

COVER

INSUFFICIENT FOOD



The food system concept emerged to encompass different stages of the food production process

In addition to poverty, research on hunger is starting to examine bottlenecks in the journey that food takes from farm to fork

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PUBLISHED IN JUNE 2023

According to the Food and Agriculture Organization (FAO) of the United Nations, Brazil is the third largest food producer in the world, and according to the Brazilian Agricultural Research Corporation (EMBRAPA), it provides food for approximately 800 million people. Such abundance, however, does not change the fact that more than half of the country's population—125.2 million people—faces some level of food insecurity. This term is defined as having not only an insufficient quantity of food to eat but also insufficient quality, according to data from the Brazilian Research Network on Sovereignty and Food Security (Rede Penssan). How can this paradox be resolved? Various fields of research have proposed that the key to addressing the problem of hunger is to analyze bottlenecks in food systems, including the journey from farm to fork, in addition to the impacts of the climate crisis.

Pioneering studies carried out in Brazil, such as the research of physician Josué de Castro (1908–1973), established direct relationships between hunger and poverty, explains Marcelo Neri, an economist and director of the Center for Social Policy at the Getulio Vargas Foundation (CPS-FGV). “In recent years, studies have begun to

indicate that financial poverty must be eradicated to reduce food insecurity in Brazil, but that doing so alone is not enough,” he says.

In 2021, 62.9 million Brazilians (29.6% of the country's total population) were categorized as low earners, with a household income per capita of less than R\$497 per month, according to the Map of New Poverty published by FGV last year. In 2023, the number fell, returning to the 2020 level of approximately 53 million people in this income bracket. Since 2020, the federal government has tripled the amount paid out by the Bolsa Família/Auxílio Brasil welfare program and increased the number of people eligible from 14 million to 21 million. However, food insecurity only fell from 36% to 34% in the same period, a change considered very small. “It is surprising to note that during the pandemic, there was a disparity between measures to reduce monetary poverty and food insecurity,” Neri highlights.

He points out that school closures during the pandemic affected one of the country's key food security policies—the National School Meals Program (PNAE), responsible for providing food to 40 million students—which may have had a greater impact on food insecurity than poverty. According to the researcher, the fact that the federal budget for school meals has not been adjusted for six years and the 2019 disbanding

of the National Council for Food and Nutritional Security (CONSEA), which served to advise the government on public policies related to nutrition and food security, also exacerbated the situation. “We are looking a lot at income but very little at hunger,” argues the economist.

Rooted in the issue of world hunger, the concept of food security emerged after the Second World War (1939–1945) with the aim of identifying situations related to food access and based on the perception that food needed to be produced in sufficient quantity to feed a rapidly expanding global population. “Today, in addition to ensuring a sufficient calorie intake, the Brazilian concept of food security encompasses nutrition and food sustainability, expanding the notion beyond production,” observes nutritionist Elisabetta Recine of the University of Brasília (UnB) and president of CONSEA, which was re-established in 2023. Nutritionist Dirce Maria Lobo Marchioni of the University of São Paulo (USP) reports that as the concept of food safety broadens, it has recently begun to include the principle of environmental preservation—the idea that diets should be healthy to help conserve the planet.

Another concept that has guided studies on food insecurity over the last five years is the food system, which encompasses the journey that

