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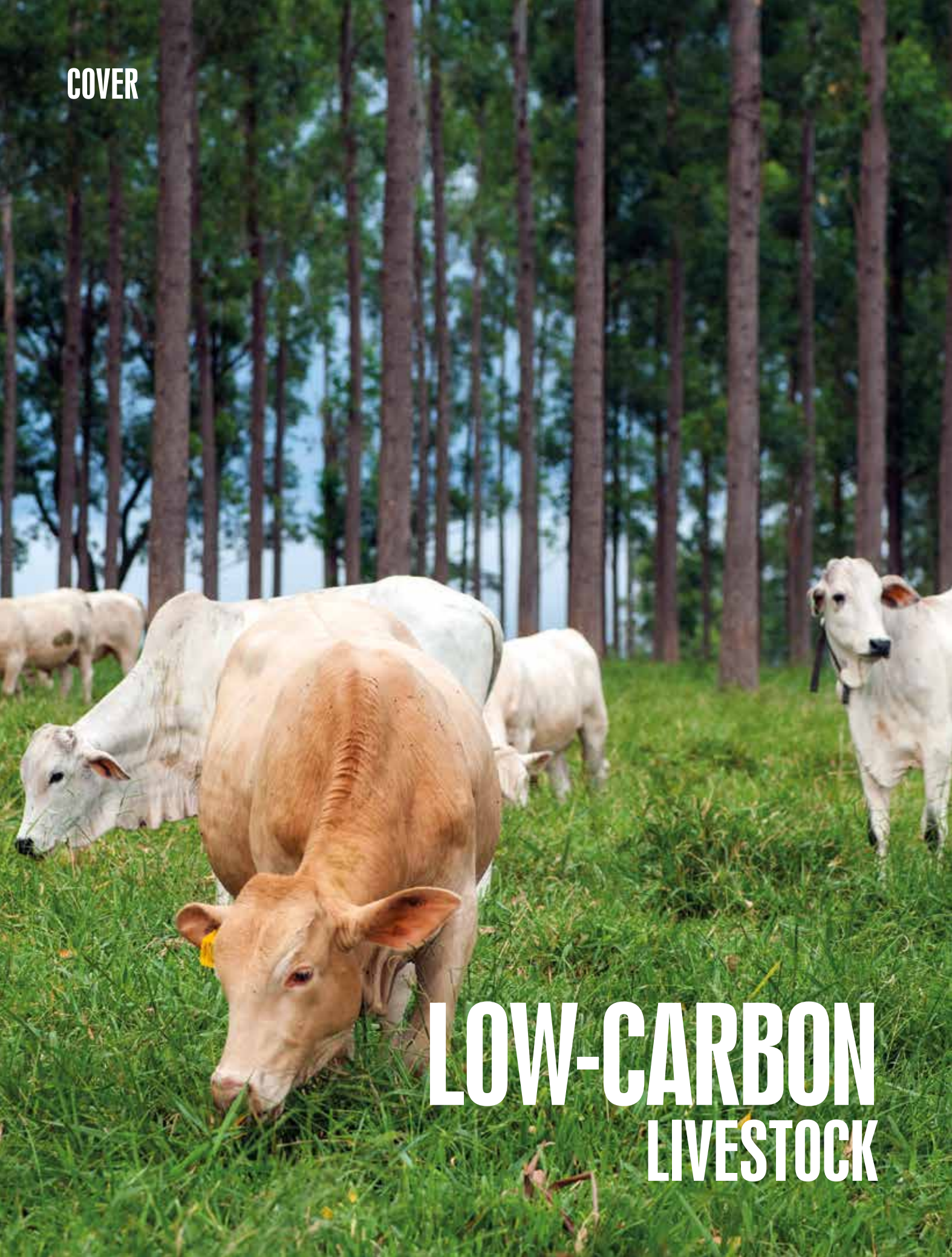

LOW-CARBON LIVESTOCK

LÉO RAMOS CHAVES / PESQUISA FAPESP MAGAZINE

Integrated pasture and forest at Canchim Farm in São Carlos, São Paulo, owned by Embrapa Southeast Livestock

With more head of commercial cattle than any other country in the world, Brazil faces the challenge of reducing greenhouse gas emissions associated with this sector

Domingos Zaparolli and Yuri Vasconcelos

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Corumbiara farm, located in the Brazilian state of Rondônia near the border with Mato Grosso, has 16,000 head of Nelore cattle, the most common breed in the country, on its 16,800 hectares (ha) of land. Until six years ago, productivity at the ranch was low, and few environmental sustainability practices had been implemented. Pasture areas were degraded, suffering from increasing erosion, and the herd drank water from springs located in permanent preservation areas (PPAs),legally-designated nature reserves that cattle are not permitted to access.

