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Food and Nutrition Security:

The Role of Brazilian Science in Fighting Hunger

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Organizer

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A photo symbolizing the past of food injustices and the hope for a future of full food and nutrition security

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Preface (Brazilian Academy of Sciences)

The Universal Declaration of Human Rights, adopted and proclaimed by the United Nations General Assembly (resolution 217 A III) on December 10, 1948, states in Article 25 that "Everyone has the right to a standard of living adequate for the health and well--being of himself and his family, including food, clothing, housing, medical care, and necessary social services, and the right to security in the event of unemployment, sickness, disability, widowhood, old age, or other lack of livelihood in circumstances beyond his control".

The International Covenant on Economic, Social and Cultural Rights, adopted by the United Nations General Assembly on December 16, 1966, and implemented since January 3, 1976, asserts in Article 11 that all states recognize the right of everyone to an adequate standard of living, including adequate food. It further ensures that states acknowledge that everyone must be protected from hunger and that they will promote specific programs to improve methods of food production, conservation, and distribution with guaranteed nutritional value, as well as the equitable distribution of world food resources. In Brazil, the Covenant entered was implemented through Presidential Decree No. 591 on July 6, 1992.

It is also relevant to note that the right to adequate food for all citizens is guaranteed by Constitutional Amendment No. 64 of February 4, 2010, which amends Article 6 of the 1988 Federal Constitution to include food as a social right.

Are we truly fulfilling all these agreements and, moreover, the constitutional right that should be guaranteed by the State for effective food security? Fighting hunger must always be on the agenda and a concern for all governments and society.

The Brazilian Academy of Sciences has always been concerned with this issue. This book, "Food and Nutrition Security: The Role of Brazilian Science in Fighting Hunger" includes contributions from 41 scientists with profound reflections on the topic. We hope it serves as a warning to society in general and especially to decision-makers about the urgency of the issue. The book covers various topics, from national sovereignty to the

importance of public policies, food production, the role of small farmers and women in production, bioeconomy as a new strategy for food security, the role of the private sector, and the importance of education and communication. Population growth in many regions of the globe, aging in others, and climate and environmental changes will impact food security. Land use, infrastructure, and markets are also dependent on policies defined by governments and nations.

The book's most important message is that Science, Technology, and Innovation, together with Education, are fundamental for achieving the desired global Food and Nutrition Security.

Helena Bonciani Nader

President of the Brazilian Academy of Sciences

Preface (Itamaraty)

At a time when global challenges demand both urgent and collective action, the fight against hunger, food insecurity and all forms of malnutrition has never been more critical. Brazil, with its unparalleled capacity for agricultural production and its long-standing commitment to reducing inequalities, holds a unique position in this global endeavor. This book, **"Food and Nutrition Security: The Role of Brazilian Science in Fighting Hunger,"** explores the profound impact of Brazilian scientific innovation and public policies in addressing one of humanity's most pressing needs: access to sufficient, safe, and healthy foods.

Under President Lula's administration, the fight against hunger has become a centerpiece of national and international efforts. These commitments were reaffirmed in the **2024 G20 Leaders' Declaration**, which, under Brazil's presidency, launched the *Global Alliance Against Hunger and Poverty*. This initiative is a concrete instrument designed to mobilize financial resources, technical expertise, and strategic partnerships to support the implementation of evidence-based public policies to eradicate hunger and poverty globally, reflecting the broader ethos of inclusion and sustainable development.

The declaration recognizes a central truth: the world produces enough food to eradicate hunger, yet political will and global collaboration are essential to ensure equitable access. Brazil's leadership in spearheading this Global Alliance reflects our vision that the right to food is a human right, and that international cooperation is essential to making the fight against hunger and poverty a global political priority.

It also underscores its commitment to leveraging science, technology, and diplomacy for transformative change. Through Itamaraty's **Innovation Diplomacy Program**, Brazil has consistently worked to promote its image as a global innovator, build international partnerships to foster inclusive and sustainable solutions, and engage stakeholders across ecosystems to address global challenges like hunger and inequality.

This book offers a comprehensive examination of Brazil's scientific advancements in agricultural productivity, climate resilience, and sustainable agrifood systems. From the

development of innovative biofortified crops to policies that empower smallholder and family farmers and reduce food loss and waste, the authors highlight how Brazilian science is addressing not only domestic needs but also contributing to global food and nutrition security.

As highlighted in the G20 discussions, combating hunger is not only a moral imperative but also a cornerstone for achieving sustainable development. By integrating cutting-edge research, inclusive public policies, and international cooperation, Brazil exemplifies how nations can lead in building a world where no one is left behind.

This book is a testament to the role of science and innovation in fostering resilience, equity, and sustainable development. It calls on policymakers, researchers, and global leaders to collaborate, ensuring that hunger and food insecurity become a scourge of the past. As you explore the pages ahead, may you be inspired by the transformative potential of science and diplomacy in shaping a just, inclusive and sustainable future for all.

Mariângela Hungria and her collaborators have gifted us with a timely and inspiring work. It is our hope that this book will guide policymakers, researchers, and citizens alike, reinforcing Brazil's role as a pioneer in the fight against hunger and a champion of innovation for the greater good.

Mauro Vieira
Minister of Foreign Affairs of Brazil

Summary

The economy assisting in the design of public policies, bioeconomy as a new strategy for food security and the role of the private sector

Knowing, educating and communicating are key parts of food and nutrition security

Introduction to the topic of food and nutrition security

Chapter 1

Where science has led us and the paths it can help us explore

Mariangela Hungria[1,2]
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[3]*Professor Emeritus of UFLA*

The theme of **Food Safety** has been the subject of several debates in recent years. However, the importance of food security has been highlighted for decades, especially since the First World War, when it became evident that the availability of food for the population should be a concern for **national sovereignty**. Josué de Castro (1908-1973, an important geographer, social scientist, politician, writer, and Brazilian activist in the fight against hunger), in his classic book "The Geography of Hunger" defined **hunger** as a non-natural phenomenon, a tragedy created by man himself, a direct product of underdevelopment, and with a strong connection with inequality and poverty (Castro, 1984). Historically, hunger is as old as humanity, and has corroded societies, but it was only in 1996 that the UN (United Nations Organization), through the "World Food Summits", defined that food security existed "w**hen all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"** (FAO, 2006). From this milestone, there have been advances in global efforts toward the **zero hunger** goal. However, the fragility of several measures regarding food production, distribution, and social inequalities was evidenced in the impactful setbacks observed with the COVID-19 pandemic. Overall, estimates are that, in 2020-2021, nearly 3.1 billion people were unable to access a healthy diet, with projections in 2030 of 670 million people, or **8% of the world's population in hunger situation**, making the target previously proposed for this date of eradication of hunger unattainable (FAO, 2022a). Although in 2022 there was a slight post-COVID-19 improvement, with 3.8 million people less in the starving stage, this recovery is still very modest and has not returned to pre-pandemic levels, including 9.2% of the world's population (FAO, IFAD, UNICEF, WFP & WHO. 2023). The setback observed during the pandemic highlighted the **multicausal complexity of hunger**, requiring multidisciplinary strategies to face it, supported by **transdisciplinarity** in what can be termed as **science fighting hunger**.

According to the Malthusian theory launched in the 18th century, when humanity reached the first billion people, the population would grow exponentially in contrast to the arithmetic supply of food, generating hunger and wars (Malthus, 1798). Today, contrary to predictions, we have 8 billion people with enough food production for everyone, yet there are still people who are hungry, and wars persist. Hunger is associated with the concentration of income, food production and distribution, and misguided public policies, while wars originate in political interests, and ideological and economic divergences, also generating hunger. In Brazil, there is a strong contradiction in relation to food security. In 2021, the country was diagnosed as being to produce enough food for **800 million people**

(Contini & Aragão, 2021) but, on the other hand, the survey of the Brazilian Network for Research on Food and Nutrition Sovereignty and Security, the "Rede PENSSAN", indicated that in 2022 there was moderate food insufficiency in **15.2% of households and severe, with hunger experiences, in 15.5**% (Rede PENSSAN, 2022). In geographical terms, although the situation is more critical in the northern and northeast regions, it occurs throughout the national territory, but more severely affecting the poorest, the families that have women as responsible, those in which the reference person is called black or brown, and those in rural areas (Rede PENSSAN, 2022). Globally, this scenario is repeated, always reaching more seriously women and rural areas (FAO, IFAD, UNICEF, WFP & WHO. 2023). Emblematic testimony of the hunger situation was given by Carolina de Jesus (1914-1977, a very poor woman who became a writer) in the book *Quarto de Despejo* (Child of the Dark: The Diary of Carolina Maria de Jesus), where a slum (*favela*) resident who works with recycling describes, every day, the struggle to get food (Jesus, 2021). It was like this in the 1950s and continues so for millions of Brazilians. We live, therefore, in a paradoxical situation, where there are **plenty and food shortages**, the result of a bold policy of agribusiness development but with a lack of effective policies to improve employment and income. Only with the survey and scientific analysis of the data it will be possible to continuously monitor, seek deviations, and suggest **public policies** to mitigate hunger. Differences in ideologies and economic interests need to be mitigated to achieve common goals. Advancing toward the fight against hunger must be a governmental priority and requires the transversality of public policies among all ministries in coordinated and additive actions.

In the last five decades, Brazil presented an increasing trajectory of records of agricultural production, **exceeding 300 million tons of cereals, legumes and oilseeds** in 2023 (IBGE, 2023a). However, production is mostly destined **for export commodities**, in agriculture practiced by **large producers and restricted to few products**, favored by tax policies for the export of raw products. It is urgent to evolve into a product-based model that brings wealth with stability. **Agribusiness** will benefit from science in the design of strategies to add value to exported products, increasing the already relevant participation of the sector in the national GDP (Gross Domestic Product). Aggravating, according to IBGE, **about 30% of food production in Brazil is lost**, positioning the country as tenth in the world ranking (Mercado e Consumo, 2023). In the case of Brazilian grain production, according to CONAB (National Supply Company) data, the estimated losses in 2020 were 15% (CONAB, 2023), which would be sufficient for the purchase of 135 million basic food

baskets (composition of foods within the scope of government policies, aimed at ensuring the food and nutrition security of a Brazilian family). There are **losses**, which refer to losses along the chain from production to processing, and there is **waste**, which occurs at the end of the food chain (FAO, 2011a). FAO estimates of losses and waste in Latin America are alarming, for example, 72% in fruits and vegetables, 47% in roots and tubers, 31% in cereals (FAO, 2011a). In Brazil, important intersectoral strategies have already been suggested for the fight against losses and waste (CAISAN, 2018) and agricultural, economic and social sciences can contribute to this theme, as even a fraction of this waste would be enough to completely reverse the national situation of food insecurity. Thus, government actions against hunger need to go from production to loss and waste reduction. As an example of this scope, the supra-party and multisectoral movement **Pact Against Hunger**, seeks to reverse the situation of empty bellies and full trash cans, with the goal of reaching in 2030 without any hungry person in the country and, in 2040, with the entire population well no

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Barley-based foods with functional properties.
Photo: Carpentieri-Pipolo. Valéria. Embrapa Trigo. Source: Embrapa Archives.

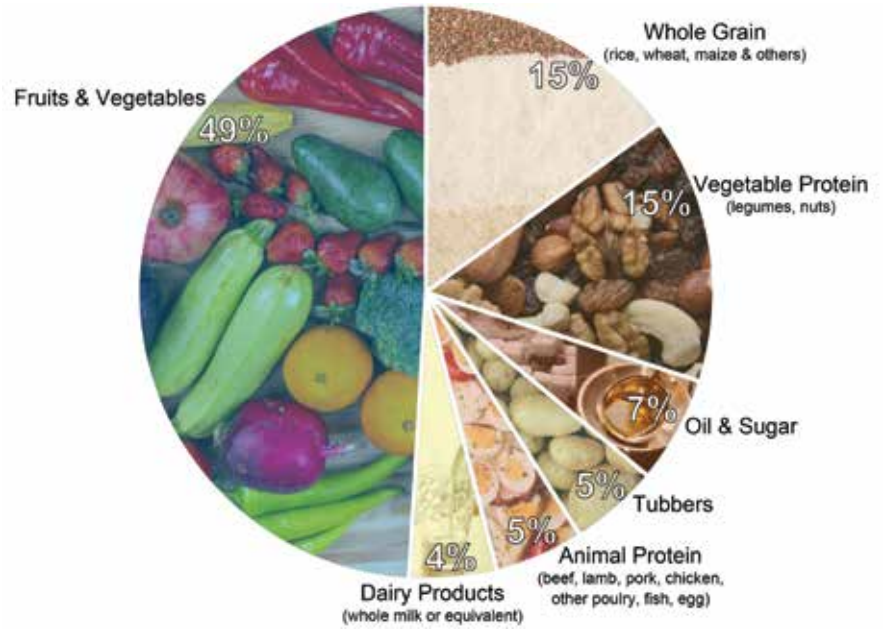
It is paradoxical that food insecurity in Brazil is aggravated in rural areas, reaching more than 60% of households (Rede PENSSAN, 2022). They are largely hungry individuals connected to **family farming** and **small-scale agriculture**. **Education** is based on all actions against hunger, as the data confirm a direct relationship between years of study and food

security (Rede PENSSAN, 2022). Consequently, investments in **education** in rural areas should provide high returns for the farmer and the country's economy. In addition to public policies aimed at these farmers, it is necessary to invest in scientific innovation to add value to products and increase their participation in the national economy. New concepts need to be incorporated into Brazilian agriculture, with a strong potential for significant participation from this less privileged segment of agriculture.. These are concepts such as **Farm to Fork**, toward **a fair, healthy, and environmentally sound diet**, a strategy strongly emphasized in the European Community toward a neutral climate continent (European Green Deal), encompassing sustainability, starting with food production, through processing, distribution and consumption and ending in loss prevention (EC, 2021). This strategy favors local food obtained directly from the producer for the preparation of food destined for school meals, restaurants, and neighboring communities. Another concept of pragmatic changes in food production and consumption, based on nutritional diversity and sustainable production is the **Planetary Health Diet** concept (EAT, 2023), where healthy eating needs to be delineated to be reconciled with the preservation of the environment. As the EAT platform emphasizes, science is the basis for all transformation to the planetary diet (Willet *et al*., 2019). It is worth noting that although they may seem different, these concepts reflect the set of the **17 Sustainable Development Goals** (SDGs) and their targets set out in the 2030 Agenda both globally and in Brazil (UN-BR, 2023). For instance, the second SDG directive establishes ending hunger, achieving food security, improving nutrition, and promoting sustainable agriculture.

Organic products of an Agroecological Farm.
Photo: Bello, Liliane Bello. Embrapa Agrobiologia. Source: Embrapa Archives.

The investment in **agricultural sciences** in Brazil led to its recognition as a leader in technologies for **tropical agriculture**. Considering an example, soybean had average yields of 1,000 kg/ha and was exclusively cultivated in the southern region in the 1960s, and by 2022/2023, yields reached 3,500 kg/ha, with cultivation extending from Roraima (north) to Rio Grande do Sul (south) (CONAB, 2023). In another example of the Brazilian daily diet, rice, and dry beans, the science has already delivered rice cultivar with a potential productivity of 10 t/ha, produced with less water and energy and emitting less methane (Chaves, 2022), and dry bean cultivars with high productive potential, almost 4 t/ha, four times higher than the national average (IAPAR, 2019). These yields were achieved thanks to investments in genetic improvement, soil and crop management, bio-inputs of quality, pests and diseases control. Agricultural sciences contribute with sustainable land-saving technologies, allowing them to produce more with less land, with other relevant examples such as maize, wheat, poultry, beef and milk cattle, pigs, and fruits growing in the semi-arid region (Telhado & Capdeville, 2021). For the **agriculture of the future**, the opportunities for the delivery of agricultural sciences have never been so promising, with **disruptive science**. Studies in **gene editing** are advanced, which allow for punctual changes in genome sequences quickly, accurately, and economically, and in **synthetic biology**, designing modular biological circuits that allow the redirection or construction of new metabolic routes (Molinari et *al*., 2020). The development of tools for **digital agriculture** and data integration will help to reach new levels of production. Science is needed to meet the challenges that are already impacting production, resulting from **climate change,** also requiring to meet **greenhouse gas (GHG) emission reduction targets**. In this case, although efforts have been made to feed the National Inventory of Emissions and Anthropic Removals of Greenhouse Gases (MCTI, 2022), it is urgent to raise data for each crop, edaphoclimatic condition, management, and transport in each region.

Producing more is the first step toward fighting hunger. However, there is a great gap between the results obtained by the agricultural sciences and the adoption in the field. Still considering the soybean crop, and the last seven harvests (2016/17 to 2021/22), the average yield of 3,292 kg/ha (CONAB, 2023) is far from the reality of 7,544 kg/ha obtained in yield context in the same period (CESB, 2023). Champions in these contexts adopt the best genetics, cultural practices, soil profile construction and fertility levels, pests and diseases control, that is, technologies already available. The same situation is found for rice (irrigated) and beans (1st, 2nd, and 3rd crops), where the average national yields of 7,767 kg/ha and 1,067 kg/ha, respectively (CONAB, 2023), are far below those achieved by producers



Concept of a planetary health diet, considering human and planet health. For this, food is divided into categories, shown in the figure as a proportion (suggestion according to several documents) of what should be consumed. Figure: Leonardo Araujo Terra.

adopting existing technologies. The gap between knowledge and implementation is exponentially increased in family farming and among small farmers. It is, therefore, necessary to innovate in **technology transfer actions**. For this, **the economic sciences** can assist in studies that allow the redirection of tax incentives for the reconstruction of the **agricultural extension**, assisting the unassisted, bringing food security to the field, and benefiting the supply of the urban environment. The discussion to overcome the challenges for the transposition of results into the field should begin with the training of the **professionals of the future**, with greater synergy between disciplines of agriculture, economics, and human sciences. It is necessary intelligence to rebuild life in the soils, diversify, and implement integrated production systems, allowing greater resilience to abiotic stresses and financial stability for the farmer.

Brazil has a rich biodiversity, and each biome has its particularities, riches, and vocations (Val *et al*., 2022). There are many opportunities for nutritional production and improvement through foods that are still little known or explored in each biome. Science can play a key role in **diversifying** Brazilian food, outlining healthy diets adapted to the palates of each region. In addition, with regionalization in the supply of foods with better nutritional value, diversification will strengthen the **bioeconomy,** always based on the agricultural vocations of each biome or, better still, those of **each community**. With the help of science, there are opportunities to create regional databases and to **prospect new**

agricultural niches. In vulnerable communities, science can assist in **rescuing germplasm and traditional technologies** and prospecting markets that allow capitalization of origin certificates such as indigenous people, and *quilombola populations* (Afro-Brazilian residents of quilombo settlements first established by escaped slaves in Brazil).

Open cupuaçu, showcasing the pulp, highlighting the potential for biodiversity exploitation. Photo: Rosa, Ronaldo. Embrapa Amazônia Oriental. Source: Embrapa Archives.

Possibilities for family farming, such as local fruit jams. Photo: May, Tomas. Embrapa Agroindústria de Alimentos. Source: Embrapa Archives.