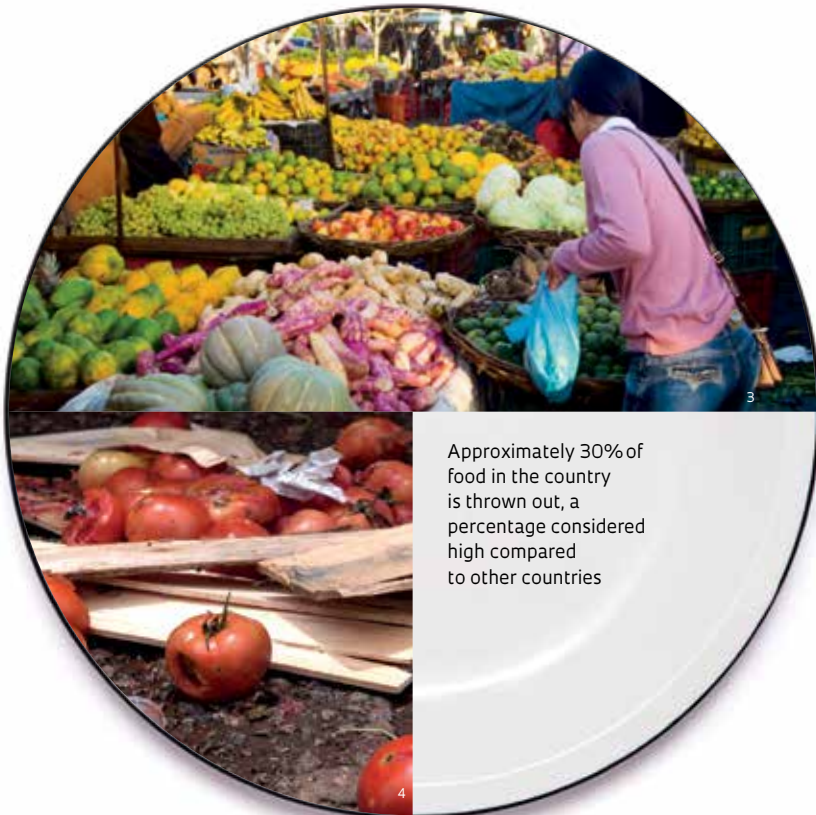
food takes from farm to fork—the stages through which it is grown, caught, hunted, processed, packaged, transported, distributed, sold, purchased, prepared, eaten, and discarded. Following this approach, scientists are working to identify the bottlenecks in each link of the system—the characteristics of which differ depending on the country or city—as a basis for seeking solutions to the issue of hunger. From this perspective, one objective may be to identify whether the difficulties in accessing food are due to a lack of healthy products available in a given region or to high levels of waste. Sílvia Helena Galvão de Miranda, an agricultural engineer from USP’s Luiz de Queiroz College of Agriculture (ESALQ), explains that agricultural research carried out in the 1950s and 1960s already highlighted the need to examine production chains and their environments rather than production alone. “This wider perspective made it possible to identify that sanitary standards in animal slaughter needed to be improved, for example, and that fruit transportation conditions could be improved to increase productivity and product quality,” she says.

At the World Conference of Science Journalists (WCSJ), which took place in Medellín, Colombia, at the end of March, sociologist Jenny Wiegel, regional coordinator of the International Center for Tropical Agriculture (CIAT), shared the results of her research into food systems in cities in the Global South. In a 2019 study, she



It is mostly small businesses that produce healthy foods consumed in Brazil

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Approximately 30% of food in the country is thrown out, a percentage considered high compared to other countries

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BRAZILIANS GOING HUNGRY

In 2022, 125.2 million people (58.7% of the population) experienced some level of food insecurity



41.3%

Food security
Permanent physical, social, and economic access to a sufficient quantity of safe, nutritious food

28.0%

Slight food insecurity
Uncertainty regarding access to food or compromised food quality

15.2%

Moderate food insecurity
Lack of access to sufficient food

15.5%

Serious food insecurity
Food deprivation

SOURCE: BRAZILIAN RESEARCH NETWORK ON SOVEREIGNTY AND FOOD SECURITY



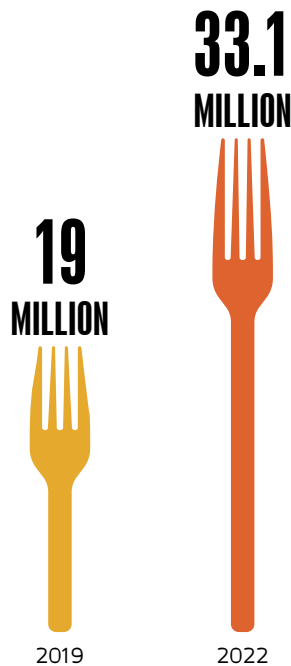
A total of 19% of premature deaths worldwide are the result of hunger and obesity caused by inadequate nutrition