Changes came with the adoption of a system based on integrated agriculture and livestock farming (IAL) conceived by the Brazilian Agricultural Research Corporation (Embrapa) in the 1990s. Under the IAL system, land use is alternated between agricultural and livestock activities with the aim of increasing the efficiency of natural resources and reducing the environmental impact of livestock. Well-managed crop fields and pasture areas can sequester carbon from the atmosphere, offsetting livestock emissions; cattle are a major generator of methane (CH_4), one of the greenhouse gases (GHGs) responsible for global warming.

The results quickly became apparent. Today, every ton of meat produced at Corumbiara generates 11.5 tons of carbon dioxide equivalent (tCO_2e). Although still considered high, this volume is approximately 40% lower than the global average, which is estimated at 19.9 tCO_2e. The carbon dioxide equivalent is used to represent the greenhouse gases in the form of CO_2. The data are from a pioneering Brazilian study by the Institute of Forest and Agricultural Management and Certification (IMAFLORA), a non-governmental organization that measured the carbon balance of suppliers of Minerva Foods in South America.

Corumbiara currently has 1,850 ha dedicated to IAL, equivalent to 22% of the property's 8,400 ha usable for farming; the rest of the land, by law, cannot be exploited. Another 1,250 ha of the usable area is PPA, which was fenced off for recovery via the planting of native vegetation. The division between crops and livestock works is as follows: in September, soybeans are planted, which are later harvested and sold. In February, maize is planted, together with a highly digestible grass, *Brachiaria ruziziensis*. The maize is harvested in May and used over time as cattle feed, complementing their grass-based diet. The combination sustains the animals in the dry period between June and August, when the IAL area is used by the cattle.

In addition to absorbing carbon, the grass allows production in the area to be intensified, with three heads of cattle occupying each ha, while the average in non-IAL areas is 1.5 heads per ha. Good nutrition in the dry season helps cattle in the IAL area reach the ideal weight for slaughter in 22 months, approximately a year earlier than the standard. The shorter the animal's life, the less GHGs emitted per kilogram (kg) of meat produced.

Growing grass also offers other benefits. Its roots and remains add organic matter into the soil, storing carbon as a result. At the same time, grass helps decompact the earth after it has been trampled by cattle, promoting better recycling of soil nutrients. "The IAL system improves productivity and sustainability," says agronomist Fábio Souza, manager of Corumbiara. "Over the next two years, we plan to expand the IAL area to 4,000 ha. We want to reduce our environmental impact even more."

THE IMPACT OF METHANE

The production system that integrates agriculture and forestation (IAF), in addition to a broader version that includes livestock (IALF), is one of the solutions being implemented in Brazil