Only the interdisciplinarity of the sciences applied to all types of agriculture and farmers will lead to the construction of **a new model of agriculture** in Brazil, with high levels of production coming from disruptive science, but with greater diversity. The ongoing goal is sustainable agriculture based on environmental, social, institutional, and economic balance, making it possible to meet the demands without reducing social well-being today and in the future. It is necessary to adopt holistic concepts such as **One Health**, with an integrated, collaborative, and transdisciplinary approach aimed at balancing the health of people, animals, plants, and the environment at local, regional, national, and global levels, through education, teaching, research and community services and closely related to agricultural production (One Health, 2008). Science has already shown that there are divergent priorities among countries in the construction of the agricultural sustainability matrix (Zhang *et al.*, 2021), and this matrix needs to be defined correctly in Brazil. In addition, it is expected the evolution of Brazil toward **regenerative agriculture**, which we define here, based on consensus taken from global suggestions, for example, by Dr. Rattan Lal, as "The agriculture inspired by **eco-innovation**, empowered by **renewable energy**, driven by **the circular economy** and **green infrastructure** and aiming at the **recarbonization of** our planet" (considering increasing soil carbon). It is urgent to define **production chains** of various foods, always with a regional view. The enormous **post-harvest losses** are inconceivable, and actions ranging from the application of science for storage pest control to distribution logistics need to be coordinated. Science needs to move quickly to solve the dilemma of the next decade, which will be to produce more with increasingly less: less soil, less water, fewer inputs, and less human effort.

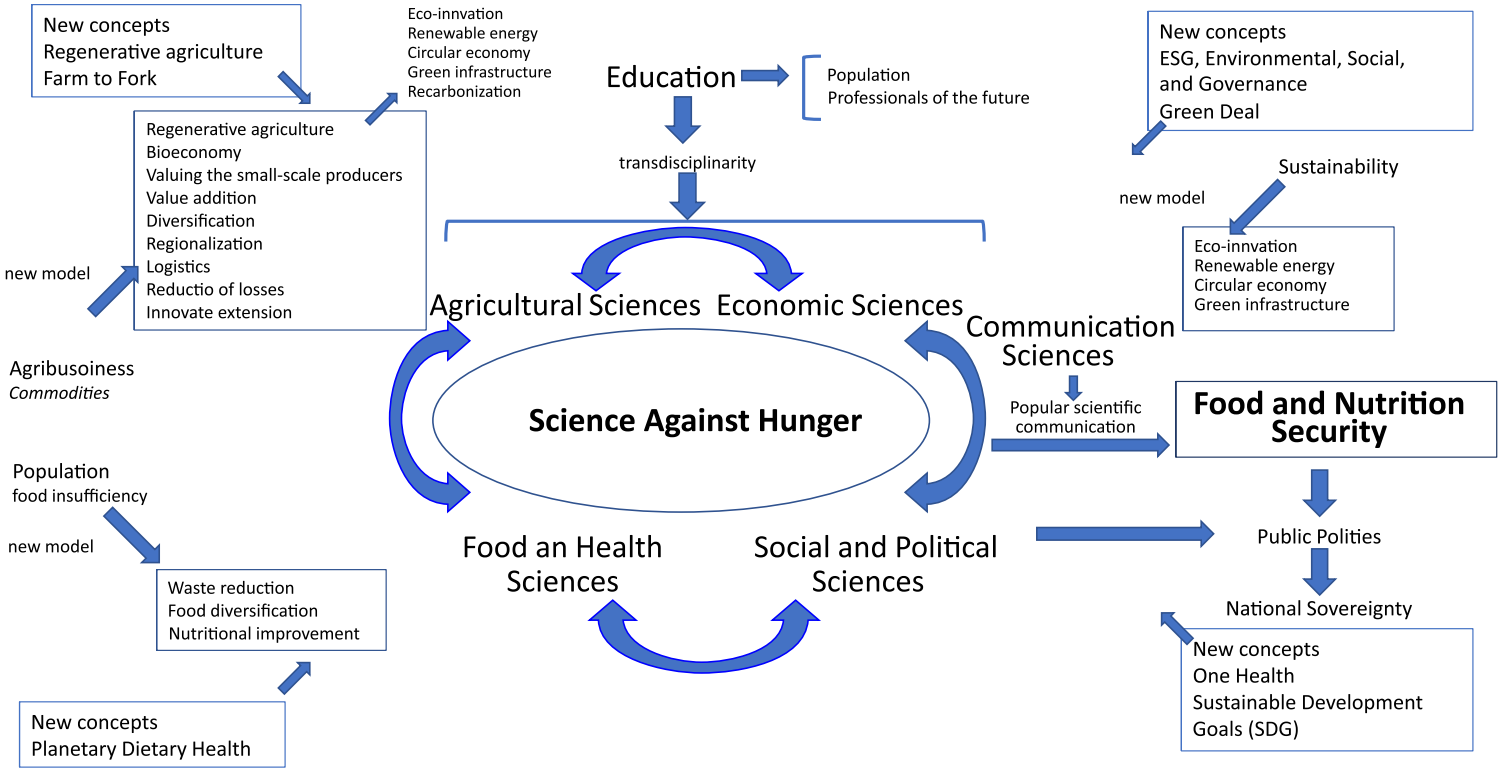
Fresh khaki cut in a post-harvest loss reduction program.. Photo: Maia, Marcos Luiz Leal. Embrapa Agroindústria de Alimentos. Source: Embrapa Archives.

Soybean nodulated root, indicative of the process of biological nitrogen fixation, of great relevance in the context of regenerative agriculture. Photo: Hungria, Mariangela. Embrapa Soja.

The **private sector**, which has had modest participation so far, can stand out as a transforming agent towards food security because, internationally, its engagement is recognized as crucial for composing a new social organization aimed at eliminating hunger (FAO, 2022a). In Brazil, agribusiness is often said not to have responsibility for food insecurity because its role is only to produce food. A new vision of agriculture will no longer accept the simple role of producing, and, once again, science can give the support that allows the protagonism of this sector through economic, environmental, and social studies. As an example, the construction of ESG (Environmental, Social, and Governance) models must contemplate environmental and social responsibilities and corporate governance. Studies in social sciences can also support the mediation of conflicts between production and the social environment.

Historically, science goes through periods of challenge in showing society its relevance to solving problems. Criticism arises even in scientific environments, such as in an editorial by the prestigious journal Nature, indicating that millions of taxpayers in the US see few benefits in scientific advances achieved by the agendas of modern science (Nature, 2017). In Brazil, during the pandemic and due to political bias, there was a strong deconstruction of trust in science and its benefits, which negatively impacted health, hunger, and the interest of new generations in scientific careers. This scenario highlights the importance of the dynamism of **the communication sciences**, with studies that can

define, for each moment, situation, and segment of society, the appropriate means of **scientific dissemination**. Humanity progresses with science and needs to be aware of it, as it is the society that will decide, through its representatives, how much of the resources should be allocated to science. The science of communication is therefore fundamental to avoid a crisis of **social legitimacy of science.The Brazilian Academy of Sciences** is assertive in stating that science is able to find solutions for obtaining impactful increases in agricultural production, with sustainability, diversification, mitigating food insecurity, and preserving biodiversity and the environment. Science can contribute to the change of the current model, in which, in **the world's fourth largest grain producer and holder of the largest cattle herd in the world** (Aragão & Contini, 2020), there **are 125.2 million people in food insecurity, being more than 33 million in hunger situation** (Rede PENSSAN, 2022). A new agriculture for a new society of 213 million inhabitants, with nutrition knowledge and easy and low-cost access to food needs. There is no single, simple solution to eradicate hunger, but that does not mean that it cannot be resolved. In order to confront complex and multifaceted problems such as hunger, science must be transdisciplinary and reflective regarding the problems of society. This document presents reflections on the past and current context and proposals on how sciences should progress in various areas to reverse food insecurity in Brazil. **This document is diverse and plural, as Brazilian science must be**. It was built by diverse and plural researchers and professors. Each topic followed the style of each author, but all with the unique principle of a strong foundation in science and a commitment to society. Because that is how Brazilian science must be: plural, diverse, and strongly committed to society. Science fighting hunger.



Transdisciplinarity of science against hunger for actions aimed at food security.
Source: Hungria, Mariangela.

National sovereignty and food and nutrition security: The importance of the diagnosis and recognition of the role of women in shaping public policies

Chapter 2

Food and Nutrition Sovereignty and Security in Brazil

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Reference Centre on Food and Nutrition Sovereignty and Security –
Federal Rural University of Rio de Janeiro

The concern with ensuring the food of the population is, of course, quite ancient, but it will occupy a central place in the national states' agenda, will be subject to systematic action, and will have repercussions on interstate relations from the first decades of the twentieth century onwards, especially in the context of the two world wars and the crisis of 1929. This is the moment when the food issue that integrates the trajectory of countries becomes a State matter and gives rise to the idea of food security **(FS**) as one of the objectives of the government's action, although the expression as such will only be used later. This perspective will appear as one of the axes underlying the Treaty of Rome that created the European Economic Community (EEC) in 1957 and will guide agricultural policies practiced by the United States since 1950 and, literally, from the *Food Security Act* of 1985.

In addition to initiatives with national or regional perspectives of communities of countries, since the middle of the 20th century, the prospect of **global food security** will be developed by the United Nations Food and Agriculture Organization (FAO), established in 1945, as well as in other bodies of the UN System. In this context, the comprehension of **food security** associated with the intensification of food production and the expansion of international trade was established, along with the regulation of factors affecting food safety and the adoption of food programs or income supplementation. Such a productivist conception considers food only in its market dimension and gives room for the growing predominance of large-scale monoculture plantations, intense use of machinery, chemical inputs, and modified seeds, characteristic of the agro-industrial chains built around these goods. This perspective was later criticized for the socioeconomic, environmental, climate, and human health impacts, and that ended up countering objectives that should be coordinated, namely food security, sustainability, water security, and climate neutrality (Shaw, 2007).

In addition to~~, in~~ this view, food supply would be ensured through international trade. Gradually, the search for national productive self-sufficiency is being replaced by the recommendations, among others, from FAO itself, of strategies aimed at self-reliance in food acquisition, that is, expanding the exporting capacity to access food based on international exchanges. Guidance that has turned most of the so-called developing or less developed countries into net food importers. In fact, despite the roles it can play, international trade would prove to be an unreliable source of food security before the strategies of the so-called central countries, of the power acquired by large transnational

corporations on production and trade flows, the closer links between the international commodity market and financial speculation and the volatility of international prices. Not to mention the recurrent outbreak of conflicts among countries affecting the regular flow of goods.

In another direction, the notion of food security has undergone paradigmatic transformations throughout the 20th century, emphasizing the one that added the dimension of access to food. Since the end of 1970, the focus on food supply has given rise to concerns about access to food to which an important contribution was made by Amartya Sen on collective hunger episodes that showed that restrictions on access to food are the greatest threat to families' food security, a diagnosis that will unfold in the author's approach to development as the expansion of capabilities.

This inflection brought to the foreground the relationship between hunger, poverty, and inequalities and **the requirement to combine coping with hunger and facing ~~coping with~~ poverty and inequalities**. Further on, the nutritional dimension will be incorporated into the formulation of food and nutrition security (FNS), which implies a connection of food production with ensuring access to adequate and healthy eating aiming at a healthy life and the prevention of diseases associated with malnutrition, **such as chronic non-communicable diseases**. Finally, the FNS multidimensionality is evident in the relationship of food with social, environmental, and cultural factors and the consequent demand for intersectoral strategies for its guarantee.

In parallel, there was the rise in the international scenario of social organizations and movements as protagonists of narratives and innovations with the perspective of producing food based on sustainable practices and respectful of ecosystem limits, in contrast to the discourse and practices of food system´s hegemonic sectors. From this movement, since the end of 1980, food sovereignty has emerged as a reference in the construction of alternative paths that face the social, environmental, and cultural impacts of the predominant productive model and the inability of food security as conventionally defined in overcoming hunger and poverty. An important moment of this political-conceptual trajectory was the Global Forum on Food Sovereignty that was held in parallel to the World Food Summit in Rome in 1996, under the leadership of the international network Via Campesina, followed by the World Forum in Havana (Cuba) in 2001 and subsequent international meetings.

The notion of sovereignty is the result of centuries of conceptualizations and exercises of the idea, which can reflect a wide range of meanings since conceptions of absolute national state power until the power emanated from people's hands. Sovereign power is ultimately expressed by the State's ability to define and guarantee its own internal order and by the presumption of non-interference in its internal affairs by the other States and bodies that make up the international system. When brought to food and eating, **the idea of food sovereignty could be translated as the search for national productive self-sufficiency**, possibly by the association of food sovereignty and independence of other states to ensure countries´ food provisioning. However, the recent development of the notion has at the heart of food sovereignty the valorization of food production by peasants and family farmers that express the socio-cultural diversity and biodiversity of the countries, as well as the benefits brought by the approximation of production and consumption.

> Food sovereignty is the peoples' right to define their own sustainable policies and strategies for food production, distribution, and consumption that guarantee the right to food for the whole population, based on small and medium production, respecting their own cultures and the diversity of peasant modes, fisheries and indigenous agriculture production, marketing, and management of rural areas, in which women play a fundamental role [...]. Food sovereignty is the way to eradicate hunger and malnutrition and ensure sustainable and sustainable food security for all peoples (World Forum on Food Sovereignty, Havana, 2001).

Food sovereignty therefore dialogs with premises related to public actions and policies guided by the guarantee of availability and fair access to food of sufficient quality, respecting peoples' socio-environmental and cultural principles and traditional communities' knowledges, putting at its heart family and peasant modes of production based on agroecological practices that respect biodiversity, local food culture and the traditional communities' knowledge. Despite their distinct origins and even being placed as opposing notions, food security and food sovereignty are concepts that turned out to be articulated in the social construction of these notions in Brazil.

From the outset, the Brazilian conceptualization of FNS has added the nutritional aspect, thus placing health and nutrition alongside agri-food and socioeconomic issues. It also highlights the meeting under the same concept of the dimensions of availability and

quality of food that are primarily inseparable and together question prevalent production models and consumption patterns, and the very meaning of quality food. Further on, an innovative conception will be found in documents by social organizations and the National Council of Food and Nutrition Security (CONSEA) bringing **together food and nutrition sovereignty and security (FNSS)** that added new components to the FNS approach.

In any way, FNS served as a reference for successful policies and programs implemented in the country - materialized in the FNS Organic Law (Law°n 11.346/2006) (Brasil, 2006). Thus, FNS becomes an objective of public actions and policies guided by the principles of the human right to adequate and healthy food (**RtF)** and food sovereignty, in clear opposition to the productive and consumption model promoted by large corporations and agribusiness.

This and more information from the text can be found in Maluf (2007); Leão & Maluf (2012); Burlandy & Maluf (2016), Nierderle (2023)

> Article 3rd. Food and nutrition security consists of achieving everyone's right to regular and permanent access to quality food, in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that respect cultural diversity and are environmental, cultural, economic, and socially sustainable (Brasil, 2006).
>
> Article 5th. The achievement of the human right to adequate food and feeding and nutrition security requires respect for sovereignty, which provides countries with the primacy of their decisions on food production and consumption (Brasil, 2006).

In the building process of these references in Brazil, a political field of FNSS/DHAA emerged with the country's re-democratization at the begining of the 1990´s, gathering social movements, civil society organizations, and scholars. Hunger in Brazil has a long history of approaches and actions to overcome it, in which Josué de Castro´s pioneering analysis stands out. He already denounced in the 1940s the social and political origins of hunger, but as the geographer argued, its solution goes through the political will - an element that, between ups and downs, throughout the second half of the 20th century, proved to be lacking for the Brazilian State. Social actors´ mobilization at the end of the dictatorial period in the second half of the 1980´s, advocating for ethics, citizenship,

and democratic participation in the formulation and implementation of public policies, contributed significantly to the consolidation of an organized civil society around the problem of hunger and poverty.

Affirming the political and multidimensional nature of hunger and, consequently, the guarantee of FSSN and RtF for the Brazilian population, this field was critical to the predominant models of food production, processing, and marketing, placing intersectionality and social participation as indispensable principles for public policies´ making. The main materialization of this conception was ~~in~~ the establishment of the National Council for Food and Nutrition Security (CONSEA) and its state and municipal analogs, with a central role in the debates and deliberations that would lead to the formulation and implementation of programs and policies that conform the National System of Food and Nutrition Security (SISAN in Portuguese) established by LOSAN, also integrated by the FNS Interministerial Chamber (CAISAN) as a government space. SISAN aims to articulate the actions of FNS/RtF at the national level and the relationship with federal entities based on intersectoral strategies to overcome hunger and promote SSAN and the RtF.

The development of FNS actions and policies in Brazil gained momentum during the governments led by Presidents Lula (2003-2010) and Dilma (2011-2016). Lula's government raised the priority of the national political agency to face hunger and poverty, with the *Fome Zero* (Zero Hunger) Program as its chief driver, encompassing a set of actions and public policies that sought to respond to the challenge of overcoming hunger and poverty in a transversal and intersectoral logic and by linking ~~in~~ the three spheres of government, through four main axes: access to food, income generation, strengthening family farming and social mobilization and control. The initiatives inherent in these areas of activity contributed greatly to improving food and nutrition security rates in the country and reducing families classified in poverty and extreme poverty.

Dilma's Government, in turn, brought an expansion of government actions to eradicate poverty in the country, focusing its initiatives on the range of the extremely poor who had not yet left this condition despite the efforts undertaken by *Fome Zero*. With this objective, **the *Plano Brasil sem Miséria* (Brazil Without Misery Plan)** was launched in 2011**,** based on the following axes: the guarantee of income for immediate relief of the situation of extreme poverty, access to public services improvement the conditions of

education, health, and citizenship of families; productive inclusion, aiming at to increase the capacities and opportunities for work and income generation among the poorest families in the countryside and the cities. The plan thus included programs for access to daycare centers, technical education, and the labor market, and included the *Bolsa Familia* Program (Family Grant Program).

The experience of this period led to positive results in reducing poverty among Brazilian families and improving the rates of FNS - for example, allowing the country to leave FAO's Hunger Map in 2014. Despite these advances, what was observed since 2016 with the legal-parliamentary coup that led to Dilma Rousseff's impeachment, was a process of policy dismantling that led to the emptying and even closure of programs of FNS in Brazil – a process that will last and worsen during the Bolsonaro's Government from 2019. This period is marked not only by the preservation of the priority to large-scale agriculture and the export of commodities but also by processes of dismantling food provisioning policies with the view of favor solutions anchored in the idea of the free market, deregulation, and policies for family farming, agroecology, and healthy eating. The dismantling of policies, increasing unemployment with the precariousness of the labor market and attacks on social rights, and the failure to cope with the pandemic resulted in 33 million Brazilians experiencing hunger and another 92 million facing some degree of food insecurity in 2022 (Rede PENSAAN, 2022). There is a significant lag in the minimum wage in relation to the value of the food staples[1], which is threatened by the presence of ultra-processed foods that contribute to the consolidation of an unhealthy food pattern[2]. The role of the State should be resumed in ensuring the right to a healthy and adequate diet, in sufficient quantity and respectful of the food crops present in the country. A state action based on the reference of FSSN and RtF and on participatory processes that give voice to social movements and organized civil society, affirming its decision-making capacity imbued in its condition as a sovereign player to exercise its right to decide on actions and policies of the food field.