analyzed the food system in the Colombian city of Cali. The study was based on the observation that 51.3% of families were experiencing food insecurity and that children and adolescents in the municipality were on average more overweight and obese than the same age group in the Pacific region. In addition, Cali was found to have had the highest values of food waste in the entire country. “Given this situation, our hypothesis was that reducing food insecurity is inextricably linked to the search for food waste reduction strategies,” said the sociologist during the conference. Wiegel also conducted research in Nairobi, Kenya. In the city of approximately 4.55 million inhabitants, 60% of people live in slums, and 65% of businesses that sell food are open-air market stalls. Her study found that 9% of the population was deficient in vitamin A, 21% was deficient in iron, and 83% was deficient in zinc. “We observed that 70% of the fruit eaten by the city’s low-income population was banana, suggesting that public nutrition can be improved by increasing the variety of fruit available at street markets, in addition to creating policies to ensure they are accessible to the low-income population,” proposed Wiegel.

However, what characterizes the food systems of an enormous country such as Brazil, and what are its bottlenecks? Answering this question is one of the central objectives of the Brazilian National Institute for Science and Technology (INCT) for Combating Hunger, founded at the end of last year with funding from the Brazilian National Council for Scientific and Technological Development (CNPq). Under Marchioni’s leadership, the center will use the food system concept as a basis for coordinating different fields of knowledge. She explains that, in general, the agro-industrial system, which produces raw materials for foreign markets, is predominant in Brazilian agriculture. FAO data for 2022 indicate that in recent years, Brazil has remained the fourth largest grain producer in the world and the second largest exporter. As a result, Marchioni says, the country faces challenges related to the production of healthy and varied foods, such as fruits and vegetables, for the domestic market. “We need to systematize and deepen our knowledge of our bottlenecks. Brazil has multiple food systems, making the fight against hunger an even more complex challenge,” she explains. The Yanomami food system, for example, is based on growing crops, hunting, and collecting fruits and insects, in stark contrast to urban populations, who usually buy their food from stores and open-air markets.

HUNGER INCREASED DURING THE PANDEMIC

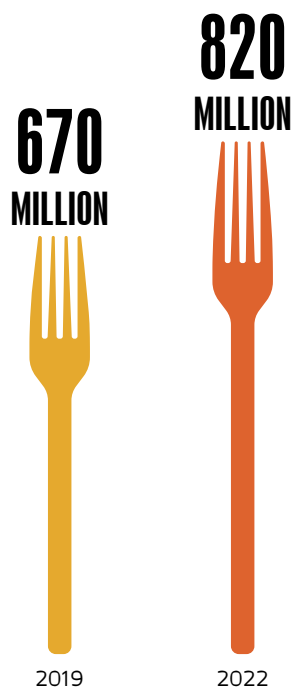
The number of Brazilians without access to food grew by 14 million as COVID-19 spread around the country



SOURCE: BRAZILIAN RESEARCH NETWORK ON SOVEREIGNTY AND FOOD SECURITY

GLOBAL POPULATION

A total of 150 million people lost access to food due to the pandemic



SOURCE: FOOD AND AGRICULTURE ORGANIZATION (FAO) OF THE UNITED NATIONS

The INCT was born from the Working Group on Public Policies to Combat Food Insecurity and Hunger, created by Vahan Agopyan, who was at the time dean of USP and is now the São Paulo State Secretary of Science, Technology, and Innovation. “The working group combined the experience of more than a dozen research groups at the university that studied food, food security, economics, and public policy,” says Agopyan. The group, coordinated by Miranda from ESALQ-USP, drafted 39 recommendations for the formulation of public policies, including the creation of minimum income and food and nutrition education programs, the development of online platforms to coordinate civil initiatives related to food security, and the strengthening of the federal policy for basic food stocks. “One of the surprising things about the report is that most of the recommendations do not require huge investments,” says Agopyan. Some of the guidelines recommend the development of integrated measures across public institutions in the state of São Paulo, such as state schools and universities, to search for answers to society’s biggest hunger-related questions and to create mechanisms to formalize the work of family farmers and help them join the food commercialization and distribution system. The secretary points out that universities and researchers are striving to translate scientific information into practical proposals for public policies. “Transforming research findings into recommendations for public managers is a complex process. Without this work, legislators would find it difficult to understand the results and incorporate them into legislation,” he points out.

