in CSA								
Cerrado	78	1,552	45.5	45.5	–	–	–	–
100 percent adoption[†] of *Brachiaria* pasture	31	713	14.7	16.8	7.4	23.5	13.5[‡]	44.5
30 percent adoption[†] of *Brachiaria* pasture	64	1,300	36.2	36.9	2.2	23.5	4.1[‡]	29.8
2a. Diet intensification: stover digestibility improvement in MR, MI systems in SSA, SA								
Baseline diet[§]	58	1,958	490.1	490.1	–	–	–	–
100 percent adoption[†] of stover with 50 percent digestibility (from 40 percent)	25	548	177	114.3	61.6	–	–	61.6
23 percent adoption[†] of stover with 50 percent digestibility (from 40 percent)	50	1,634	418.1	403.6	14.2	–	–	14.2
2b. Diet intensification: grain supplementation in MRH, MRT, MIH, MIT systems in SSA, SA								
Baseline diet[§]	58	1,958	148	148	–	–	–	–
100 percent adoption[†] of increasing grain supplementation from 0.5 to 2 kg/head/d	18	395	39.3	22.5	22.1	–	–	22.1
23 percent adoption[†] of increasing grain supplementation from 0.5 to 2 kg/head/d	49	1,598	123	119.1	5.1	–	–	5.1
3a. Land use: restoration of degraded pastures in the LG systems in CSA and SSA								
In CSA	–	–	–	–	–	53.6	–	53.6
In SSA	–	–	–	–	–	96.7	—	96.7
3b. Land use: increasing agroforestry practices in the MRH, MRT systems in CSA, SSA, SA, SEA								
Baseline diet[§]	58	1,958	287.6	287.6	–	–	–	–
1 kg Leucaena supplement replacing 0.5 kg stover and 0.5 kg concentrate (100% adoption[†])	25	523	103.9	59.2	40.3	–	102.7[¶]	143
1 kg Leucaena supplement replacing 0.5 kg stover and 0.5 kg concentrate (23% adoption[†])	50	1,628	245.3	235.1	9.3	–	23.6[¶]	32.9
4. Changing breeds of large ruminants in the LG (meat) and MRH, MRT, MIH, MIT (milk) systems in CSA, SSA, SA, SEA								
Local breeds	31	713	363.3	172.8	–	–	–	–
100 percent adoption[†] of crossbreeds	26	568	171.6	77.8	19.5	–	–	19.5
29 percent adoption[†] of crossbreeds	30	671	307.7	145.2	5.6	–	–	5.6

[*] Rates of carbon sequestration from ref. 10.
[†] "Adoption" refers to the proportion of total milk and meat production in 2030 that comes from implementing the option analyzed.
[‡] Carbon sequestration data from ref. 9.
[§] Baseline diet: grazing (1.3 kg DM), stover at 45% digestibility (2 kg DM), cut-and-carry (1 kg DM), grain concentrates (0.5 kg DM).
[¶] Carbon sequestration data from ref. 15.

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About The Carbon War Room

Carbon War Room works on breaking down market barriers for capital to flow to entrepreneurial solutions to climate change, by employing a sector-based approach focusing on the solutions that make economic sense right now. We target the movement of institutional capital into a working marketplace and the elimination of market inefficiencies (in the form of insufficient information and high transaction costs, among others). Policy and technology are necessary conditions to the solution; however, they are neither sufficient, nor the bottleneck to progress.

Our vision is to see markets functioning properly, and clean technology successfully scaling to promote climate wealth, business and economic growth. In the role of a climate wealth catalyst, Carbon War Room focuses on areas where a sector-by-sector approach to climate change can be applied to generate gigaton-scale carbon savings. We seek to complement existing efforts and organizations, leveraging our convening power, our market-driven, solutions-oriented focus, and our powerful global network to develop and implement catalytic change.

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