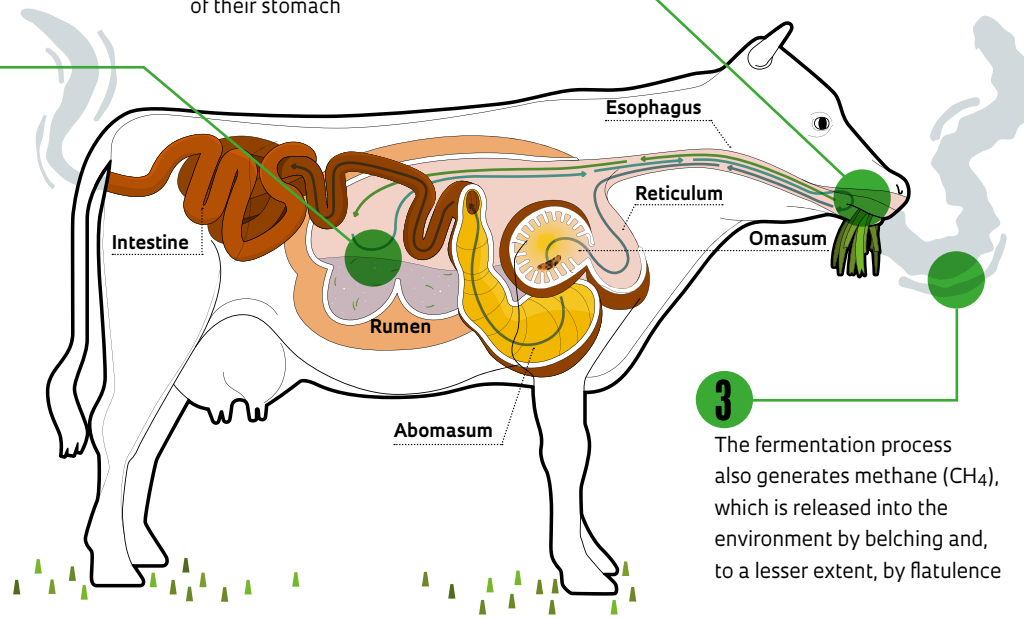
METHANE FACTORIES

The digestive process of cattle generates one of the most harmful gases to the planet's climate

1 To digest grass, which is rich in fiber, the animals rely on microorganisms that live in the rumen, one of the four compartments of their stomach

Livestock also releases another greenhouse gas, **nitric oxide (N_2O)**, which is formed through the microbial transformation of nitrogen compounds in animal waste (feces and urine) deposited in the pasture

2 These microorganisms are capable of breaking down the cellulose and hemicellulose in the fiber, as well as other nonfibrous carbohydrates, through fermentation. Carbohydrates are converted into volatile fatty acids (acetic, propionic, and butyric acids), which are the main energy sources for cattle



3 The fermentation process also generates methane (CH_4), which is released into the environment by belching and, to a lesser extent, by flatulence

SOURCE FLÁVIO PORTELA SANTOS / "GASES DE EFEITO ESTUFA E A SUSTENTABILIDADE DE FAZENDAS DE PRODUÇÃO DE CARNE BOVINA" (GREENHOUSE GASES AND THE SUSTAINABILITY OF CATTLE FARMS), BY JOÃO JOSÉ ASSUMPÇÃO DE ABREU DEMARCHI, ZOOTECHNICAL INSTITUTE

to make cattle farming more environmentally friendly. Brazil has more commercial cattle than any other country in the world, with 218 million animals, ahead of China and the USA. In 2020, it exported more meat than any other nation, at 2.2 million tons (t), 14% of the global market.

An important source of foreign income, livestock has been targeted by the environmental movement since it generates high volumes of GHGs, particularly CH_4, that are released into the air. The digestive process of ruminants, known as enteric fermentation, produces methane in the rumen, one of the four compartments of the bovine stomach, which is then released mainly by eructation, better known as burping or belching (*see infographic above*). Its potential to raise the global temperature in as little as 20 years is 80 times higher than CO_2; over the course of 100 years, it is 28 times higher. Deforestation in the Amazon rainforest to make room for cattle pasture and crops also indirectly contributes to carbon emissions generated by the agricultural sector. Another gas generated by livestock is nitrous oxide (N_2O), which comes from animal feces in pasture areas. Nitrogen fertilizers applied to crops to correct soil acidity also release the gas.

GHG emissions in Brazil totaled 1,467 teragrams (Tg) of CO_2e in 2016; one Tg is equivalent to one million tons. The data were contained in the report "Fourth National Communication of Brazil to the UNFCCC [United Nations Framework Convention on Climate Change]," issued by the Brazilian government in 2020. Agriculture emitted more GHGs than any other sector, with 33% of the total, and the subsector for enteric fermentation, which accounts for the methane released by ruminants (cattle, buffalo, goats, and sheep), represented 19% of the total. Cattle farming alone was responsible for 97% of livestock emissions. Cattle belching was the source of 18.5% of GHGs generated in the country (*see infographic on Page 10*).

At the United Nations Conference on Climate Change (COP26) in Glasgow, Scotland, last year, Brazil was one of approximately 100 countries that signed the Global Methane Pledge, an agreement to reduce emissions of the gas by 30% by 2030. To fulfill its commitment, Brazil will have to make its livestock industry cleaner.