In addition to the concept of food systems, another element that has guided recent studies on hunger is the climate crisis. Marchioni highlights that in *Geografia da fome* (The geography of hunger; 1946), Josué de Castro (see *Pesquisa FAPESP issue no. 324*) reflects on the relationship between hunger and ecology, but global climate change has led to new and challenging factors for academics.

These new investigative approaches were punctuated by two dossiers published by the medical journal *The Lancet* in 2019, systematizing the argument that science needs to seek coordinated solutions to three major challenges that have been addressed only individually until recently: malnutrition, obesity, and the climate crisis. The reports showed that malnutrition in all its forms, including obesity and undernutrition, causes 19% of premature deaths worldwide. The term syndemic, coined by American anthropologist and physician Merrill Singer in the 1990s, is



The climate crisis and extensive cultivation of products for the foreign market, such as soy, have exacerbated food insecurity

BRAZIL PLACED 5TH IN RESEARCH RANKING

A survey conducted by the publishing house Elsevier on global scientific output related to the Sustainable Development Goals (SDGs) set by the United Nations (UN) ranked Brazil fifth in the world for studies into hunger and sustainable agriculture between 2019 and 2022. With 10,000 articles published in that period, the country's scientific output was 110% above the world average.

The Brazilian National Council for Scientific and Technological Development (CNPq) and the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES) ranked 3rd and 4th, respectively, among funding agencies that invested the most in research related to SDG 2, which aims to eradicate hunger. The survey data came from the SciVal platform, which provides research results from more than 20,000 institutions in 230 countries.

used to describe a situation where two or more diseases interact in such a way that they cause greater harm than they would separately. In recent years, the meaning has evolved, and the term has been adopted by researchers investigating the complexity of global hunger. Malnutrition, obesity, and the climate crisis have thus come to be considered syndemics that share a common determinant: food systems. “These systems are the main drivers of poor health and environmental degradation. Urgent global efforts are needed to collectively transform diets and food production,” urge the authors of one of the reports.

The Lancet dossiers recommend developing policies with the potential to reduce the global consumption of foods such as red meat and sugar by 50% and to increase the intake of foods considered healthy—such as nuts, fruits, vegetables, and legumes—by 100%, arguing that doing so could prevent 10.8 to 11.6 million deaths per year. They also stress that agriculture needs to be reoriented toward the cultivation of food for domestic consumption while incorporating practices to preserve biodiversity and to reduce water consumption and carbon dioxide emissions. Halving food losses across the entire supply chain, from production to consumption, is another recommendation. Andréa Rossi Scalco

of São Paulo State University (UNESP), Tupã campus, whose research on food waste reduction strategies was funded by FAPESP, explains that it is estimated that 30% of the food produced in Brazil is thrown away—a percentage considered high. Specific legislation is therefore needed to regulate the disposal of products that cannot be sold but that are suitable for consumption. “Argentina, Colombia, and Mexico, for example, have laws that oblige commercial establishments to donate this food, stipulating the necessary conditions,” she explains.

Despite the lack of specific legislation, technological advances can contribute to improved food use. Nutritionist Eliana Bistrice Giuntini of the Food Research Center (FORC), one of the Research, Innovation, and Dissemination Centers (RIDCs) funded by FAPESP, gives an example of a technique developed to produce green banana flour. “Banana is a sensitive fruit, and producers record significant losses throughout the supply chain. Selling the product while it is still green, to be used to make flour, offers a potential way of mitigating this waste,” she points out. A patent for the methodology has been filed by FORC. The secret is to maintain

the resistance of the starch during production of the flour, avoiding the nutritional losses caused by inadequate processing.

Artificial intelligence (AI) resources offer other alternatives in the search for solutions to the problem of world hunger. A group of researchers from MapBiomias, a collaborative network of nongovernmental organizations (NGOs), universities, and technology startups, has been using AI to analyze satellite images of cattle pastures across Brazil since 2008. Remote sensing expert Laerte Guimaraes Ferreira of the Federal University of Goiás (UFG), current director of programs and scholarships at the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), says that pasture areas, which currently occupy approximately 20% of Brazil's national territory, could be used to double food production in the country without increasing deforestation. To do so, she says investment is needed in the recovery of degraded pastures and intensification of livestock farming, which would free up pasture areas for other uses.