1According to the Interunion Department of Statistics and Socioeconomic Studies (DIEESE), the value of food staples in 2022 increased in the 17 capitals where it conducted its research. The most expensive food staple value was observed in São Paulo ($R 791.29), equivalent to 70.58% of the net minimum wage in December 2022 (DIEESE,2023a).

2 A 2023 study by the Brazilian Institute of Consumer Protection (Idec) and the ACT Health Promotion illustrates how tax incentive policies and sanitary rules that affect the food staple are causing ultra-processed foods to be favored and introduced into the list of foods considered essential that make up the food staple - contributing, consequently, to a process of changes in food habits in the country toward the consumption of foods associated with the development of chronic diseases and that do not contribute to the guarantee of food safety (IDEC, 2023).

The government recently inaugurated in 2023, again under Lula's command, gives evidence that overcoming hunger and poverty is again playing a prominent role in the national political agenda, as evidenced by the resettlement of CONSEA and CAISAN, the reformulation of ministries, the launch of the reformed *Bolsa Família* with an increase in the minimum value to beneficiary families, the strengthening of the School Meal National Program and the resumption of programs to support family farming. It is necessary to advance public policies integrated among the federative levels - national, state, and municipal - grouped under a common framework that values the articulation of food production and eating, health, social and environmental justice, and the active participation of civil society. Regulatory policies on ultra-processed foods (such as rules for labeling and banning the selling in schools), the establishment of institutional and local markets for the supply of food from family farming, fiscal and technological incentives to the agro-ecological transition and incentive programs for urban agriculture (such as the granting of public spaces for community gardens) are examples of policies that, jointly and integrated, can contribute to the transition toward a sustainable, healthy, just and climate-friendly food systems in Brazil.

Chapter 3

Science, data, and information: Tools for the guidance of public policies on food and nutrition security in Brazil

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Food and Nutrition Security (FNS) is achieved when all individuals at all times have regular and permanent access to adequate food in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that are environmental, cultural, economic, and socially sustainable (Brasil, 2006; FAO, 2009). In Brazil, this 'concept-action' is based on **the recognition of adequate food as a human right, implying the duty of the State to plan, implement, and monitor public policies** aimed at the FNS of the Brazilian population.

The term **FNS brings together three** inseparable components that characterize the complexity of this concept. The **food component** refers to the processes of production, availability, and supply of food, while the nutritional component directly addresses a process that contemplates the choice and preparation of food up to consumption and its relationship with the health and nutrition of individuals (Burity *et al*., 2010; Cervato-Mancuso *et al*., 2015). These components are strongly related from a systemic perspective because, at the same time that food production in a country can be shaped to meet the demand of population consumption, the availability of food is also decisive in the process of choice and physical and economic access to food (Burlandy *et al*, 2015). Especially in communities marked by social and income inequality, access to food stands out as a central dimension of the FNS concept. The **temporal component** of the concept contemplates the notion of law, that is, adequate and healthy food should be guaranteed uninterrupted, welcoming the debate on stability, regularity, and environmental and social sustainability of the models of food production and consumption in force.

The translation of the FNS concept into public policies is a great challenge to governments and society, due to its nature, necessarily transdisciplinary in the conceptual, intersectoral dimension in the practical and sustainable dimension in its fundamental principles (Santos & Sampaio, 2013). The governance structure of the FNS policy in Brazil has as a legal framework the Organic Law on Food and Nutrition Security (LOSAN) number 11.346, promulgated on September 15th, 2006, which created the **National System of Food and Nutrition Security** (SISAN in Portuguese), with a view to ensuring the human right to adequate food (Brasil, 2006; Brasil 2010). SISAN must promote a set of planned and articulated actions to ensure the supply and access to food for the entire population and promote nutrition and health for all (Santos & Sampaio, 2013), based on six fundamental guidelines: *(i)* promotion of intersectionality; *(ii)* decentralization of collaborative actions among governmental spheres; *(iii)* monitoring

of the food and nutrition situation in order to subsidize management; *(iv)* conjugation of direct and immediate measures to guarantee access to adequate food, with actions that increase the population's autonomous subsistence capacity; *(v)* articulation between budget and management; and (vi) stimulation of research development and training of human resources.

At the federal level, the SISAN implementation provides for the existence of two institutional arrangements: (1) The FNS's National Council **(CONSEA**), a civil society participation agency that exercises social control and acts in the formulation, monitoring, and evaluation of FNS's policy; and (2) the Inter-ministerial FNS's Chamber **(CAISAN**), exclusive participation body of the executive, with the intersectoral arrangement and direct advice with the public manager who must act to enable the dialogue relationships between the managers of the pieces of equipment and services that constitute the SISAN's operational network. The periodic holding of the SAN's National Conference also comprises the system, space for society to contribute to the debate, and FNS's formulation of national plans (**Plansan**), with guidelines and goals to be implemented and achieved with the performance of different government sectors (Brasil 2006; Brasil, 2010).

The FNS's governance encompasses the integration of government programs and initiatives allocated in different ministries and government secretariats, and this intersectoral challenge is also involved in the debate on monitoring FNS in society. Monitoring or measuring FNS necessarily involves the application of different indicators and tools that may indicate problems, in at least four dimensions (Santos & Sampaio, 2013):

(1) Production, availability, and supply of food, which aims to estimate the capacity and conditions of food production in a country, as well as what are the ways of disposing of production toward the internal supply of the population, also considering the variety and quality of the food produced and available, the food systems present in the territory and their socioeconomic, health and environmental implications;

(2) Access to food, with the aim of monitoring if there is experience of the population with deprivation of access to food, including hunger;

(3) Food consumption, contributing to characterize the food practices of a population;

(4) Biological use of nutrients in order to understand conditions for access to social, sanitation, and health services that may constitute a risk context and limit the use of nutrients present in food consumed.

Many are the indicators and tools available in the technical-scientific literature and implemented for monitoring the FNS's dimensions (Kepple & Segall-Corrêa, 2011; Pérez-Escamilla *et al.*, 2017; Shamah-Levy *et al.*, 2017; HLPE-FSN, 2022). There is, however, no tool or methodology that can contemplate all the dimensions of the phenomenon, considering the multi-disciplinary nature previously highlighted.

Food photo taken during the National Food Safety Survey.
Source: Rede PENSSAN.

In Brazil, FNS's monitoring involves the use of indicators from various ministries and sectors related to FNS, such as health, agriculture, development, and social assistance, demanded in the intersectoral articulation (CAISAN, 2017a; Oliveira *et al.*, 2022). In addition, the Brazilian Institute of Geography and Statistics (IBGE) plays a role of relevance in collecting, analyzing, and making available information about society in various dimensions of interest to FNS, in addition to the fact that, in addition, the universal health systems (SUS in Portugues) and social assistance (SUAS in Portugues) have advanced information storage systems of the population that uses its services, as it can be seen in

the figure elaborated to show the relations among science, data and information in the FNS context.

However, in addition to the availability of a population database, there is a reflection: has the information produced been incorporated into the political debate in the context of the FNS's governance in the different spheres of government and civil society?

Data are tools for public managers and civil society to be able to know the challenges and problems experienced in a community, municipality, state, or country, which allows the diagnosis and monitoring of the FNS's situation from different dimensions, as well as the understanding their social, political and economic determinants and their short and long-term outcomes in people's lives and health. However, there are numerous challenges. Initially, the government databases (information systems and IBGE's surveys) and other sources in health, education, and social assistance, for example, adopt different territorial units to generate and disaggregate information. Thus, there are impairments in integrating the results of the different indicators and for formulating convergent policies and actions. The resumption of the "Unified Registry" by the federal government, with much relevant social and demographic information from the individual, home, neighborhood, municipality, favors intersectoral action. However, other information regarding the availability of food is needed for action in FNS, for example, which is not presented in the same format.

For the scientific community the challenge remains referred to the ability to prepare reports, publicize and communicate the results of research in an intelligible way to society in general and applied to the context of public policies. The data production and availability do not necessarily determine that this information will guide public policies in a given field, or that it will be appropriate by civil society in its citizenship fulfillment. In the context of FNS policy, the data produced are useful when used in decision-making, leading to the definition of guidelines for public policies and planning and the implementation of programs and actions, as well as they can support monitoring and evaluation systems that allow the progressive improvement of public action.

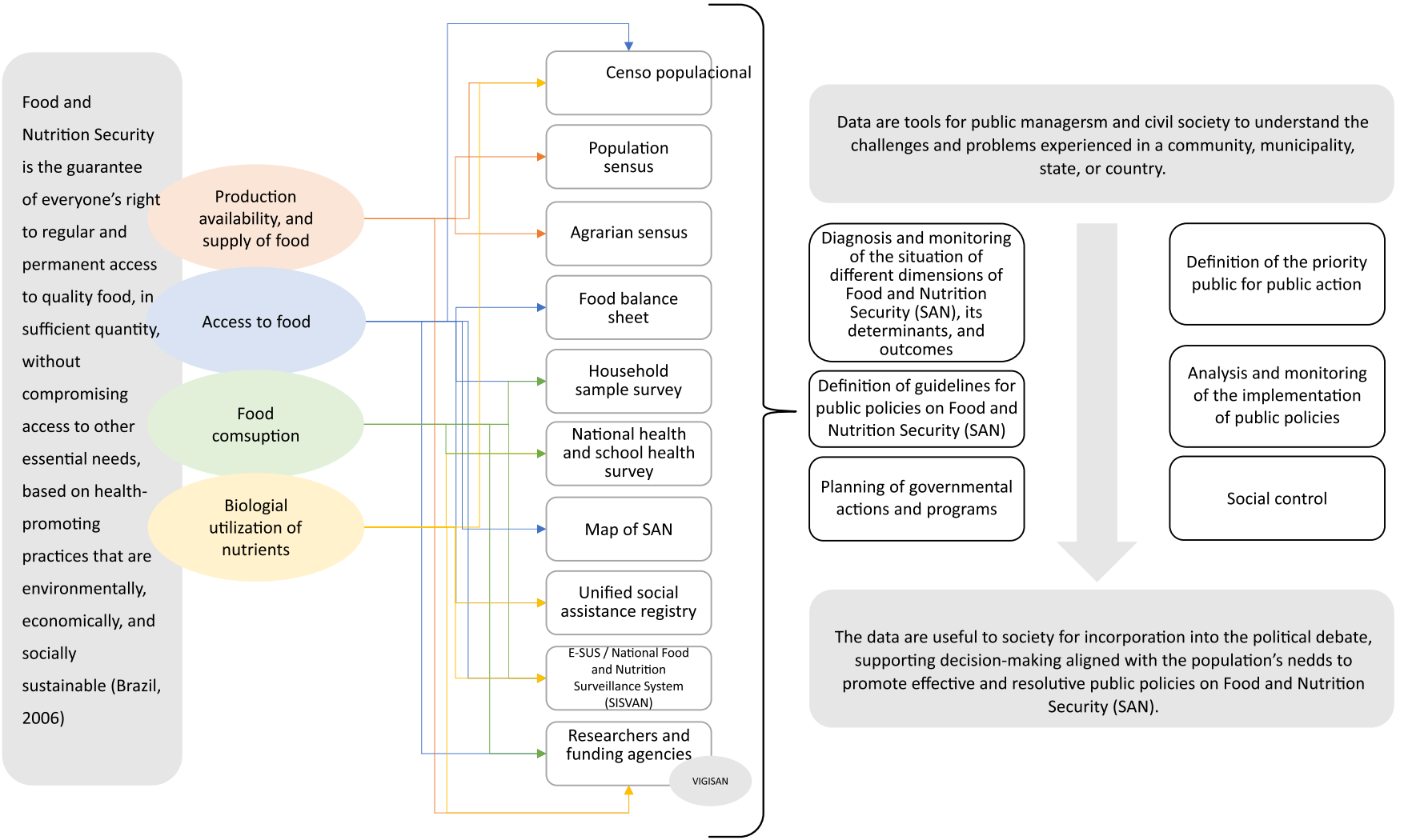
In an exercise of **citizen science, that is, the one that is built and shared with society**, the Brazilian Network for Research on Food and Nutrition Sovereignty and Security (Rede PENSSAN), in partnership with national and international civil society

organizations, held in 2020 and 2021-2022, two National Food Insecurity Surveys in the context of the Covid-19 pandemic (VIGISAN). The data produced documented the return of the severe hunger situation in the country in 2020, when more than 50% of Brazilians were classified as food insecure, and 19.1 million lived with the experience of hunger (Rede PENSSAN, 2021). **In 2021-2022, the results showed 33.1 million people without having what to eat and 57.8% in some degree of food insecurity** (Rede PENSSAN, 2022). The results of the I and II VIGISAN support the social struggles of various segments of Brazilian society during the pandemic and, currently, they have been accepted in the spaces of social control and by governments impacting decision-making in the FNS's field of public policies and fighting hunger in Brazil.

Some learnings can be highlighted from this experience of Rede PENSSAN. **The performance of a population diagnosis requires adequate and validated methodology, the solid design of the research, and the teams prepared for data collection, treatment, and analysis**. In VIGISAN, the tool chosen to measure hunger and food insecurity was the Brazilian Food Insecurity Scale (EBIA), an experience-based scale adapted from the American Household Food Security Survey Module, and validated for use in Brazil since 2003 (Pérez-Escamilla *et al*., 2004). The theoretical conception of the instrument considers food deprivation as a progressive phenomenon experienced at the home level and, in the most severe cases at the individual level, from dimensions that include fear of suffering from food deprivation, the reduction in the quality and/or quantity of food accessed by the family and hunger (Kepple & Segall-Corrêa, 2011). The EBIA application is associated with a socio-demographic information questionnaire, so that the results of the evaluation of food insecurity in gradients of mild, moderate and severe can be associated with different biological and social conditions.

Since the validation, EBIA has been used by researchers and IBGE in actions to research and monitor food insecurity in Brazil (IBGE, 2014; IBGE, 2020a), so that, when the VIGISAN's results were launched, it was possible to compare the scenario of hunger during the pandemic with previous research results carried out by IBGE. The persistence of the methodology, with adaptations that have been validated, ensures comparability and adds historicity to the analysis, as the advances and setbacks can be analyzed considering the sociopolitical moments experienced.

Another feature of a good search tool is the clarity of its results. EBIA classifies and allows to estimate the number of families living with deprivation in access to food, quantifying the number of people in hunger situations. The experience of Rede PENSSAN, revealing the 33.1 million Brazilians in the hungry situation has generated demand for public policies in all government spheres. In addition to the scientific legitimacy and clarity of information for the scientific community, the experience of translating the data found into an accessible and intelligible language for society was another learning. At VIGISAN, from its conception to the analysis of the results, the researchers were talking with organized civil society and with experts in communication, building data and information that, in fact, could be appropriate by social movements, as well as communication and dissemination strategies were also elaborated in the collective. The group of researchers also prioritized the dissemination of results, primarily in the form of technical reports directed to society, politicians and communication vehicles, with adapted language. On the site www.olheparaafome.com.br the research reports are published with methodological information and highlighted results, in an interactive, intuitive way in navigation, being public domain. With this, Rede PENSSAN understands that it is also fulfilling its commitment to citizen research.



Science, data, and information: tools for guidance of public policies on food and nutrition security in Brazil From the perspective of these players "availability of food" tries to make available to people an adequate diet; "access to food" includes sufficient resources for families and individuals to obtain food for a nutritious diet; and "use of food and nutrients" treats the human body's ability to ingest and metabolize food, which includes consuming them in a biological and social environment suitable for good health.

Final Considerations

The promotion and guarantee of FNS for all, with sovereignty and commitment to the human right to adequate food, especially in a historical situation of multiple structural inequalities as in Brazilian society, demands scientific information that guides public policy decisions, as well as mobilizations and actions of civil society.

The information of interest, besides being produced systematically, with adequate design and with validated tools to ensure reliability, must be submitted to the challenges of transparency, communication, and utility. Transparency to reach all stakeholders and generate learning and commitment. Communication to promote dialogue in all sectors of society. Utility to be translated into effective action, able to be monitored and evaluated. Transparency, communication, and utility for food advocacy and accountability.

Rede PENSSAN, by bringing together researchers from all over the country, and also by building international partnerships around common objectives, guides its debates and actions by the principles of citizen science. It could not be different in dealing with food and nutrition sovereignty and security, essential citizenship rights. Upon carrying out strategic research, such as the I and II VIGISAN, reading was made that it was necessary to maintain the production of information in a context of denial of science as the basis of public action by governments and society. The learning has been enormous, and from them, we list some actions suggested at the end of this text so that the production of scientific data and information can be, increasingly, a support for the changes we expect to build a country without hunger.

For the scientific community that dialogs with several of the FNS's dimensions, the challenge is to advance in some conceptual and methodological boundaries. Certainly, the challenge of reaching other dimensions of phenomena with validated tools that can generate local, regional, and national data is an agenda. In conceptual terms, researchers, especially those who work in unequal contexts, have the challenge of appropriation, translation, and execution of studies and research that can contemplate the human rights approach, intersectionality, and decoloniality, among other frontier topics, so that together we may make **citizen and inclusive science.**

Actions to strengthen the scientific contribution to FNS

- Strengthening of national and state research institutes enabling the monitoring of different dimensions of FNS in the country through public population databases available to researchers and civil society.
- Inclusion and maintenance of the Brazilian Food Insecurity Scale in national, state, and municipal research surveys.
- Investment in the integration, including territorial, of national research databases and information systems, since an intersectoral/multisectoral public policy requires integrated data to expand the scope of FNS analysis.
- Investment in technological apparatus and human resources training to improve the capacity of state governments and municipalities to collect and analyze their databases from public policy information systems.
- Expansion of government funding for strategic research in the FNS's field, with a longer term of support since the prevailing deadlines of 12 to 24 months may be incompatible with the challenges of transdisciplinary and intersectoral research that imply structural changes.
- Expansion of the recognition of FNS as a scientific field in Brazil, from the inclusion of the topic in the knowledge tree of the National Council for Scientific and Technological Development and Coordination for the Improvement of Higher Education Personnel.
- Promotion of opportunities for integration of researchers with managers and rulers, aiming to expand the dialogue of data produced by science as a tool for implementation, monitoring, and evaluation of public policies in FNS.
- Including the dissemination and publicization of research results for civil society and government officials as a planned stage for the elaboration and submission of projects in funding agencies in Brazil, it is also to encourage the inclusion of the participation of civil society organizations and technicians as members of the teams of researchers.
- The integration of teaching, research, and extension is essential so that researchers, graduated and graduating students in universities, in which national research is concentrated, can carry out citizen research. To stimulate this perspective, it is also important to rethink the evaluation system of researchers and graduate programs, so that other forms of science dissemination can be valued alongside articles published in high-impact international journals.