"It is a major challenge, but the conditions needed to achieve the COP26 target are there. We currently have 165 million hectares of pasture and plenty of space to manage these areas in order

PHOTOS LÉO RAMOS CHAVES / PESQUISA FAPESP MAGAZINE **INFOGRAPHIC** ALEXANDRE AFFONSO

to make them more sustainable," explains Flávio Augusto Portela Santos, an agronomist from the Luiz de Queiroz College of Agriculture (ESALQ) at the University of São Paulo (USP) who specializes in bovine production and nutrition.

According to the researcher, Brazil has several technologies available to increase the efficiency of the livestock sector by lowering carbon emissions. In addition to the IAL system and its variants, which have already been implemented in an estimated 16 million ha of pasture, there are other techniques for correctly managing pasture and supplementing feed with additives to reduce methane generation (*see report on Page 12*). Genetic improvements to produce more easily digestible grass and breed cattle that can reach slaughter weight earlier (*see* FAPESP's 50-Year Special Issue) are also potential solutions.

"Research has advanced a lot in recent years. Now this knowledge needs to be put into practice and the technologies applied on a larger scale in the production process," emphasizes Santos, who led a project funded by FAPESP on cattle feed supplementation in tropical pastures.

One of the agronomist's current lines of research is the processing of corn and sorghum to improve feed efficiency and reduce the amount of methane generated per kilogram of meat and liter of milk produced. Another study, in partnership with multinational agrichemical company Syngenta, is focusing on genetically modified corn, given an enzyme called amylase that helps animals digest the grain. "With more efficient digestion, we were able to reduce methane generation," he explains.

MITIGATION STRATEGIES

Guilhermo Congio, an agronomist who specializes in mitigating greenhouse gas emissions in ruminant production systems, also believes it is possible to make Brazilian livestock more climate-friendly. "Several studies carried out in the country in recent years indicate that the sector can offset emissions by adopting new technologies that allow it to sequester more greenhouse gases from the environment than it emits," he explains.

Congio earned his PhD from the Graduate Program in Animal Science and Pastures at ESALQ, USP, and was one of the coordinators of the recently concluded Latin America Methane Project (LAMP), an international research project that carried out a meta-analysis of 34 potential enteric methane mitigation strategies. The approaches were divided into three groups: animal genetic improvement, nutrition, and rumen manipulation.

"Of the 34 strategies evaluated, 16 reduced at least one metric related to methane emission without compromising animal production. Of these 16, three reduced absolute methane emissions from cattle, measured in grams per day, and 13 reduced relative emissions, measured in grams of methane per kg of meat or liter of milk produced or per kg of food ingested by the animal," says Congio. The study involved 80 researchers from 26 institutions in eight countries across Latin America and the Caribbean. The results were published in the *Journal of Cleaner Production* in August 2021.

Congio explains that methods to make livestock more environmentally friendly generally focus on reducing enteric methane emissions and nitrous oxide emissions from the soil and animal feces or on absorbing carbon from the environment to offset emissions by the sector. The use of additives in animal feed is an example of the former, while planting forests alongside pasture areas is an example of the latter. "Although cattle farming accounts for a considerable percentage of Brazilian emissions, well-managed pastures and integrated production systems that include trees have a great capacity to sequester CO_2 from the atmosphere," says Congio. To offset 1 kg of methane emissions by animals, 28 kg of CO_2 needs to be removed from the environment.

Alexandre Costa, a climate scientist from the State University of Ceará (UECE), questions the effort the country has made to reduce the meat industry's carbon footprint and argues that the sector needs to review its practices. "The Brazilian model is not sustainable," he says. Costa, who was one of the authors of the first report by the Brazilian Panel on Climate Change (BPCC), highlights that agriculture has expanded in biomes such as the Cerrado (wooded savanna) and the Amazon, causing widespread destruction. "As we know, deforestation results in CO_2 emissions."

A Brazilian study published in the scientific journal *Communications Earth & Environment* in 2001 showed that the Amazon produces 8% of the planet's methane, with 11% of this volume generated by livestock (*see* Pesquisa FAPESP issue *no. 312*).