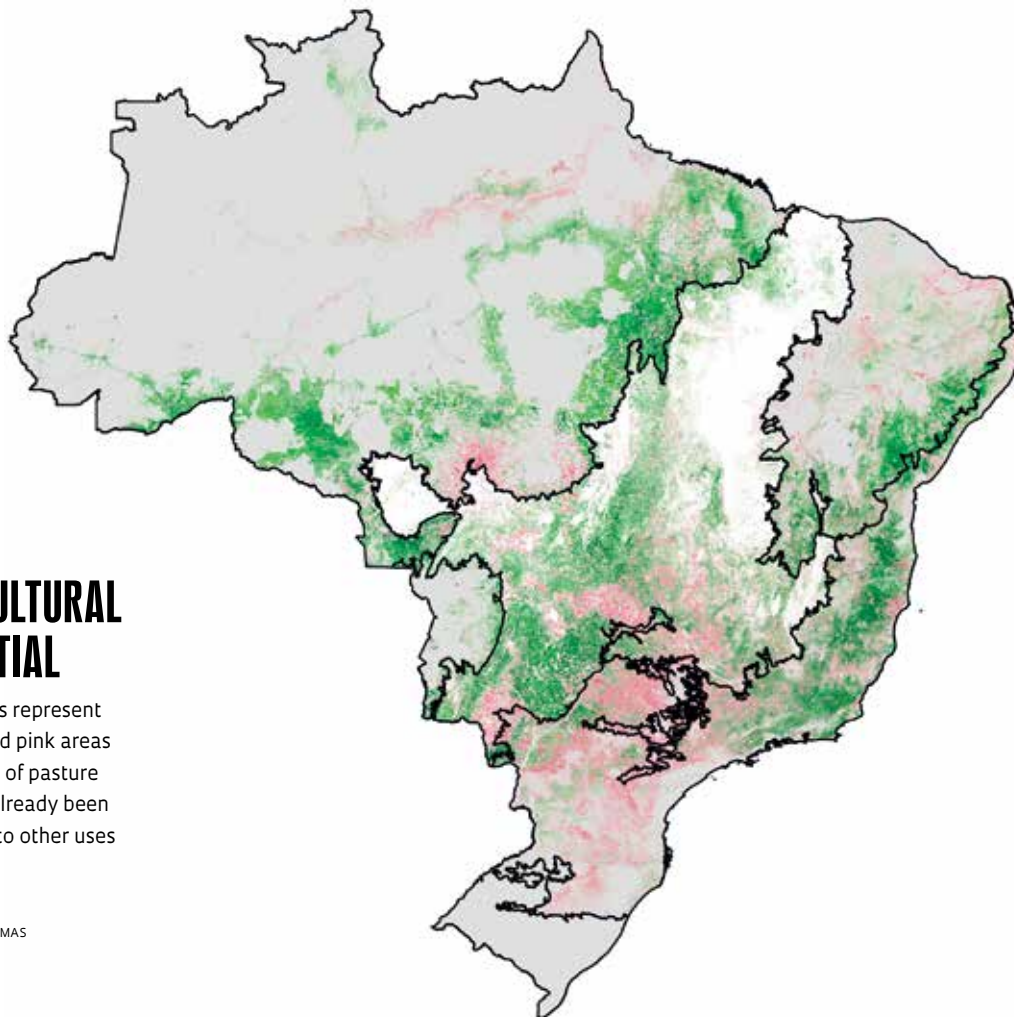
Antonio Mauro Saraiva of USP and the Combating Hunger INCT conducts research into how AI can contribute to the development of small-scale farmers who sell products for local con-

sumption. Considering the complexity of food systems, Saraiva maintains that AI is essential in research and the formulation of public policies since information on food is spread across different databases, such as EMBRAPA, the Agromomic Institute (IAC), the Brazilian Institute of Geography and Statistics (IBGE), and state and municipal departments. In response to the *Lancet* recommendations, many researchers have suggested that food security measures need to impact two or three links in a food system simultaneously. "We cannot solve hunger by changing just one factor, and AI is crucial to integrating all of the dimensions involved," concludes the engineer, who is also part of the Center for Artificial Intelligence funded by FAPESP through an agreement with IBM. ■