Chapter 4

The complexity of food and nutrition security

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Food and nutrition security (FNS) results from the fulfillment of the right to "...regular and permanent access to quality food in sufficient quantity, without compromising access to other essential needs, based on health-promoting food practices that respect cultural diversity and are environmentally, culturally, economically and socially sustainable" (Brazil, 2006). This concept expresses the **inseparability of the food and nutrition dimensions**, which is a milestone in the Brazilian contribution to the debate on the FNS approach. The Brazilian FNS concept highlights different processes that food undergoes, from planting to final consumption/destination, as well aspects related to the incorporation of foods into the organism, contributing, for example, to the state of health (adequate or not) (Maluf, 2007; Leão & Maluf, 2012). Furthermore, it is important to highlight that the FNS concept, described in the Organic Law on Food and Nutrition Security (*Lei orgânica de Segurança Alimentar e Nutricional* - LOSAN), has two guiding principles: food sovereignty and the right to adequate food (RtAF). RtAF refers to the regular and permanent accessibility of food, especially when people face economic, geographical and other constraints to meet their needs (Burity *et al*., 2010; Leão & Maluf, 2012).

The Brazilian concept recognizes the FNS as a condition resulting from the performance of different sectors such as health, agriculture, education, social welfare, culture, civil society, etc. This intersectoral approach of FNS guides its institutionalization in the government and leads to research activities and policy formulation (Burlandy, 2009). This approach also allows us to observe the different manifestations of food insecurity (FI), i.e. from the most severe form - hunger - to other food and nutrition issues such as low birth weight, malnutrition, specific nutrient deficiencies (examples: iron deficiency, hypovitaminosis A, among others) as well overweight, obesity and other non-communicable diseases - NCDs (CONSEA, 2004; Souza & Marín-León, 2013; Gregory & Coleman-Jensen, 2017; IBGE, 2020a; Brasil, 2022c).

In this sense, being in FNS is not an outcome that depends on the choices and actions of individuals or families. Since FNS has as one of its foundations the RtAF, which was included in the Brazilian Federal Constitution in 2010, it is the responsibility of the state to ensure that this condition is achieved (CAISAN, 2017b). Food has been reaffirmed as a state responsibility that must be respected by the three branches of government: executive (local, state, and federal), legislative, and judicial, in order to protect and promote access to adequate and healthy food for the entire population

(Burity *et al*., 2010). This implies the responsibility of the state to ensure regular access to food, especially in situations of lack of food resources and climatic disasters (Pinstrup-Andersen, 2009). The state must have a variety of strategies to promote FNS, such as public policies that strengthen and support production, supply, access to income, education, health monitoring, social income transfers, etc. (Rede PENSSAN, 2022; Salles-Costa *et al*.., 2023).

In order to identify the determinants of FNS, explanatory models have been formulated (Kepple & Segall-Corrêa, 2011; Bem-Lignani *et al*.., 2020; Piaskoski *et al*., 2020). From the field of health comes the explanatory model of the determinants of health or illness, which is linked to the approach of the social determinants. Social determinants of health (SDH) are factors related to the conditions in which a person lives and works, and include social, economic, cultural, ethnic/racial, psychological, and behavioral factors that influence the occurrence of health problems and risk factors in the population, and nutrition is one of these factors (Buss & Pellegrini-Filho, 2007; WHO, 2011). Using the SDH approach in the health conditions analysis has been recommended by the World Health Organization (WHO) as well by scientists/researchers (Marmot, 2005; Buss & Pellegrini-Filho, 2007; Solar & Irwin, 2010). In Brazil, the most widespread model organizes determinants into levels of influence on individuals (individual, community/collective, and macro) and is widely used in studies of malnutrition - a biological condition directly related to hunger.

This debate on determinants is also present in the field of FNS. Kepple and Segall-Corrêa (2011) propose an FNS determinant model based on multilevel (macro-socioeconomic, regional and local, household), intersectoral, and relational elements. In this model, the determinants associated with the household level are related to the socio-economic characteristics of the inhabitants, such as schooling, race/skin color, reference person, distribution and access to income, work/employment situation, access to social programs, and support networks. At the intermediate level, food prices, policies related to social security, racism and other forms of discrimination, and food culture are highlighted. At the macro-social level, the national political-economic system, national macro-social policies, and the RtAF institutionalisation (Kepple & Segall-Corrêa, 2011). Other determinants were highlighted, such as access to land, inadequate access to basic social services (such as education, health, and basic sanitation, among others), the reduction or elimination of FNS policies, access to a minimum income, unemployment,

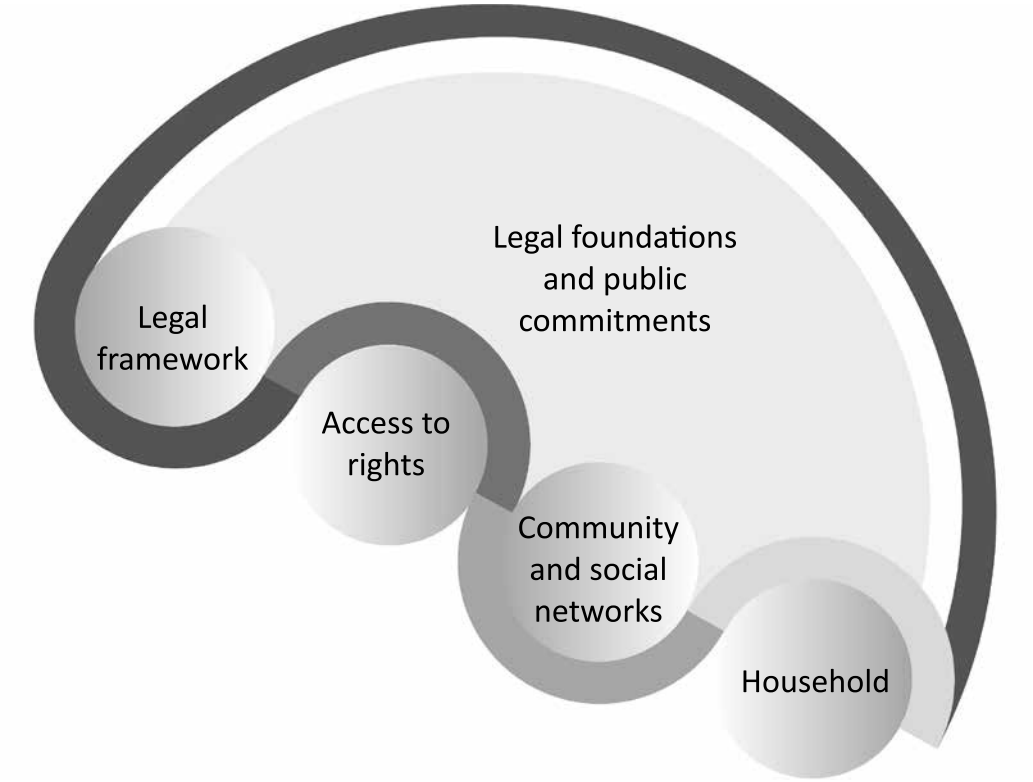
and inflation rates. Those elements constitute a set of determinants and reflect obstacles to achieving adequate living and working conditions. There are also structural barriers to a potential break in the cycle of poverty and FI (CONSEA, 2004; Kepple & Segall-Corrêa, 2011; Bem-Lignani *et al*.., 2020; Valente, 2021).

Similar to the SDH, the explanatory models for the determinants of FNS explain the different factors that affect access to adequate and healthy food. Family income plays a central role among these factors (Bem-Lignani *et al*.., 2020).

The complexity of the FNS: Reading in the light of referencing social determinants of health.

In this section, we propose an exercise aimed at identifying measures related to FNS in Brazil. This was done based on the interface between the concepts of SDH, FNS, and the explanatory models of FNS determinants (Kepple & Segall-Corrêa, 2011) and the relationship between social indicators and FNS (Bem-Lignani *et al*., 2020). This exercise, summarized in the figure and table, has attempted to characterize the complexity of the FNS and can be a mapping and action planning tool for individuals, households, municipalities, and states of Brazil. Another potential contribution is the detailing of the elements present in the FNS concept, based on the SDH model.

DIMENSIONS ASSOCIATED WITH FOOD AND NUTRITION SECURITY



Dimensions associated with Food and Nutrition Security (FNS). Source: the authors.

Details of the dimensions associated with Food and Nutrition Security (FNS): approach to the debate on determinants in the Brazilian context.

Dimension of Legal Foundations and Public Commitments	**Legal basis** Ratification by Brazil of international human rights declarations and treaties. Signature to the Voluntary Guidelines in Support of the Progressive Implementation of the Right to Adequate Food in the Context of FNS, adopted at the 127th Session of the FAO Council in November 2004. Publication of the Organic Law on Food and Nutrition Security (LOSAN) - Law No. 11.346/2006 and Decree 7.272/2010. Approval of the inclusion of the right to food in the Federal Constitution in 2010, which includes food as one of the social rights described in Article 6. Global commitments made by the country to the implementation of the 2030 Agenda/Sustainable Development Goal.

Legal Framework Dimension	**Economic** Macroeconomic policies aimed at reducing inequalities and income disparities. Annual updating of the minimum income, formal job creation, and regular income strengthening policies.
	Environmental Food production without pesticides, preferably organic/ agroecological. Food production, processing, distribution, consumption, and final destination are based on sustainable environmental practices and low gas emissions. Supporting food production integrated with environmental protection.
	Cultural Preservation and valorization of traditional culture, especially those related to the production, processing, distribution, consumption, and final use of food.
	Democratic Active operation, with favorable conditions for carrying out the planned actions of the social participation councils. Mechanisms and opportunities for participation and social control. Policy decisions involving political actors and coalitions to support commitment to RtAF.
	Agricultural Strengthen, through public policies (credit, institutional markets, crop insurance, technical assistance, and public rural extension), the production of food and livestock for human consumption by family farming, traditional peoples and communities, and indigenous peoples. Expand access to land through land reform. Ensure access to technical assistance, and public rural extension services for family farmers. Promote policies that support and empower women as food producers.
	Social security Social policies and measures to ensure access to social protection. Health promotion and disease prevention policies, including actions aimed at the production, marketing, access, and consumption of adequate and healthy food. Social and social security policies to guarantee income.

Dimension of Access to Rights (in living territories: urban and rural)	**Education** Access to quality public education. Favorable conditions for attendance and regular participation in teaching/training activities. Access to vocational training and income-generating opportunities linked to studies (internships, etc).
	Safety Safe living environment. Promoting the culture of peace in the different areas.
	Transport The existence of an urban/rural mobility network allows food to be properly transported, avoiding waste, reducing costs in the food chain, etc.
	Production and availability of food Varied food derived from environmentally, socially and economically sustainable cultivation and production processes. Regular, permanent, and affordable physical availability of food. Access to land and water for small producers to produce food.
	Information From a factual and/or scientific perspective, obtain and publish truthful information.
	Work/employment Access to secure, decent-paid employment to meet basic human needs.
	Water/sewage Presence of a treated sewage network in households. Access to treated water.
	Dwelling/housing Access to food in the neighborhood.
	Income Stable and regular income to buy food and other basic products/ services.
	Life free from discrimination Elimination of all forms of discrimination and barriers to life development: sexual violence, sexism, racism, prejudice (age, disability, gender, religion), etc.

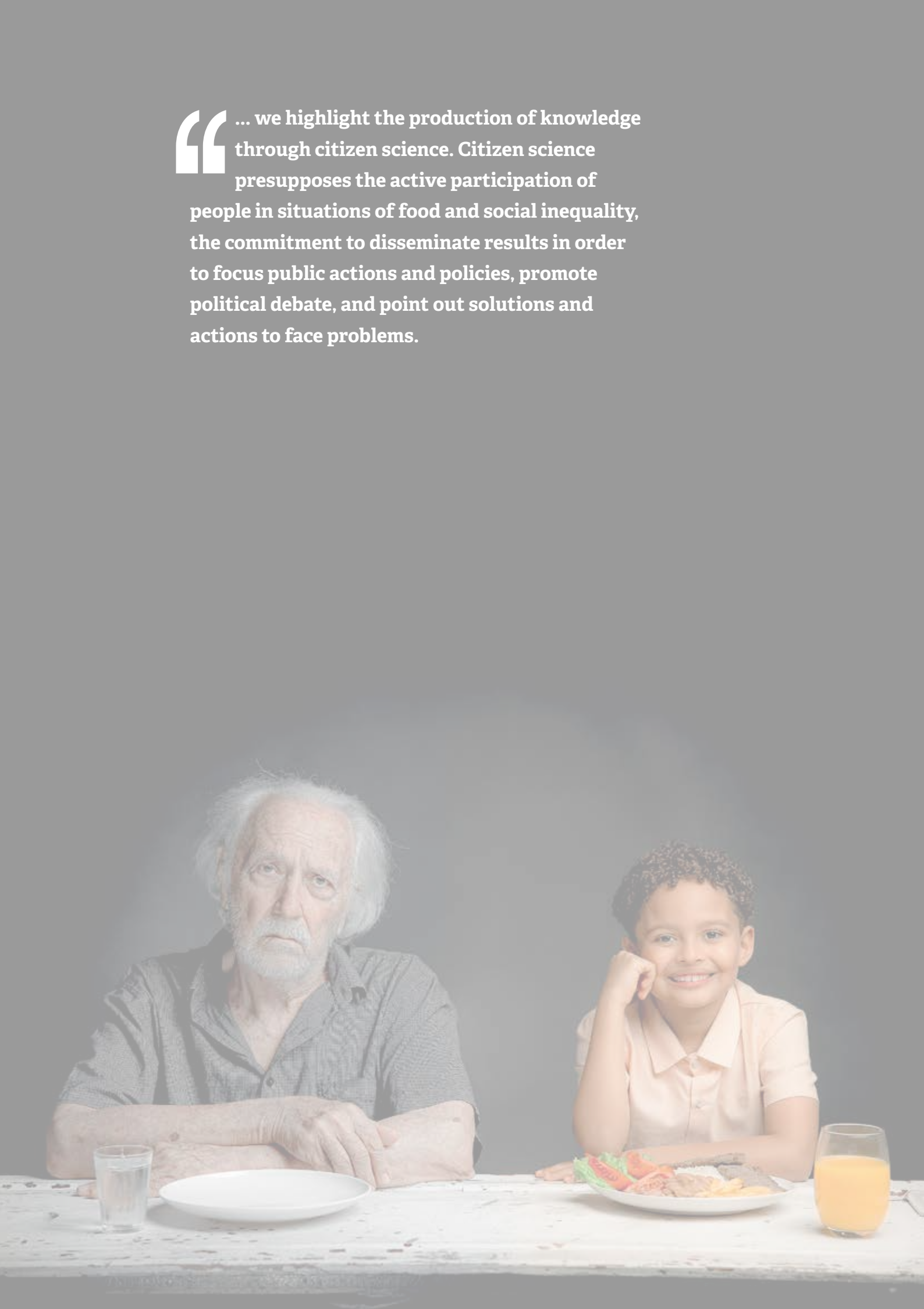
Dimension of Community and Social Networks (neighborhood or metropolitan region/ city)	**FNS promotional public equipment** Community gardens, popular restaurants, and other social facilities that provide access to food.
	Support groups Access to and participation in health education groups, vocational training/income generation, neighborhood associations, religious groups, etc.
	Local production of healthy and sustainable food Articulation between producers and consumers to ensure a regular and sustainable supply based on fair and sustainable trade practices from a social, cultural, economic and environmental point of view. Access to technical, financial and educational support for the consolidation of agroecological and organic farming and livestock breeding.
	Access to food from non-monetary exchanges Food production and animal husbandry based on community actions, Access to food through solidarity economy actions.
Household dimension	**Sex** Women have living conditions that make them (and their households) more vulnerable to manifestations of FI.
	Age Children and the elderly are more vulnerable to the effects of FI.
	Race/skin color Black people experience living conditions that make them (and their households) more vulnerable to FI.
	Physiological condition Women in pregnancy and lactation, people with physiological and health conditions, chronic and acute, who require adequate nutrition to maintain health.
	Severe food allergies/intolerances Biological conditions leading to a drastic reduction in food consumption and/or the need for food with special characteristics

Implications of FNS's complexity for research and public action

This text is the first input to reflect the complexity of the FNS from the perspective of the theoretical and analytical framework of the SDH. The dimensions of the FNS point to avenues for greater coordination between sectors and territories, aimed at formulating actions to guarantee the FNS and combat hunger. In this sense, **we highlight the production of knowledge through citizen science. Citizen science presupposes the active participation of people in situations of food and social inequality, the commitment to disseminate results in order to focus public actions and policies, promote political debate, and point out solutions and actions to face problems.**

We also reiterate the need to strengthen the FNS councils at national, state, and municipal levels as dialogue arenas between the State, researchers, representatives of civil society, and social groups that experience the manifestations of FI. The reopening of the National Council of the FNS and the maintenance of the activities of the State and Municipal Councils of the FNS are fundamental actions for the development of FNS policies in an intersectoral way and more effective for local problems and challenges. The strengthening and implementation of the FNS National System will enable the political articulation between actors, councils, and chambers in the search for the achievement of the RtAF, the effectiveness of the FNS, and the eradication of hunger in Brazilian society.

“... we highlight the production of knowledge through citizen science. Citizen science presupposes the active participation of people in situations of food and social inequality, the commitment to disseminate results in order to focus public actions and policies, promote political debate, and point out solutions and actions to face problems.



Chapter 5

Untying knots: Women and food safety

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Elisabetta Recine

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Food and Nutrition Security (**FNS**) is a central issue in the debate on food and health assurance, as it covers a set of elements, dimensions, and subjects that, from seed and earth, bring (or not) food to our dishes. FNS requires continuous and articulated efforts to be effective before the challenges of food systems and current socioeconomic dynamics. Ensuring food is fundamental for the exercise of freedom and, therefore, is inherent in human dignity (Brasil, 2006; Silipriandi, 2012).

In 2015, the United Nations approved the 2030 agenda with 17 Sustainable Development Goals **(SDGs**). SDG 2 aspires by the year 2030 to end hunger and ensure access to secure and healthy food. According to Agarwal (2018), SDG 5 (gender equality) has the potential to contribute to SDG 2, considering the role of women in society. **In the production, processing, distribution, preparation, and consumption of food, it is possible to perceive their participation in the actions that involve the guarantee of FNS** (Silipriandi, 2012; Agarwal, 2018).

Women play a fundamental socio-cultural, economic, and political role in domestic and community food. Therefore, discussions on such aspects should, above all, consider gender issues. By determining what is expected and allowed for men and women, society creates differences and assigns levels of responsibilities to both ends, consequently generating inequalities. As a result of social constructions, these factors directly affect the lives of women and, above all, their work and food-related roles (UN-BR, 2016; CSM, 2019; FAO, 2022c).

On the inequalities that affect women, we highlight **their constant disempowerment in the processes and policies that involve food, ranging from production to consumption** (Patel, 2012). Inequalities are also expressed in Food Insecurity (IA), which, in 2021, reached 31.9% of the female population in the world and 64% in Brazil (Rede PENSSAN, 2021; FAO; 2022c). This situation is exacerbated in households headed by black women, due to structural interactions between racism and economic vulnerabilities (Rede PENSSAN, 2021).

In addition, according to the V Civil Society Light Report 2030 Agenda for Sustainable Development Brazil, 2021 of the nine goals present in SDG 5, seven suffered negative impacts that influenced the achievement of gender equality. Namely**: the increase in domestic violence, the intensification of the sexual division of domestic**

labor, the decline of parliamentary female representation, barriers in access to technology, etc (GTSC-A2030, 2021).