The endeavor to decarbonize Brazilian livestock is not new. Universities and research centers have been searching for solutions to

Experiments conducted in the laboratory at ESALQ, USP, to evaluate nutritional ingredients that could potentially reduce methane emissions by cattle

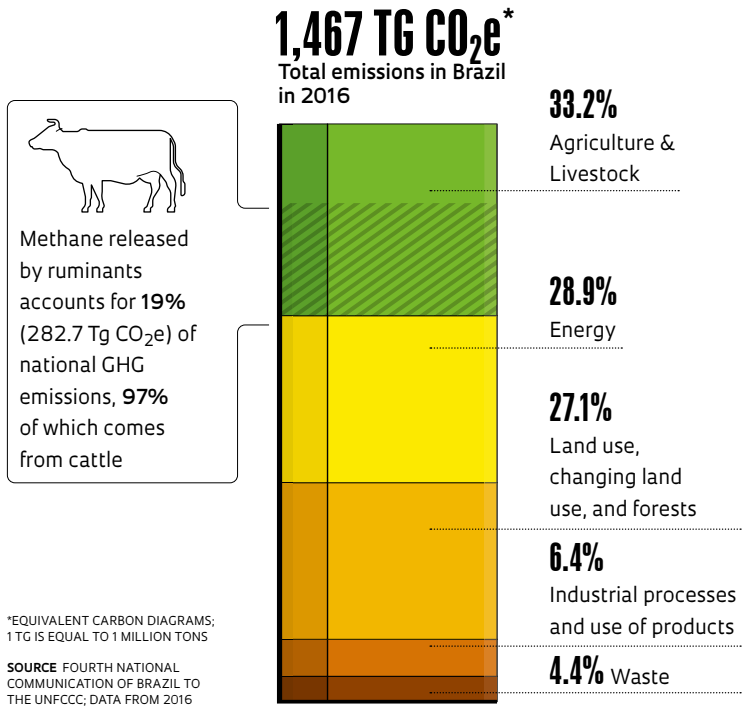
the problem for more than two decades, and in 2010, the government launched Plan ABC (standing for low-carbon agriculture in Portuguese). The plan was created by the Brazilian Ministry of Agriculture, Livestock, and Food Supply (MAPA) to increase the use of sustainable technologies and improve productivity in rural Brazil. It includes establishing the IALF system and its variants, as well as the recovery of degraded pastures and treatment of animal waste, as public policy.

Fernanda Garcia Sampaio, a zootechnician from MAPA's Department for Climate Change and Conservationist Agriculture, explains that the government's approach is divided into supporting technological developments, offering technical assistance to give producers access to innovations, and funding various other programs. In 10 years, Plan ABC signed 38,000 credit agreements aimed at stimulating more sustainable practices in the countryside, worth a total of R$32 billion.

The plan, now renamed ABC+, has incorporated new practices for the 2020–2030 period, including a method known as intensive termination, which reduces the time taken for cattle to reach slaughter weight. The objective is to expand the agricultural land using the technologies outlined in the plan by 72 million ha—the