Projects

1. FORC – Food Research Center (no. 13/07914-8); **Grant Mechanism** Research, Innovation, and Dissemination Centers (RIDCs); **Principal Investigator** Bernadette Dora Gombossy de Melo Franco (USP); **Investment** R\$47,236,474.87.
2. Artificial Intelligence Center (no. 19/07665-4); **Grant Mechanism** Engineering Research Centers; **Principal Investigator** Fabio Gagliardi Cozman (USP); **Investment** R\$7,050,377.09.

Other projects, scientific articles, books, and reports consulted for this article are listed in the online version.



AGRICULTURAL POTENTIAL

Green areas represent pasture, and pink areas show areas of pasture that have already been converted to other uses

SOURCE MAPBIOMAS

IMPACT ON FOOD PRODUCTION

The way basic Brazilian ingredients are cultivated needs to be adapted to withstand the effects of the climate crisis



The cultivation of rice and beans, two central ingredients in the Brazilian diet, faces challenges related to rising global temperatures, higher levels of carbon dioxide in the atmosphere, and declining water availability for irrigating crops. Confronted with the worsening climate crisis, the country needs to invest in the research and development of technologies capable of improving the adaptability of its food production processes.

Coffee, beans, and rice are the most consumed daily items per capita in Brazil, according to a 2020 survey by the Brazilian Institute of Geography and Statistics (IBGE). Domestic production is not sufficient to meet the demand for beans, which is supplemented by imports. To meet local demand by 2050, EMBRAPA found that bean production will have to expand by 44%, equivalent to an increase of 1.5 million tons. The research, carried out in partnership with the Luiz de Queiroz College of Agriculture at the University of São Paulo (ESALQ-USP), was published in the journal *Agricultural Systems* in 2022. “This expansion will have to take place in a scenario marked by the adverse effects

of climate change,” warns Alexandre Bryan Heinemann, an agronomist from the Rice and Beans Unit of the Brazilian Agricultural Research Corporation (EMBRAPA) in Goiás.

The total area in Brazil used to grow rice and beans decreased by more than 30% between 2006 and 2022, according to the IBGE’s Systematic Survey of Agricultural Production. In the same period, the cultivation of soybean and corn—two of the country’s largest agricultural exports—increased by 86% and 66%, respectively. “Growing products for export is more profitable, but it does not help improve food security in the country,” notes Heinemann. Another study led by the researcher, published in *Frontiers in Sustainable Food Systems* in 2022, found that by 2050, the effects of the climate crisis could lead to a reduction of up to 60% in the amount of water needed to produce upland rice in Goiás, Rondônia, Mato Grosso, and Tocantins.

In 2018, concerned about the impacts of droughts and rising temperatures on the production of basic foodstuffs, the Agronomic Institute (IAC) of São Paulo’s Department of Agriculture and Food Supply launched its first bean cultivar designed to cope with water shortages. The research identified that bean plants

with more aggressive roots are able to absorb more nutrients and water from deeper in the soil. Another finding was that precocious plants with short growing cycles are more tolerant to climatic stresses. “Improving the adaptability of our crops is one of our greatest challenges,” says IAC agronomist Alisson Fernando Chiorato.

Cassava, named the food of the twenty-first century by the Food and Agriculture Organization of the United Nations (FAO) in 2018, is one of the crops that can best adapt to the effects of climate change, according to other studies by EMBRAPA. Research carried out since 2017 by agronomist Jailson Lopes Cruz concluded that high atmospheric concentrations of CO₂ alleviate the inhibitory effects of drought on the physiology and growth of cassava plants. This means that new areas can be incorporated into the cassava production process, especially in semiarid regions, improving the supply of this product. “This crop is also highly versatile. It can be eaten directly, but its derivatives, such as starch flour, can also be used as ingredients for other products, generating income for producers,” concludes Carlos Estevão Leite Cardoso, an agronomist from EMBRAPA Cassava and Fruit Crops. ■

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