Such problems affect women who produce and consume food in rural and urban areas. Therefore, we believe that FNS goals will only be achieved if gender inequalities (and also racial and economic inequalities) are addressed from the perspective of women's rights (CSM, 2019; FAO, 2022c). From this point on, we propose to discuss here, the role of women in FNS, highlighting the challenges faced by women in guaranteeing FNS and their social rights.

Women in food and nutrition security: from production to consumption

Much of the food that comes from the countryside to our tables is produced by family farming. Women constitute a relevant proportion of agricultural producers, as they account for about 43% of the total quota (FAO, 2011b). In this scenario, women perform fundamental activities in all stages of production, ranging from collection, preparation of the land, cleaning of the crops, cultivation of vegetable gardens, harvesting, local marketing, and supply networks (Silipriandi, 2012; Agarwal, 2018; CSM, 2019).

We emphasize, here, the role of family farmers in view of the particularities surrounding their agri-food practices. First of all, when talking about FNS, it is important to recognize the bonds between sustainability and food because the guarantee of environmental, social, **and economic sustainability tends to ensure healthy eating for people as well**. **At this point, farmers are key players in the development, realization, and maintenance of often sustainable practices**. They focus **their actions on domestication, preservation, and acclimatization of species, conservation of creole seeds, cultivation, and use of medicinal plants,** etc. They often employ traditional experiences and knowledge transmitted generationally, engaging in the preservation of culture and biodiversity. Thus, the dialogue between women's agri-food production and agroecology is evident from the perspective of food production under the aegis of sustainability (CSM, 2019; Schottz, 2019; Leal *et al.*, 2020).

An interesting point in this context is the existence of yards cultivated in different scenarios, which present a diversity of plants, vegetables, and medicinal

herbs used in the daily family diet and shared by the communities. These align with agroecological practices where traditional and sustainable knowledge is also applied. These spaces contribute significantly to the economic dynamics and FNS of families and the surrounding community, promoting the greater use of fresh and healthy foods (Leal *et al.*, 2020).

Through the yards, women tend to initiate the agroecological transition, having as the main stimulus concern for the family's health and food, the preservation of biodiversity, and resistance to the hegemonic agri-food model. Not for nothing, many agroecological movements are also feminist movements. Therefore, it is **urgent to recognize that women are building agroecology in their daily practices** (CSM, 2019; Schottz, 2019).

Women also contribute in contexts that transpose food production, **relating to processing, marketing and preparation intended for family and community consumption** (Schottz, 2019). The female role in the supply sector is visible in terms of its massive presence in free fairs, public markets, fruit and vegetable markets, grocery stores, supermarkets, street trade, etc, performing activities that involve the food trade.

The so-called "informal food sector", for example, employs a large number of women and is defined as a type of trade that covers small producers, traders, and service providers involved in food-related activities. Unfortunately, such people suffer from a lack of recognition in the formal market, not having guarantees of labor and social security rights (FAO, 2011b). This sector contributes to FNS by providing affordable food in places with a population of socioeconomic vulnerability and providing income and food to marginalized contexts. Thus, women are **often responsible for the retail sale of fresh products such as fruits and vegetables, food supply, and sale of meals and street food**. Such activities promote access to food for a large number of people at low cost, favoring FNS to some extent (FAO, 2011b).

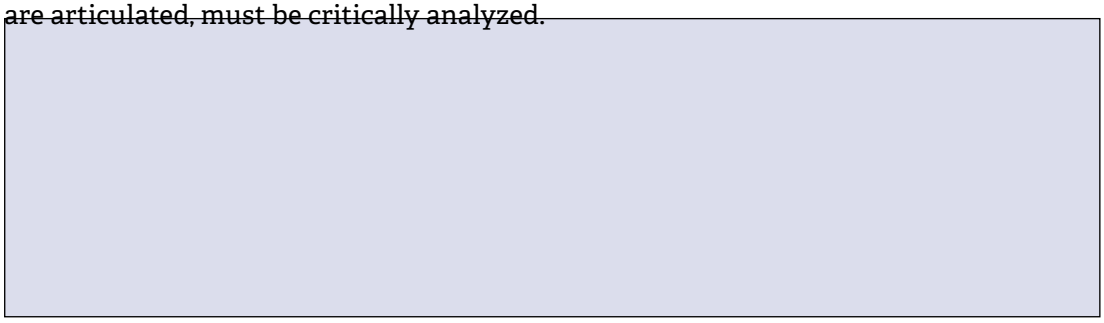
When it comes to the choice, planning and preparation of food, a means that allows the food consumption of the family, the female presence is also a remarkable condition (Anigstein, 2020). The tasks involving the domestic kitchen move between the planning of the menu, the purchases, the storage, the conservation, the preparation, the

service, as well as the cleaning of the materials used. Thus, cooking requires notions about the use of resources from the most primitive to the most technological ones, as well as knowledge about the use of fresh food and its processes of transformation and processing in domestic kitchens.

Knowing which foods, utensils, and techniques should be used, as well as managing the time employed in preparing meals, are examples of skills developed and directly imply the promotion of a healthy diet. Women's roles in the domestic scenario involve strategies of provision, preparation and consumption of meals. Therefore, each recipe and cooking preparation comes from an articulated context based on strategic planning and targeted activities (Anigstein, 2020).

Cooking covers a repertoire that is built, in the specific case of women and domestic cuisine, in daily life and tends to be transmitted generationally. It is possible to state, then, that the maintenance of traditional kitchens and dishes have in these their substantial maintainers. Faced with a context of food and world transformations, **the female role preserves the "ways of knowing how to do" of culturally significant food** for the groups they integrate, preserving memories, stories and feelings (Schottz, 2019).

In addition to the domestic context, women are also present in other activities that involve the preparation of daily food through cooking and that contribute somehow to FNS. The work of domestic cooks, dinner ladies, community cooks, cooks of popular restaurants, etc., from their work, solve the food needs of certain groups, also providing health. Such professionals are involved in the preparation of meals, linking themselves to the guarantee of a daily diet in a way almost always accessible to most of the population. However, this issue must be taken with care when we think about the work of domestic workers and cooks who, because they are in a complex context whose racism and sexism are articulated, must be critically analyzed.



- Due to socio-cultural constructions, women play an important role in ensuring FNS, from production to food consumption.
- Gender inequalities affect the lives of women, food producers, and consumers, in rural and urban areas and imply their performance in FNS.
- It is necessary to reflect on the appreciation of women's contributions and question the burden experienced by women in guaranteeing FNS.
- It is important to implement social protection policies for women, policies that understand their demands and encourage them to have autonomy and lightness in their practices.

Challenges and possibilities for the performance of women in FNS

As noted, women perform numerous activities in different contexts involving food, ranging from production to consumption. Despite this, many players claim that the female role tends to be devalued due to its bond with domestic and care work, besides being judged by sociocultural constructions that attribute to women notions of fragility and inferiority.

Women's agricultural work is an important resource for the guarantee of FNS, but it does not acquire social and economic prestige, especially when it comes to small-scale agriculture. It is necessary to point out that such a devaluation occurs before two points. The first concerns sociocultural aspects that consider such activities secondary to those of men in rural areas and do not recognize female protagonism. The second is related to the economic context that, in a capitalist and global scenario, suffocates alternative practices of food production (Slipriandi, 2012; CSM, 2019; Leal *et al*., 2020).

The patriarchal power relationships, the sexual division of labor, the capitalist system, and the androcentric agricultural policies form a structure that causes profound inequalities and marginalization of women in rural areas. In this scenario, women have difficulties in acquiring and exercising their right to land, which is necessary for agri-food production (Agarwal, 2018; CSM, 2019). At this point, SDG 5 points out that **ensuring access to property and resource control is one of the goals of achieving gender equality** (UN-BR, 2016).

The concentration of power in the current food system also brings adverse consequences that reinforce and reproduce gender inequalities. The dominant productivist logic uses the environment as an infinite source of wealth for the increase of productivity and profit. In contexts in which women hold alternative agricultural practices, they find barriers to having their knowledge supplanted by ideologies and technologies of industrial agriculture (Patel, 2012; Slipriandi, 2012).

As rights holders, women must have equal participation in decisions about their territories, productions, and their lives (CSM, 2019). Patel (2012) points out that democracy in food and agricultural policies can be achieved through women's participation in the discussion spaces in a fair manner. Participation in public life, especially in decision-making, is a crucial measure of female empowerment and a strategy to promote gender equality (UN-BR, 2016).

The **full capacity of female contribution to FNS depends on their access to land, credit, technology, and technical and government incentives** (Agarwal, 2018). Only through the paradigm of food sovereignty and sustainable agricultural practices will women achieve recognition and validation of their work. This direction extends to guaranteeing food for all, socialization of care tasks and promoting respectful and equal relationships (CSM, 2019).

Female food workers in the domestic sphere also go through a lack of recognition. According to IBGE, in 2018, women performed twice as many weekly domestic chores compared to men, and cooking was the activity that showed the most difference between both of them (IBGE, 2020b). This shows that **domestic food is a unilateral responsibility that overloads women**.

Providing daily food implies planning and dedication of time and effort. According to Anigsten (2020), the relationship between material conditions and care actions makes women guilty and feel better or worse caregivers when they do not meet expectations. This situation occurs especially in a scenario of reconciliation of double working hours and economic vulnerability.

When it comes to black and low-income women there is a greater complexity because, when exposed to socioeconomic disadvantages, they hardly get social or

governmental support. The lack of sharing of activities, the burden, the collection, the difficulty of access to resources, the degree of mobility, obstacles in the labor market and other vulnerabilities impact the guarantee of FNS, enabling the consumption of unhealthy foods and even hindering access to them (Silva & Recine, 2023)

Female involvement with family health issues is a strategic issue in promoting lasting healthy eating habits. Despite this, caregivers and/or heads of the families are among the main profiles of people suffering from IA due to factors such as low income, low-quality food consumption and even food abstention for the other family members(Silipriandi, 2012; Anigstein, 2020).

Thus, it is necessary to recognize this context and discuss a new sexual division of domestic work, the core of female socioeconomic vulnerability, the unilaterality of food care in the private sphere, and racism (Silipriandi, 2012; Silva & Recine, 2023). Shared responsibility implies a balanced distribution among family members, as it contributes to reducing gender inequality (UN-BR, 2016).

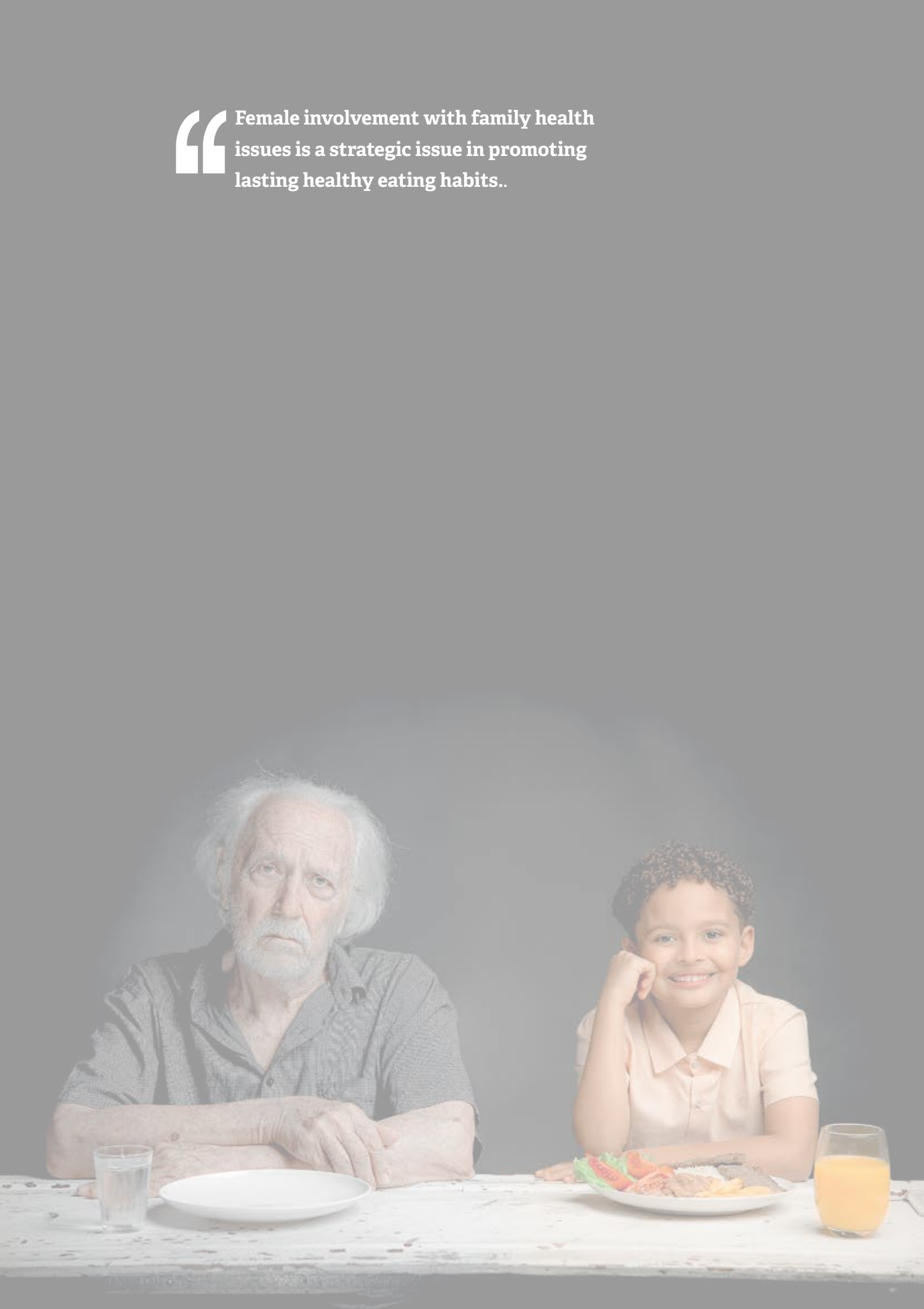
Empowerment and social protection are important factors for women's well-being and, consequently, a greater guarantee of FNS. The first provides the right to freedom, full participation on the basis of equality in all social fields. The second is a key element of social policy and consists in the prevention, management and overcoming of situations that affect the well-being of people. It is based on policies and programs that provide access to essential services, ensuring a level of security that enables people to maintain a quality standard of living (UN-BR, 2016).

Final considerations

From this, we believe in the importance of recognizing the role of women in FNS, from production to consumption, which requires recognizing the existence of the challenges they face in the social, cultural, economic, and political landscape. It is necessary to reflect on the appreciation of the women's contributions in this scenario, but also to question the necessary burden for the feeding to materialize in our dishes.. To reverse this situation, it is necessary to **implement social protection policies for women**, policies that understand their demands and encourage them to have autonomy and lightness in their practices. Science can contribute to this.

Some of these would be: **incentive for the acquisition of land and agricultural resources, considering their traditional and sustainable practices; support their insertion in the agri-food economic market in a fair way; social and labor protection policies for women who work with the food trade; expanding of the number of daycare centers and community kitchens; campaigns that encourage the sharing of household activities**, etc. We believe that such issues, because they are structural, require a long way and only with collective and social work it is possible to promote well-being and guarantee FNS simultaneously.

Female involvement with family health issues is a strategic issue in promoting lasting healthy eating habits..



Producing food is the first step in ensuring food safety

Chapter 6

Agricultural sciences and revolutions in food production: from the past to the future

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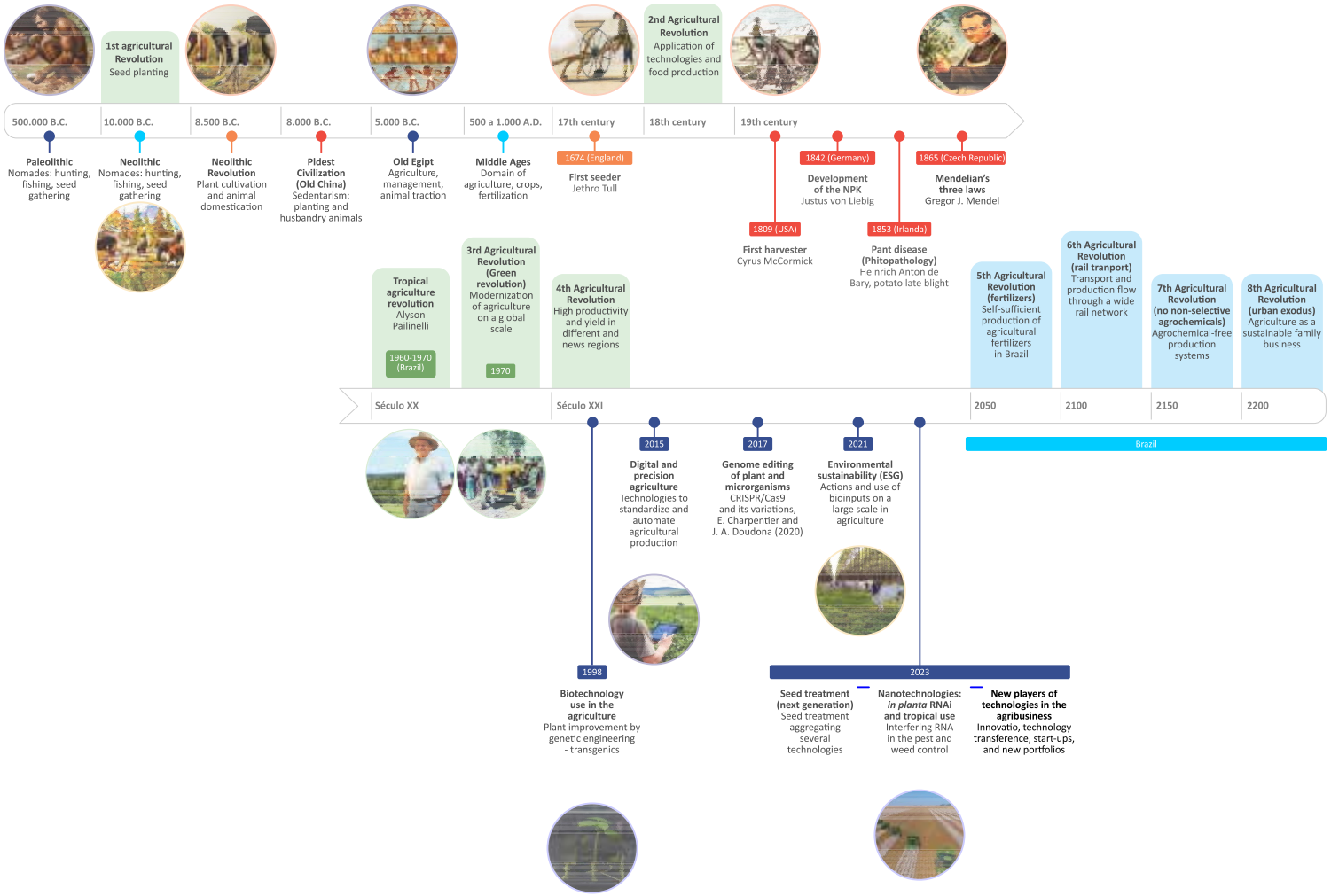
Humans emerged about 2.5 million years ago in East Africa. In the Paleolithic period (500,000 B.C.), they were characterized by nomadic life and fed essentially hunting, fishing and collecting plants, fruits and seeds. In the Neolithic period (10,000 B.C.), humans began to experiment with agriculture, although still living as nomads, considered that seed planting was a safe way to produce and harvest their food. It was from this planting initiative that **the 1st Agricultural Revolution** or **Neolithic Revolution occurred** (8,500 B.C.), which comes down to **the possibility of not only extracting, but also planting and raising animals for survival needs** (Fig. 1). Observing these possibilities of growing plants and raising animals, humans realized that sedentary and civilized life would be the most viable way in the face of this scenario.