THE IMPACT OF LIVESTOCK ON GLOBAL WARMING

Cattle is one of the largest generators of greenhouse gases in Brazil



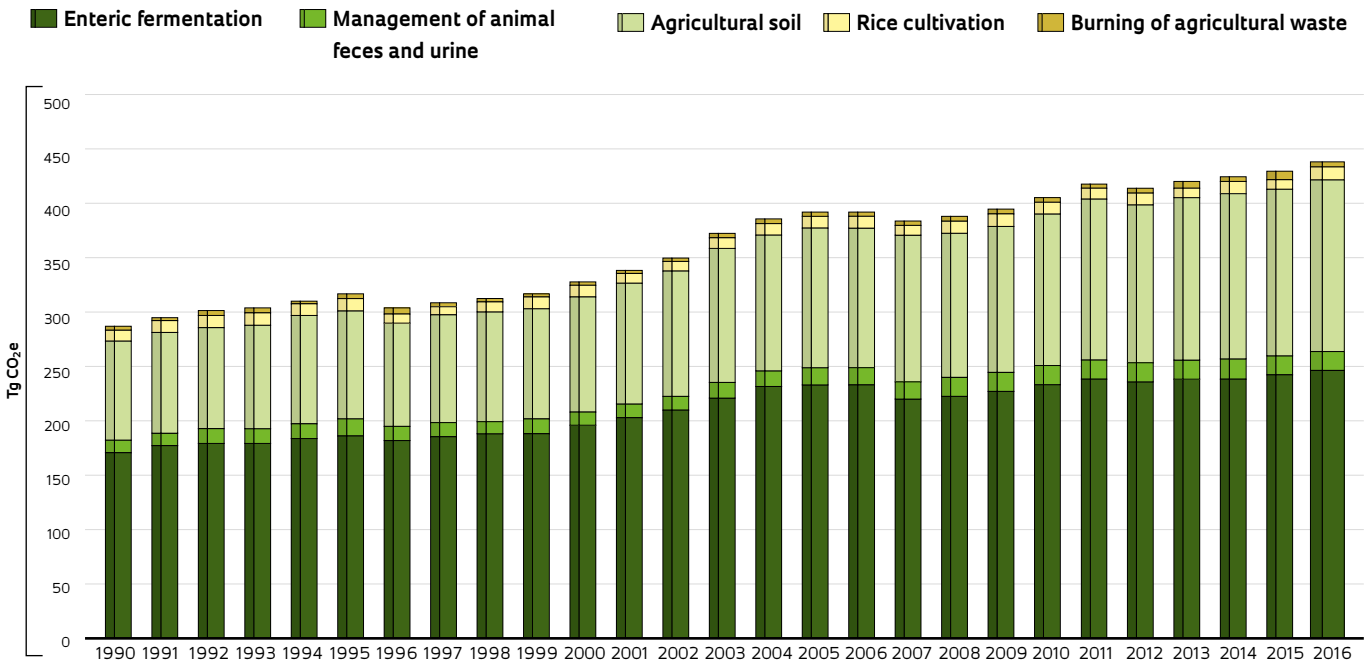
*EQUIVALENT CARBON DIAGRAMS; 1 TG IS EQUAL TO 1 MILLION TONS

SOURCE FOURTH NATIONAL COMMUNICATION OF BRAZIL TO THE UNFCCC; DATA FROM 2016

Cattle herd on a farm in the State of Minas Gerais: approximately half of the country's pasture area is in poor condition

EMISSIONS FROM THE AGRICULTURAL SECTOR OVER TIME

The largest volume of gases is methane, the result of enteric fermentation in cattle



SOURCE ANNUAL ESTIMATE OF GREENHOUSE GAS EMISSIONS IN BRAZIL, 2020

area is currently close to 50 million ha—and achieve an estimated mitigation capacity of 1.1 billion tCO_2e by 2030.

According to Plan ABC+, areas using the IALF system are projected to expand by over 10 million ha in the period. If successful, the integration of crops, forests, and livestock will account for approximately 23% of Brazil's 112 million ha of pasture. Every ha of IALF pasture has the potential to remove an average of 3.79 tCO_2e from the atmosphere per year.

A study led by José Ricardo Pezzopane, an agronomist from Embrapa Southeast Livestock in São Carlos, São Paulo, proved that planting eucalyptus in an IALF production system benefits the global climate. Seedlings were planted on 12 ha of land in simple lines, with 15 meters (m) between each line and 2 m between each tree, resulting in a density of 333 eucalyptus trees per ha. "The eucalyptus trees accumulated 65 tons of carbon per ha over eight years until they were cut, generating 225 cubic meters (m3) of wood—an extra source of income for the farmer. An article describing the study was published in the journal *Agriculture, Ecosystems & Environment* last year.

According to Pezzopane, which tree species to plant in an IALF system depends on several factors related to the pursuit of environmental, economic, and social benefits. "There are many options, including native and exotic species, as well as decisions to be made on planting density [number of trees per hectare]," he explains. Some types of trees, such as fruit or nut trees, theoretically remain in the environment for longer and can absorb more carbon than species destined for timber.

The IALF production strategy is also being adopted outside Brazil in countries that include Australia and New Zealand. In these two countries, the system is an important part of policies being implemented to achieve zero net livestock carbon emissions by 2050.

Other global meat producers are also investing in ways to make their livestock cleaner. In November 2021, Joe Biden's administration launched an ambitious plan that includes decarbonizing the USA's livestock industry. The USA is also leading the Global Methane Initiative, an international partnership that includes Brazil and aims to reduce methane emissions in various sectors, including agriculture. ■

All research projects and scientific articles consulted for this feature are listed in the online version.

PHOTO LÉO RAMOS CHAVES / PESQUISA FAPESP MAGAZINE **INFOGRAPHIC** ALEXANDRE AFFONSO