The first civilizations were reported in Ancient China (8,000 B.C.), in the valleys of the Huang-Ho River (Yellow River) and the Yang-Tsé River (Blue River). However, it was in Ancient Egypt (5,000 B.C.), on the banks of the Nile River, that agriculture had its outstanding importance for the maintenance of civilizations. In addition to the floods of the Nile River, which were considered important for local agriculture, due to the land becoming more fertile and productive, animal traction became relevant to agriculture. However, it was in the Middle Ages (500 to 1,000 A.D.) that agriculture again had its importance highlighted as a result of its greater domain, by the use of soil management techniques and cultivation systems, although not yet having great technologies, a fact that characterized agriculture at the time as totally dependent on human and animal labor.

The first technological milestones in agriculture emerged in the 17th century, with the invention of the first mechanical seed planter by Jethro Tull, in 1701. This invention served as a reference and incentive for the development and application of new technologies in agriculture, aiming to reduce labor dependence and increase crop productivity and yield. The **use of these first technologies in agriculture marked the 2nd Agricultural Revolution**, which took place in the 17th century. Later, another technological milestone that marked agriculture in the 19th century was the invention of the first seed harvester by Cyrus McCormick, in 1809, indicating that, in addition to planting, the harvest could also be mechanized. Other factors, besides mechanization, began to prove important for the evolution of agriculture, such as soil fertilization. Although fertilization was highlighted in the Middle Ages by the use of organic waste, manure, carcasses and humus of rivers, the main milestone in soil fertilization was with the emergence of mineral nutrition from NPK (nitrogen, phosphorus, and potassium) in the 19th century, in the concept of Justus



Evolution of global agriculture and its techniques over the years to the present day, and optimistic forecasts for the next 200 years of Brazilian agriculture based on the demand and benefits for agribusiness that can be impactful for self-sufficient food production. The timeline presented highlights the main milestones of agriculture worldwide, with emphasis on technological advances achieved in recent years in Brazilian agriculture. Credits: photos retrieved from Google (original authors not mentioned). Abbreviations: B.C.: Before Christ; A.D.: Anno Domini.; NPK: Nitrogen, phosphorus and potassium macronutrients; CRISPR/Cas9, clustered regularly interspaced short palindromic responses-associated Cas9 endonuclease; ESG: Environmental, Social, and Governance.

von Liebig, in 1842, as a result of the fact that nutrition via organic waste was no longer enough.

Despite the momentary domain of planting, management, and harvesting technologies, it was also in the 19th century that Gregor J. Mendel, in 1865, demonstrated that it was possible to make targeted crosses between sexually compatible plants, indicating that characteristics of interest could be combined or transferred between different compatible species (Miko, 2008). Just before Mendel's three laws were validated, the occurrence of potato reburn disease in Ireland (1845 to 1850), which devastated potato cultivation and caused 2 million people to die of hunger and 1 million to emigrate, was characterized by Heinrich Anton de Bary, in 1853, as being caused not by abiotic conditions, but by phytopathogenic fungus *Phytophthora infestans* (Bourke, 1964).

These collective discoveries warned that agriculture had great potential for expansion and growth, but that it depended on constant technological and scientific evolution. This message brought good fruits, marked by advances highlighted, mainly, in tropical Brazilian agriculture, through the application of knowledge and concepts for a better exploitation of agriculture considering its specificities. The generation and application of scientific knowledge in agriculture marked the **Revolution of Sustainable Tropical Agriculture in the 20th century**, which had a great exponent in Brazil the agronomist Alysson Paulinelli. The agrarian sciences in Brazil led to revolutionary technologies, such as no-tillage, at least two crops a year, more efficient land use, complete fertilization, crop-livestock-forest integration, research centers focused on solutions for agriculture, among others, leading the country to self-sufficiency of food. This contributed to the **3rd Agricultural Revolution in the 20th century**, **marked by the modernization of agriculture on a global scale** (1960-1970), through **the use of technologies on the different fronts of agriculture.**

Soon after, with the important advance of genetic improvement in different crops and animals, domain of technologies and cultivation systems, **the 4th Agricultural Revolution occurred** (21st century), **marked by high productivity in different regions of the country, yield, quality of products, process traceability, use of artificial intelligence, bigdata, unmanned aircraft coupled to** cameras with RGB color system (red, green, and blue), thermal and multispectral for aerial images. This digital age in agriculture has been conceptualized as **precision and digital agriculture**, which has come to automate

agricultural production and turn it into a more dynamic, friendly, and interconnected environment. Particularly, digital agriculture 4.0, which uses information technology, aggregates a large set of technological tools that collect, process, analyze, and store data from various operations, supporting the producer in decision-making in a more assertive way. Similarly, large-scale DNA sequencing techniques, using platforms that allow generating a large amount of data in a few hours or days at low cost, have enabled obtaining and using DNA level information from plants, animals, pathogens and microorganisms in general (Marks *et al.*, 2021).

More recently**, the use of plant biotechnology in agriculture** (soybean tolerant to glyphosate, 1998), via plant breeding by genetic engineering (transgenic), revealed that new technologies could be developed from the manipulation of the genetic material of a plant to meet the needs of agriculture, leading to the development of GMOs with several properties of interest for food production (Rolla *et al.*, 2014; Ribeiro *et al.*, 2017; Basso et *al.*, 2020). In addition to herbicide tolerance, other already commercial technologies that use transgenics were developed for resistance to pest insects through the expression of Cry and/or VIP proteins and for tolerance to water deficit through the expression of transcription factor HaHB4 (Ribichich *et al.*, 2020). As an example, there are no sources of varietal resistance or commercial cotton transgenic events to control the insect cotton boll weevil. However, several studies in progress at Embrapa Recursos Genéticos e Biotecnologia (Brasília, DF) seek the development of technologies for the control of this pest, through the expression of Cry toxins, or combining the expression of these proteins with the Interferent RNA (RNAi) technology, both already with good results observed with transgenic cotton lines evaluated in greenhouse (Ribeiro *et al.*, 2017; Ribeiro *et al.*, 2022; Vasquez *et al.*, 2023).

In parallel, with multidisciplinary technologies and their constant evolutions, CRISPR/Cas9 genome editing technology was established and applied in cultivated plants (Jinek *et al.*, 2012; Basso *et al.*, 2019). Genome editing technology, being simpler and more effective, has brought new alternatives for plant breeding through genetic engineering, which allows binding or disconnecting genes from the target cultivated plant itself, without the need to introduce a gene of another species, enabling superior plants with unprecedented agronomic characteristics and less time and cost of development (Basso *et al.*, 2020; Távora *et al.*, 2022). Genome editing allows the development of crops with greater resistance to abiotic stresses (lack or excess of rainfall, soil acidity) and biotic (pests),

increased productivity, yield and quality (health and nutrition content). More specifically, the editing of genomes using the CRISPR/Cas9 technique allowed obtaining superior sugarcane plants with better digestibility of the cell wall by Embrapa Agroenergia (Brasilia, DF), soybean with greater tolerance to water stress by Embrapa Soja (Londrina, PR), soybean with higher productivity or without antinutritional factors by GM seeds (Londrina, PR). The negative post-transcriptional regulation via RNAi of the *AIP10* gene of soybean and cotton was shown to increase the precocity and yield of biomass, grains, and floral buds, and with genomic editing technology Embrapa Recursos Genéticos e Biotecnologia is seeking to develop plants with the *AIP10* gene turned off (Ferreira *et al*., 2011; Hemerly *et al*., 2022). In addition to plants, the editing of genomes of microorganisms beneficial to cultures has also been explored in order to obtain improvements in the interaction with plants (Yi *et al*., 2018; Wang *et al*., 2021).

It is also important to note that global climate change has been increasingly evident and intense, bringing negative impacts to agriculture. In view of this, **the balance and sustainability of ecosystems have gained more and more importance worldwide**. The recent emergence of the ESG (Environmental, Social, and Governance) concept organizes a new path based on environmental sustainability to be followed by global agriculture, as well as agribusiness in its entirety. These good business practices already reflect directly on the greater use of bio inputs (natural and biological products) in agriculture and the reduction of dependence on synthetic agrochemicals. The use of microorganisms that promote better growth and productivity of plants by increasing nutrient availability, such as N and P, and improving the rhizosphere is one of great relevance and leadership in Brazil (Meyer *et al*., 2022). There is also the use of genetically improved plants (obtained by methods of transgenesis and/or genome editing) with improved relevant agronomic characteristics, and the use of antagonist microorganisms or that exert biological control of pathogens and pest insects are some examples of this new direction of agriculture (Costa *et al*., 2019; Ribichich *et al*., 2020; Meyer *et al*., 2022).

It is noteworthy that Brazil has great potential to take the lead in sustainability in agribusiness. Estimates are that 30.2% of its territory for agriculture (8% native pastures, 13.2% planted pastures, 1.2% planted forests, 3.5% in infrastructures, and 7.8% for crops), while 66.3% correspond to areas destined for protected and preserved vegetation (16.5% native vegetation, 13.8% indigenous lands, 10.4% total conservation units and 25.6% preservation of rural vegetation) (IBGE, 2017). Another highlight is that Brazil was a pioneer

in the exploitation of biofuels and today is among the two largest producers in the world, with emphasis on bioethanol produced from *sugarcane* and biodiesel from processed soy. In addition, Brazil has adopted the Low Carbon Agriculture Program (ABC Program), which integrates actions of federal, state and municipal governments, the productive sector and civil society to reduce greenhouse gas emissions from agricultural and livestock activities (MAPA, 2023). For example, the Soy Low Carbon Program, led by Embrapa Soja is creating a protocol to certify soybean-producing areas with low greenhouse gas emissions, which will enable the recognition of properties with sustainable production. Another important example, the National Institutes of Science and Technology (INCTs in Portuguese), financed by the Federal and State Governments, has been instrumental in articulating, aggregating, and boosting, at the national and international level, the best scientific and technological research groups in science frontier areas and strategic fields to contribute to the sustainable development of the country. In this same context, in 2023 Embrapa completed 50 years, being recognized for the decisive action for the development of Brazilian agribusiness through scientific research and development of solutions.

Combined with these recent advances aimed at the sustainability of agriculture, seed treatment aggregating several technologies, such as a mixture of biological inputs for pest and disease biocontrol, growth promotion, macro and micronutrients, elicitors (or inductor molecules) to enhance the immune system and the development and plant growth, it has contributed to the emergence of the new generation of seed treatment (Cardarelli *et al.*, 2022; Meyer *et al.*, 2022). In addition to the world of **new generation seeds, the use of nanotechnologies associated with RNAi technologies directly in plant genetics or topical use via the spraying of molecules, which will be active only in the target organism,** is revolutionizing agriculture (Ribeiro *et al.*, 2022; Tabora *et al.*, 2022; Vasquez *et al.*, 2023). Brazilian agriculture records annual losses greater than 15% due to pathogens (e.g. nematodes; Lopes-Caitar *et al.*, 2019), pest insects, e.g. cotton boll weevil (Oliveira *et al.*, 2012; IMEA, 2023), and weeds (Cruz *et al.*, 2020), which can be minimized by the use of these biotechnologies. Particularly in reference to nanotechnologies, the development of nanoparticles or carrier polymer nanostructures has revealed their potential for use in protection, better internalization, and greater effect of encapsulated biomolecules (DNA, RNA, proteins or elicitors) (Vasquez *et al.*, 2023). This new control strategy is based on biological inputs (nucleic acids of natural origin) that are not aggressive to the environment and act highly specific in the target organism, be it a phytopathogenic agent, pest insect, or weed.

All these new technologies and their evolutions have opened the opportunity for the emergence of new players of innovation, technology transfer, startups, and portfolios in agribusiness for the democratization of access to markets. The increase in the supply of innovative solutions, services, and disruptive technologies has contributed significantly to greater implementation and use of these assets in agriculture. The valorization by the agribusiness sector of technologies and assets generated by the Brazilian public or private initiative will be of great importance for a greater financial return of agriculture and strengthening of research and development in the country. Of course, **a greater incentive for basic scientific research, applied research, or the development of new products is of extreme relevance for the country to monitor emerging technologies and their implementation in agriculture**. **Likewise, greater financial support and opportunities for the education system of all levels of education are of extreme importance for the good training of human and professional resources in all areas, mainly focused on agribusiness**. In addition to this indispensable support to the teaching, research, and development sector, other sectors related to agribusiness need initiatives for its development. As an example, the fertilizer sector, which has been impacted by the Russia-Ukraine-US war (and the imminent China-Taiwan-US tension), and its consequences on foreign trade and public and private embargoes, has warned Brazilian agribusiness about the high risk of dependence on imports of fertilizers from countries in geopolitical conflicts. Due to that, the government's support for initiatives aimed at increasing local production and making Brazil less dependent on fertilizer imports is of extreme importance for agribusiness in the coming years. Brazilian self-sufficiency in fertilizers is predicted as one of the important milestones for the stability of a country in which agribusiness is the main activity that moves the economy, a factor that could mark the **5th Agricultural Revolution in Brazil**. This 5th Agricultural Revolution, as well as from **6th to 8th Agricultural Revolution** cited in sequence, are optimistic forecasts for the next 200 years of Brazilian agriculture based on the demand and benefits to agribusiness that can be impactful to the self-sufficient production of food. Likewise, more intense and effective efforts of the public initiative in the logistics sector for transport and disposal of agricultural production via development, expansion and improvements of the railway network, as well as the ports infrastructure, are important to improve the dynamics and reduce the costs of transporting agricultural products. Combined with this, investments for improvements in the infrastructure portion of agricultural products´ storage are necessary and may bring more stability to the sector. The implementation of a wide rail network that connects all Brazilian

states and ports assertively and improvements in storage infrastructure will bring great transformations to agribusiness and may mean the 6th Agricultural Revolution in Brazil.

This new geopolitical reconfiguration and its impacts, combined with the effects of pandemics on human health (COVID-19, Monkeypox, etc) and animal health (African swine fever in China, avian influenza, mad cow disease), extreme weather events (frequent and intense droughts, off-season frosts, excessive rainfall, La Niña phenomenon), trade war (China, Russia, United States, European Union), political conflicts between democracies and autocracies, unprecedented private boycotts to conflict countries, consumer agglutination (social media, online and *offline* media, influencers, *e*-commerce, marketplace, censorship, fake news, activism for different causes), crisis in international logistics (strikes, maritime accidents, interruptions, geopolitical conflicts, high prices), large price fluctuations in general (supply and demand gaps, product shortages, inflation, currency volatility) and strengthening pest insects and diseases (increased production costs) reinforce the importance of immediate actions. These actions are critical to ensuring food safety in Brazil and worldwide. These actions also aim to improve the quality of life and the production of healthy food, preserving the environment, such as the long-term adoption of production systems without pesticides, or at least without synthetic or non-selective pesticides, that could result in the **7th Agricultural Revolution** in Brazil. All these disruptive technologies and advances in different segments of agribusiness can stimulate the return of part of the population from urban centers to the agricultural environment, resulting in what could be the **8th Agricultural Revolution in Brazil**, **marked by the urban exodus, which is the most important factor in the development of the agricultural sector, valorization of small producers, diversification of agriculture and use of agriculture as a sustainable family business and a healthier life**.

Finally, the constant generation of knowledge, technological innovation, the transfer of technology to agribusiness, dynamic communication, and sustainability of ecosystems will be decisive for global agriculture, for improving the quality of life of people in all social classes, and for food security. In this same sense, the strengthening of a long-term thinking mindset, with more investments in priority areas and exports of industrialized products, with higher added value and less raw material, will be important for the country's socioeconomic development. These initiatives can maintain Brazilian agribusiness among the four largest world powers in food production, or even increase this position, but with emphasis on environmental and social sustainability as a reference country.

Government initiatives of short, medium and long term, without politicization or harmful partisanization of agribusiness, and with the harmony of the public and private sector, between the urban and rural population are the path of the future that will enable the increase of production, ensuring food security with less cultivation area and invested resources. Only with investment in science will this be possible.

Chapter 7

Public investment in agricultural sciences and return to hunger eradication: Teachings of our past and present

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Sílvio Crestana[2]

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In 2023 we are 8,029 billion inhabitants on planet Earth (Worldometer, 2023). Properly feeding more than 8 billion people is a remarkable achievement. Currently, however, FAO estimates that more than 800 million people do not have their minimum food needs met (FAO, 2021). Brazil, unfortunately, does not escape this recklessness. Although in proportions that have already been soluble in the past, millions of Brazilians still suffer from some form of food insufficiency.

In 2050 we will be 9.8 billion (United Nations, 2023). The expectation is that this year, the unworthiness of hunger ravaging populations will be only a black spot in the previous history of humanity. The reduction of hunger should happen due to the increase in per capita income, supported by the increase in sustainable productivity, as a result of technological development and adequate public policies. Higher per capita income has induced a progressive change in eating habits, increasing the demand for proteins and reducing that of starches and carbohydrates-based products, which implies strong quantitative and qualitative pressure on agricultural production, on a global scale.

Context of food production and technological development. Crops and pastures cover more than one-third of the Earth's ice-free surface (Ritchie & Roser, 2023). From water taken from rivers, lakes and aquifers, 70% goes to agriculture (World Bank, 2017). Producing food to meet the effective needs of the world's population in the coming decades means overcoming monumental challenges. The largest of them, without a doubt, is the conjunction between the area available for food and water production for crops and creations.

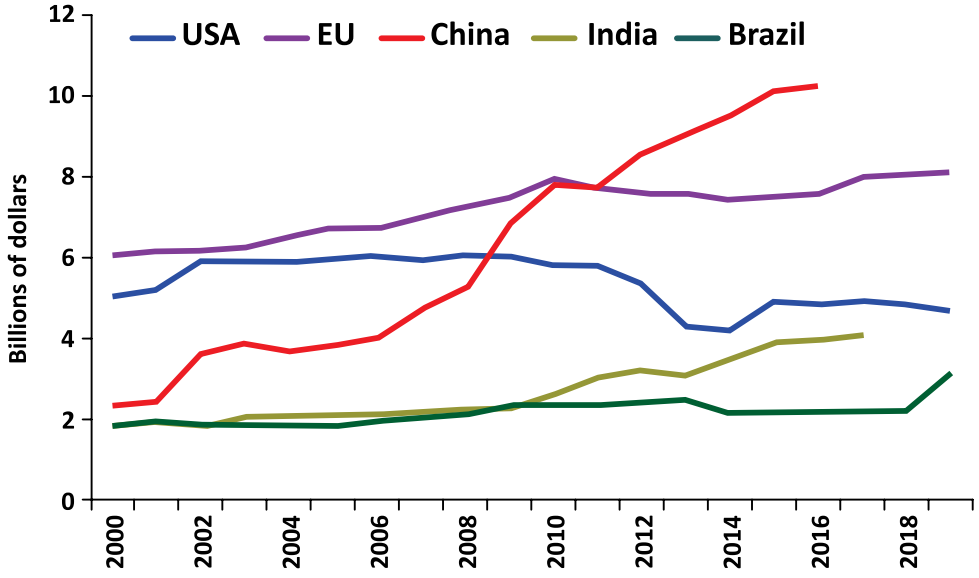
The most fertile areas with other desirable characteristics are in the process of running out. This problem is being progressively aggravated by climate changes, which, on the one hand, reduce areas conducive to agriculture and, on the other, reduce the productive potential of others, due to the change of essential climatic parameters, especially the rainfall regime and temperatures. Producing food in marginal agricultural areas, in adverse conditions, and with increasing sustainable productivity, is the synthesis challenge of the coming decades.

The key words are **science and sustainability**. There is no other solution to overcome the challenge other than massive investment in science, with the development of adequate and sustainable technologies, which allow food to be produced with minimal

negative impact on soil, biodiversity, waterways and climate. Over the past 60 years, **it has been possible to reduce the number of hectares needed to feed a person from 1.5 to 0.5** between 1960 and 2020 on a global scale (Short, 2022). The advances were possible with productivity gains, resulting from genetic advances, and the use of modern inputs such as seeds, machines and implements, fertilizers, and pesticides. Nowadays, the challenges are other, more intense and more complex, and the tools of science that have brought us here will not be enough to ensure adequate food for the future of humanity.

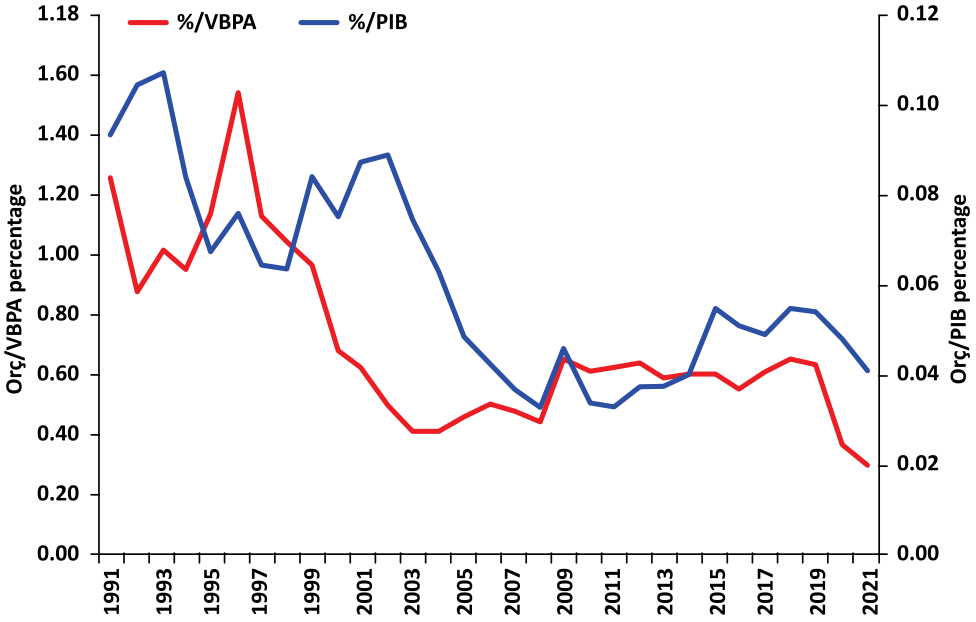
The investments that brought us to the present. Until 2009, the United States of America (USA) had the largest public budget of a country for agricultural research and development, although quantitatively surpassed by the European Union. Since 2012, the largest investment has occurred in China. Currently, around US$ 35 billion annually are invested in the world, compared to approximately US$ 17 billion registered at the beginning of the century. The US, once the great engine of agronomic science, has reduced its investment by about a third in the last 20 years (USDA, 2022). Another important study showing this trend can be found in Heisey & Fuglie (2018). In Brazil, in this same aspect, the work developed by Silva *Junior et al* is highlighted. (2019).

In figures corrected for 2021, **Embrapa's budget, the main agricultural research institution in Brazil with 50 years of deliveries to the company completed in 2023,** increased from R$ 2 to R$ 3.35 billion reais, with a peak of R$ 5.59 billion in 2018 .



Investments in research and development in the agricultural area, in four major agricultural countries and in the European Union (values updated by inflation of each country and weighted in the PPP exchange rate of 2015). Source: USDA (2022).

However, only the amounts invested do not give the full view of the priority given to R&D investments To qualify the analysis, it is necessary to analyze the historical series of Embrapa budget correlated with the evolution of the Gross Domestic Product (GDP) of Brazil and the Gross Value of Agricultural Production (VBPA). **There is a fall in the budget from 1.6% of GDP (1993) to 0.04 (2021) and from 1.59% of VBPA (1996) to 0.02% (2021).** Although a linear relationship of the two indices was not expected, the figures show a marked fall in the priority given to technological development, which has been the great engine of the Brazilian economy.



Percentage ratio between Embrapa's budget VBPA (Gross Value of Agricultural Production) and GDP (Gross Domestic Product) of Brazil. Sources: Embrapa, National Budget, Ministry of Agriculture, Livestock and Supply. Authors' calculations.

Although this analysis requires a complementation, since Embrapa's global budget was used for it, which includes the personal item, if only the budget for discretionary expenses (costing and investment) is examined, after a peak of R$ 1.154 billion (2012), the budget was drastically reduced to a historic minimum of R$160 million in the proposed budget for 2023, subsequently increased to 360 million in the proposed Constitutional Amendment (PEC) proposal for transition. **These values are blatantly insufficient for the maintenance of the flow of technological development required by the exuberant dynamics of agriculture and national agribusiness**.

Historical photos of the early years of Embrapa. On the left, PhD. Johanna Döbereiner in field test, checking the biological fixation of nitrogen. On the right, construction of Embrapa Soja headquarters in Londrina-PR. Source: Embrapa Archives.

Return on investments. A striking example of the results of R&D investment and technology transfer in agriculture is the Green Revolution. It was funded by the Rockefeller and Ford foundations in the 1960s and later by public-funded institutions and governments. The revolution promoted the use of high-yield varieties, irrigation, mechanization, fertilizers, and pesticides, generating great advances in crop productivity in various countries, particularly in Southeast Asia. Its leader, the agronomist Norman Borlaug, was awarded the 1970 Nobel Peace Prize for actions that enabled more than one billion people to be saved from extreme hunger (Easterbrook, 1997).

In 1960 Brazil was a net importer of agricultural products. Currently, it is one of the largest exporters in the world. **The growth of agriculture over the last 50 years has a direct relationship with investment in research and development**. Brazil had a Minister of Agriculture, Alysson Paolinelli, who clearly envisioned this association and unconditionally supported the implementation of the National Agricultural Research System. As a result of his vision, agribusiness currently represents about one-third of Brazil's GDP, accounting for almost one-third of the formal jobs and for the total balance of the Brazilian trade balance. In 2022, this balance was US$ 62.3 billion (Brazil,2023a), a result of agribusiness exports worth US$ 159 billion (Brazil, 2023b). During this **period, the cost of food for the Brazilian people decreased**, which can be attested by the Dieese data, showing that the prices of the staple food, deflated by the IGP-DI, went from R$ 1,054.75 (1970) to R$ 599.41 (2021), a reduction of 43.17% (Embrapa, 2022).

This reduction was obtained, in large part, by increasing the productivity of crops and creations. It should be noted that, between 1960 and 2020, the productivity of grain crops in Brazil increased by more than 150%, with emphasis on soybean, which grew by 227% (Gazzoni & Dall'Agnoll, 2018). In the US, the movement with public opinion grows again to show the importance of investment in agricultural research and inflation control, as it can be seen in Glickman (2023), recalling the motivation that led to the creation of the *Land-Grant Colleges* (Morril Acts of 1862 and 1890). in that country.

Embrapa has also invested in research on diversification of food and access to new proteins. A remarkable program was the use of soy in human food, introducing this vegetable protein in the diet of millions of Brazilians. Source: Embrapa's Archives.

Since 1997, Embrapa has calculated, annually, the social profit, that is, the return to society of investments in research and development of agriculture, executed by the institution. In 2021, a balance sheet of 25 years of investment in the sector was made (Embrapa, 2021), concluding that **a social profit of R$ 1.2 trillion, which returned to the company about R$ 12 for each R$ 1 invested in Embrapa.** There are hundreds of technologies launched by Embrapa in the 50 years of its existence, and choosing only a dozen, we can mention: biological nitrogen fixation in soybean; integrated pest management; disease management; low latitudes soybean; low latitudes wheat; fruits for semi-arid; neutral carbon meat; system integration crop-livestock and crop-livestock-forest; improved pastures, early and late peach.

Some technologies launched by Embrapa, such as (A) crop-livestock-forest integration system; Photo: Rosa, Ronaldo. Fazenda Diana Pagominas. (B) systems with pastures, including annual summer pastures (millet), summer perennials (Quicuio and Tifton 68) and Santa Fé system (established perennial forage harvesters associated with maize). Photo: Fontaneli, Renato Serena. Source: Embrapa Archives.

Investments that will lead us to the future. Radical changes are taking place in the world, and the context of agricultural production lies in one of the main epicenters of change. Great challenges are expected, and can be listed: *(i)* the most suitable area for food production has been exhausted; *(ii)* climate change further restricts the available area and reduces the productive potential of others; *(iii)* new pests arise continuously, requiring immediate solutions.

The world society, which consumes food, is also rapidly changing, especially in its eating habits, as commented, migrating from intensive consumption of high carbohydrate products to higher consumption of animal proteins. At the same time, it is accompanied by an energy transition, requiring the reach of new technological levels.

A new environment imposes rapid transformation in research institutions, toward the implementation of new paradigms and consolidation of some old ones, which remain important. For an analysis of the conditions that need to be offered to scientists and their collaborators, we emphasize the importance of training, improvement, updating, and network. This set is essential for Brazil to remain at the frontier of scientific knowledge in the area.

Investment in training was essential to Embrapa's success, especially during the period of its institutional genesis – an essential component of Minister Alysson Paolinelli's vision for the future. And it must be maintained actively, intensely and permanently. Equally opportune is the incentive for Brazilian scientists to participate in courses and events abroad, in addition to the resumption of hiring both internal and external consultants to the country. In addition to compatible budgets, sectoral policies should be adjusted to facilitate greater synergy between basic, applied, technological and adaptive research developed by the various players of the scientific scene, highlighting the importance of basic sciences and the protagonism of universities.

It should also be noted that new scientific tools are emerging constantly, and Brazilian institutions need not only incorporate them at the same speed as they are created but also actively participate in their creation. Mastering the new tools has a direct relationship with technological development at the frontier of science, which will allow Brazil to consolidate its role in the international market, being an active agent to meet the qualitative and quantitative needs of food for the world population.

Among the main tools of modern agronomic science, one can mention, without keeping order of importance, biotechnology, with the opportunities offered by gene editing, DNA synthesis, recombinant DNA, interfering RNA. No less important, is bioprospecting, seeking biological diversity still unknown, of natural occurrence, which can serve as a source of material for use in agriculture. Bioinformatics applied to the "omics" sciences or computational biology will be increasingly critical for the acquisition, storage, analysis and diffusion of biological data, as well as for the establishment of gene functions and new metabolic routes. There are numerous applications envisioned by nanotechnology, for example, in agrochemical and biological nano formulations, nano sensors in crop protection for the identification of diseases and residues of agrochemicals, nanodevices for plant genetic engineering, diagnosis of plant diseases, animal health therapy and post-harvest management.

The generation of an immense universe of data in agriculture demands new tools for *big data* analysis, which will enable the extraction of fundamental information for the technological development and optimization of food production systems. The processing of this large volume of data will require quantum computers. Finally, science must deliver several other potentially disruptive technologies if applied to agriculture,

such as artificial intelligence, automation and robotics, blockchain, autonomous vehicles, constellation of microsatellites, new sensors and equipment with greater sensitivity, portability, compact and cheaper. Overall, **science leading to food production intelligently will impact and assist in mitigating hunger**.

It is not the focus of this article to exhaust the topic of new scientific tools, but to demonstrate how there is a new environment in the field and in the market, which requires new approaches, which will be faced with greater probability of success if the new scientific tools are used. This means continuous training; network , partnership and exchange of information among peers; modernization of laboratory equipment and experimental fields, which includes an increasing degree of automation, precision and detection limits far higher than currently available, requiring less time between conceptual formulation and the arrival of information or technology in the field.

However, we cannot fail to mention that the technological achievements achieved, if on the one hand allowed such success, on the other hand they still represent a formidable challenge to be overcome: the existence of millions of producers who do not use the best available technologies. Therefore, the integration between the generation of new technologies and the transmission belt of the technology transfer system is fundamental.

- **Vision of the future**

- The challenges for food production in the coming decades will be much greater than in the past.
- Production systems will have to be sustainable.
- The scientific tools that have brought us to the present will not be enough to solve future challenges.
- The new tools of science will allow us to solve the pre-posed challenges and produce food in sufficient quality and quantity to meet global demand, as well as add greater value to our *commodities.*

Food production in the future will increasingly need the support of science. For this, continuous investments in talent, in their permanent training, in the interaction and partnership with peers from national or international institutions, in the acquisition, modernization, maintenance, and supply of the field and laboratory equipment required by the new research and development environment, and in a new

institutional and management framework, flexible to allow fast deliveries, become necessary.

Only in this way will it be possible to overcome the challenges that producers will face in producing food on time, in the quantity and quality demanded by the national and international markets and by society.

Chapter 8

Climate change and social injustices in fighting hunger

Eduardo Delgado Assad

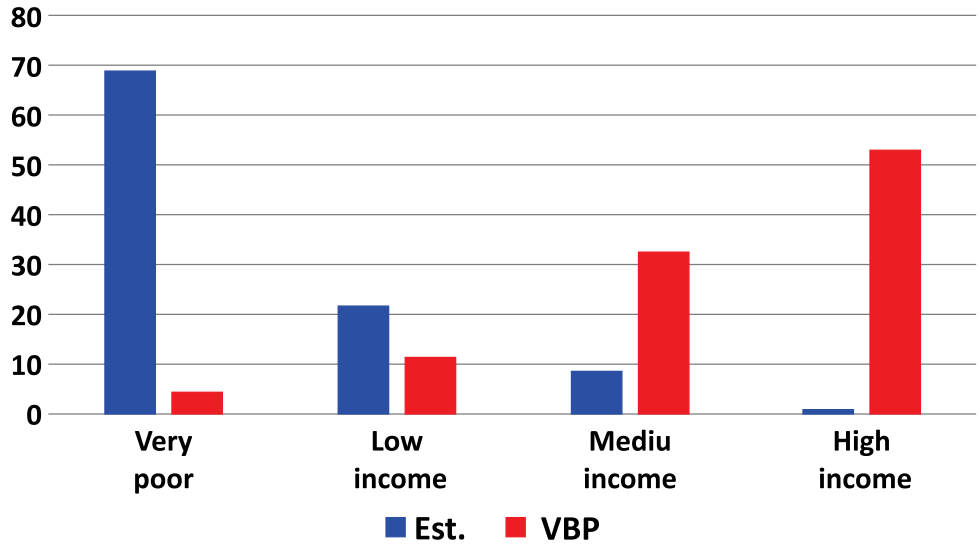
Cepagri/Unicamp; Observatory of Bioeconomics FGV/GVagro

Since the first IPCC report (2007), the intense discussion on climate change has indicated that **the most affected populations will be the poor and unassisted.** Reports by Brazilian scientists Barcellos & Hacon (2016) and Aragão *et al.* (2016) also clearly point to **health problems, amplified by the increase in temperature and floods**, affecting peripheral populations. In this study, it was clear that health impacts can be expected for a scenario where the increase in the global temperature average exceeds the value of 4˚C and that, for the sector, the outcomes are complex, multifactorial, and non-linear. In Brazil, the scenarios indicate that **there may be an increase in dengue, chikungunya, Zika, and malaria, as well as an increase in deaths among the elderly**. The increases are intensified by population growth, inadequate urbanization, migration, city infrastructure problems (lack of basic sanitation), global mobility of the world population, deterioration of health systems, and increased climate variability. It is not difficult to understand that **even if the temperature increases for everyone, the impact will be much higher in poor populations**. Climate injustice begins to be clearly drawn in the health sector. The rich connect the air conditioning and have access to safe drinking water and basic sanitation. Therefore, the impacts of climate on populations are selective. More recently, the severe drought in the northeastern semi-arid region, the intense rains on the coast of São Paulo, and the persistent drought in the southern region of Brazil have affected, mainly, the unassisted populations and small farmers.

The enormous social difference between the rich and the poor in Brazil is reflected in all sectors. As pointed out in other texts of this document, how can a country where the agricultural sector accounts for about one-third of the country's gross domestic product (GDP) and more than 250 million tons of food in 2022, have a hungry population of more than 30 million inhabitants? It is often heard that the function of the sector is to produce, but that the problem of hunger is the responsibility of others. Now, the tax that generates the financing for the crop plan is the same that should generate the supply and distribution of food for all.

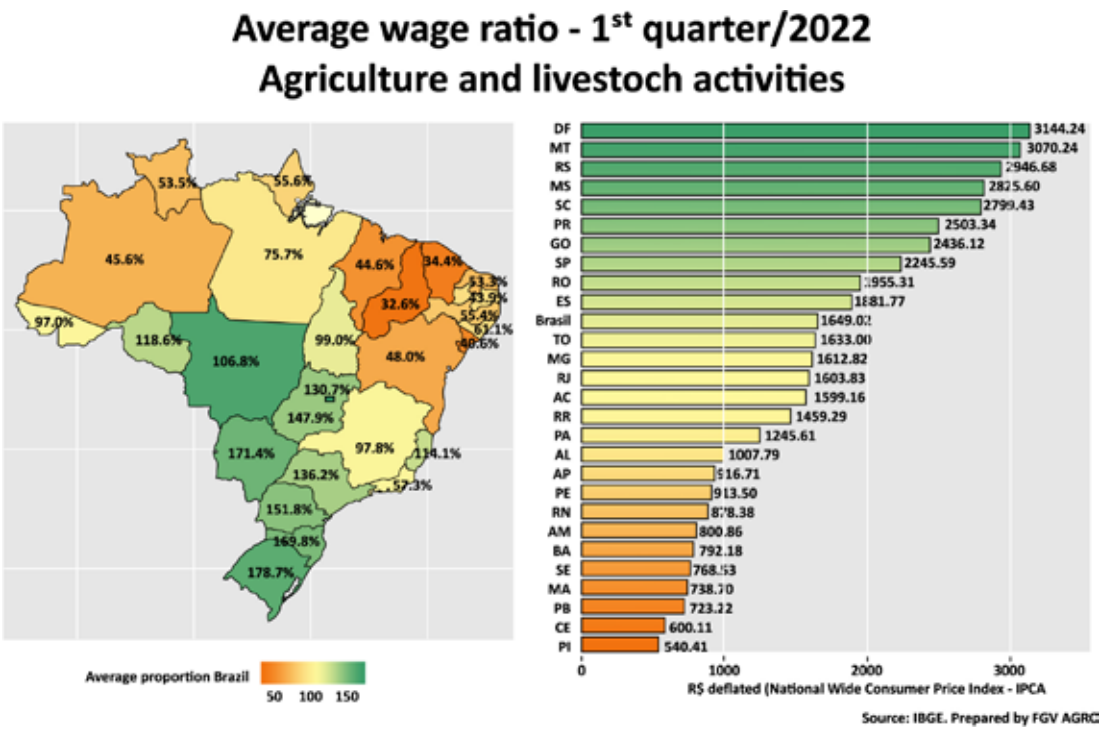
How is the portrayal of poverty in the Brazilian countryside? The IBGE Agricultural Census of 2017 pointed out that the family farming of Brazil covered 3,897,408 rural establishments, representing 77% of the country's agricultural establishments and occupying more than 10 million people (67% of the total census), responsible for a significant portion of the supply of basic foods of the Brazilian table. At the time, family farmers accounted for 11% of rice production, 42% of black beans and 80% of cassava, for

example (IBGE, 2017; IBGE, 2019). In livestock, they produced 64% of the country's milk and accounted for 31% of the national cattle herd, 51% of the pig and 46% of the poultry farming (IBGE, 2017). Although in the period from 2016 to 2021 there was a dismantling of public policies to support family farming and rural development, with the extinction of administrative agencies, budget cuts, discontinuity of actions, among other setbacks aggravated in 2020 by the COVID-19 crisis, family-based agriculture continues to play a key role on food production in Brazil. According to IBGE data, a work developed by Vieira Filho (2020) using data from 2017, 3,288 million farmers were responsible for 4.0% of the gross production value (GPV) of agriculture and were part of the extreme poverty income group. On the other hand, 27.5 thousand establishments accounted for 52.9% of the GPV, being in the high-income extract. This difference is in access to technology, credit and option for production of agricultural commodities that guarantee the commercialization and profitability obtained.



Percentage of Brazilian farmers according to the stratification of income (Est.) and the Gross Production Value (GPV) of these farmers, according to the 2017 census. Source: IBGE (2017).

A study by FGV Agro highlights the **enormous gap that exists between the remuneration of labor in the field in the different regions of Brazil**. The difference between the lowest and the highest remuneration is close to six times. In this sense, the climate impacts will be much greater in those regions where income is lower. Migrating may be the best solution for individuals. Graciliano Ramos has shown this situation very clearly in his book *Vidas Secas*. On the other hand, cities no longer have the capacity to receive these hungry populations affected by extreme weather events.



Ratio of the total average remuneration in agricultural activities in the first quarter of 2022 in all Brazilian states and in the Federal District. Source: IBGE, Elaborated by FGV FGV/GVagro.

The climate impacts that are being observed have their very clear aspects of climate injustice, not only in Brazil but throughout the planet. The latest World Meteorological Organization report (WMO-1316) on the global climate situation in 2022, indicates that, throughout the year, dangerous climate-related events and conditions played a significant role in driving new population shifts. Most climate-related displaced persons or climate-related events remained within the territories where they lived, while in other situations, people were forced to flee from international borders in search of security and assistance. At the same time, climate and climate-related risks worsened and prolonged the situation of millions of people who were already in displacement at the beginning of 2022. The main countries affected were Ethiopia, Kenya and Somalia, with extreme drought events. The same was observed in Brazil, between the years 2015 to 2020. It is estimated that 95 million people have been hit by these catastrophic drought impacts on pastoral and agricultural livelihoods over the past four years. In Brazil, several phenomena have been observed that impacted populations, including drought, floods, heavy rains, windstorms, heat waves and cold waves. Unlike African countries, in Brazil we are affected by almost all the climatic events that have intensified each year, and where the most affected are the poor and unassisted.

Returning to Brazilian agriculture, this information helps to understand the difference in the impacts of climate change on large and small producers. A major factor is that only 35% of small producers, with areas of 1 to 100 hectares, have the Declaration of Aptitude to PRONAF (DAP), which allows access to credit. What is the importance of this document? It is the document that identifies family and settled farmers of land reform who can apply for rural credit and access other government programs, such as the *Programa de Aquisição de Alimentos* (PAA) (Food Acquisition Program) Without this document, the access to technologies and technical guidance to reduce the impacts of climate change is limited. Techniques such as no-tillage, crop-livestock-forest integration, and the best option for agroforestry systems do not reach this immense population of producers, which greatly reduces the resilience of this category to the impacts of the climate. The indigenous and *quilombola* populations are included there.

But there are examples that are spreading slowly and that can be followed. In the third sector, there are important initiatives. Three will be mentioned herein. SIAMA - Agroforestry Systems in the Atlantic Forest (https://siama.eco.br/), which aims to promote agroforestry systems (SAFs) in the Atlantic Forest as a regional development strategy, recently published, a report on a survey of SAFs in Brazil and detailing three Brazilian agroforestry experiences: the Cocoa Forest project; the Joint Agricultural Cooperative of Tomé-Açu (CAMTA), involving more than 1,400 hectares of SAFs in 308 rural properties; and the Program for the Expansion of the Forest Coverage of Espírito Santo (Reforestation).

In the Amazon, the Alliance for the Restoration of the Amazon presented, in 2022, at the 5th World Congress of Agroforestry Systems, the results of a systematic survey carried out in 2020, through primary and secondary data collection. A total of 1,643 restoration initiatives were identified with SAFs, covering 15,554 hectares (average of 9.47± 40.79 ha), most led by civil society (74 % of the area). It should be noted that the research did not capture all the SAFs in the region because, in the Amazon, most rural populations have agroforestry livelihoods backyards.

In the Brazilian semi-arid region, two important examples are the CAATINGA – Center for Advice and Support to Alternative Workers and Non-Governmental Institutions and the Sabiá Center. Among several actions, both established a partnership in Projeto Terra de Vidas, with the support of the German Caritas, which aims to store water that would be wasted after use in the bath and in the sinks of the kitchen and bathroom.

Through the installation of 450 water reuse systems (reuse of ash waters, RACs) it was possible to make irrigation of 450 SAFs. Families were also monitored in the construction of knowledge about RAC/SAF management, of which 30 multiplier farmers were part of the process, which ended up being shared with another 600 families. It is expected that, with these actions, the impacts of climate change will be reduced, as well as the huge difference in dissemination of techniques to help small farmers.

More recently Louback & Lima (2022), with the support of the Climate Observatory, published the book "Who Needs Climate Justice?", where several interviews are presented on the subject with *quilombolas*, indigenous communities, small farmers, and can guide, very clearly, the directions that must be taken to reduce climate injustice in Brazil. The main points raised in this work were: *(i*) to research and present concepts and data on the subject in Brazil;*(ii*) to systematize information on climate justice from an intersectional perspective;*(iii*) to gather narratives to illustrate the multiple dimension of the concept and practice of climate justice, considering the perspectives of gender, race and social place. The portrayal of climate justice in Brazil is presented as a harsh reality in which we live.

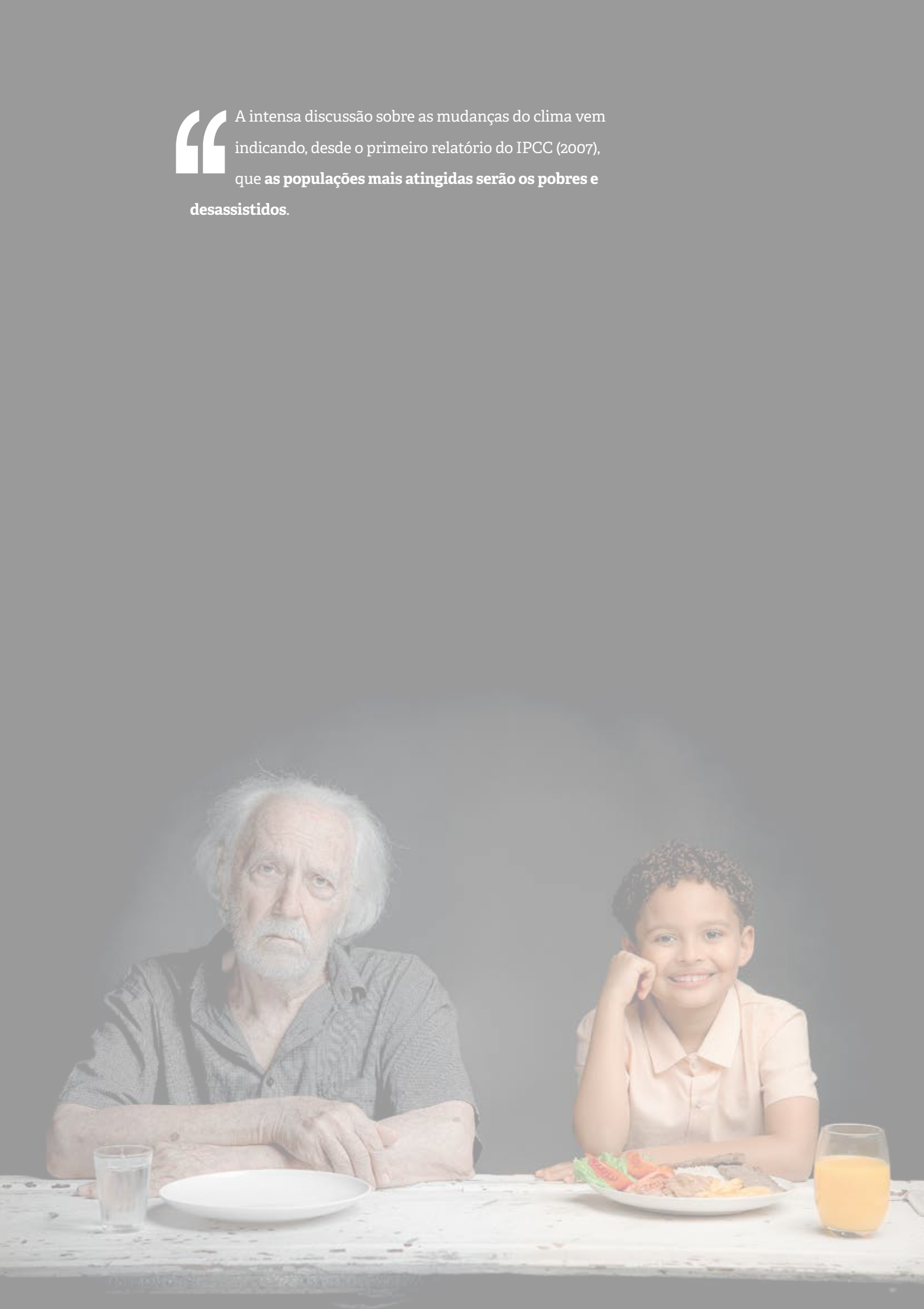
Final comments

There is an abyss between the rich and the poor in Brazil. At the time of the dictatorship, an important minister of the Economy said that "**the cake needed to grow, and then be divided**". **The cake grew and was not divided**, becoming concentrated over and over in the hands of the Brazilian elite, which needs to quickly review its concepts. Climate change will reach everyone, but the poor will hit it hardest and fastest. Remaining as the greenhouse gas emissions are today, the most influential and powerful will also be achieved. It will only take a little longer if we do nothing to reverse or minimize this situation, called climate emergency. Actions to reverse the climate situation have already been pointed out to government agencies. Among these actions, it is important to highlight bringing taking education to the field countryside. Those who question investment in education do not know the cost of ignorance.

Proposed actions to reverse the climate situation, promoting food security

- To avoid the socio-environmental collapse of the Amazon.
- Reactivation of climate funds and allocate resources strategically.
- To adopt preventive disaster policy and climate risk management.
- To improve environmental licensing.
- To eliminate public land grabbing and consolidate land information.
- To accelerate the environmental regularization of private properties.
- To combat environmental racism.
- To increase incentives for small farmers.
- To increase the credit value for small farmers.
- To encourage low carbon farming practices.
- To expand the marketing of primary products directly related to staple food.
- To take education to the field.

A intensa discussão sobre as mudanças do clima vem indicando, desde o primeiro relatório do IPCC (2007), que **as populações mais atingidas serão os pobres e desassistidos**.



Agricultural development and production by small farmers: More food on the table and redistribution of income

Chapter 9

Agricultural development, rural development, climate change and hunger: Strategic agendas for the agro of the 21st century

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Introduction

In the one-generation interval, Brazil has moved from the condition of a deficient country in food production to being among the largest exporters in the world. The eradication of hunger and poverty has taken much longer and has presented a more erratic trajectory.

The reason for this apparent paradox lies in a cognitive dissonance that reaches the common sense, but also leaders of the agricultural sector and a part of the specialized literature on these topics: **many continue to believe, despite the evidence to the contrary, that the expansion of production in agriculture would in itself lead to the solution of the other problems.**

Half a century since the leverage of the so-called Green Revolution model in Brazilian agriculture, it is time to update these cognitive frameworks and tune them better, both with is showed by the data about what was achieved. But also with the evidences concerning what was not possible to solve. And, finally, with expectations about what agriculture should be of the 21st century, freeing the public debate from the visions that insist on thinking problems and solutions for the present and for the future with the same analytical and technological tools developed in the middle of the last century.

We intend to argue in the following lines that there may be – and there is – coexistence between agricultural development and hunger, **but it is not possible to have rural development without fighting hunger and without greater economic inclusion of the most vulnerable populations in rural Brazil.**

For this, two movements will be made: the first, of an analytical and demonstrative character, aims to recover, even topically, a small history of ideas about the interdependencies between these three topics – agricultural development, rural development, and hunger. The second, of a more positive character, aims to argue that the **future of Brazilian agriculture will have to be rethought in the light of a new composition of agendas** and that its legitimacy and even its viability will depend precisely on its ability to promote, or not, this type of update.

Agricultural development, rural development, hunger.

In the 1960s and 1970s, when the production pattern emerges in Brazil, there was an expectation that the modernization of agriculture, promoted through the **technological package based on the use of chemical inputs** (fertilizers and pesticides), **machinery and subsidized credit would expand production and, with it, employment**.

What was found over time is that **this model proved to be expensive, with strong environmental impacts, and highly selective, excluding much of the rural population, which was negatively affected by the concentration of land, income and investments**. This model proved to be labor-saving, due to the technological intensification that replaces human labor with machines. It is true that the hardiness of rural work decreases and there is a significant increase in productivity, but there is also a decrease in opportunities for productive inclusion, boosting the increase in poverty.

At the end of the 20th century, it was the turn to try to differentiate agricultural policies. In a context of scarcity of resources and **dismantling of the large structures that enabled the productivist standard** (for example, with the extinction or dismantling of public technical assistance companies), the concern becomes the identification of segments of Brazilian agriculture that could deliver a good performance, with few investments, in a context of crisis of state financing and increased unemployment. The PRONAF – *Programa Nacional de Fortalecimento da Agricultura Familiar* (National Program for Strengthening Family Agriculture), was created and directed to an intermediate segment of this group. Today PRONAF is still considered a successful program, but it has never reached massively the poorest, nor has it been designed for that. For the poorest, the most visible effects would be achieved by other policies, such as the extension of **social security rights to rural workers and, later, with the programs for conditional transfers of income, such as the Bolsa Familia**.

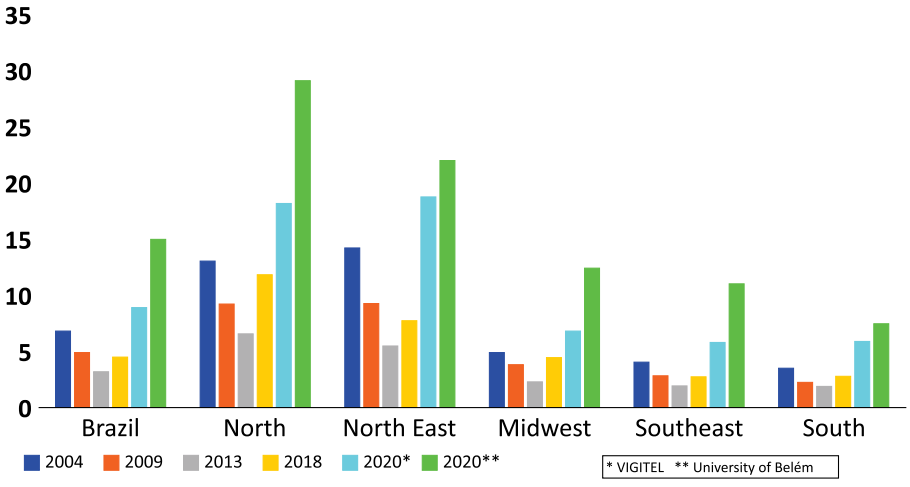
This is how, at the beginning of the 21st century, agricultural policies began to be accompanied by policies to combat poverty in a multidimensional perspective. The social agenda is now taking place of even greater prominence in the State's actions. The *Fome Zero* (Zero Hunger) Program, the constitution of the *Bolsa Família.* and finally, the *Brasil*

Sem Miséria Program not only greatly expanded the transfers of income to the poorest, but also began to consider that **poverty is the result of a set of social and productive hardships.**

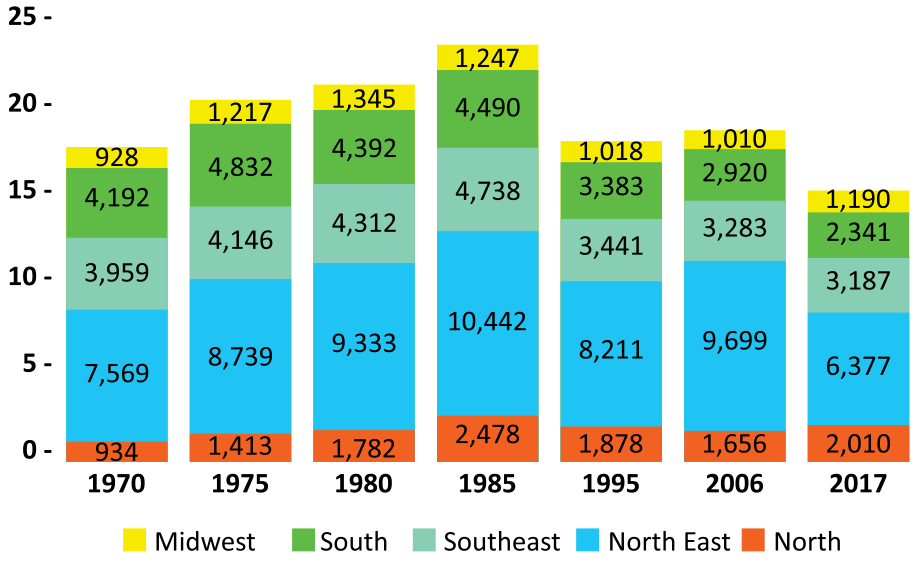
Specifically on rural productive inclusion, a strategy was designed , starting with basic infrastructure supply, such as water, housing, and energy; then moving to productive support; until finally reaching forms of access to markets, primarily through public purchases.

As a result, poverty was decreasing, but at the same time, occupations in rural Brazil decreased, because something was missing in this strategy, especially in two aspects: the volume of resources focused on the productive assets of the poorest has never been enough due to the size of exclusion bottlenecks in rural Brazil. In addition, despite the interesting mix of policies mobilized in the strategy of productive inclusion, there was low coordination between them, not arriving at the idealized sequence for the beneficiaries, or reaching the same beneficiaries.

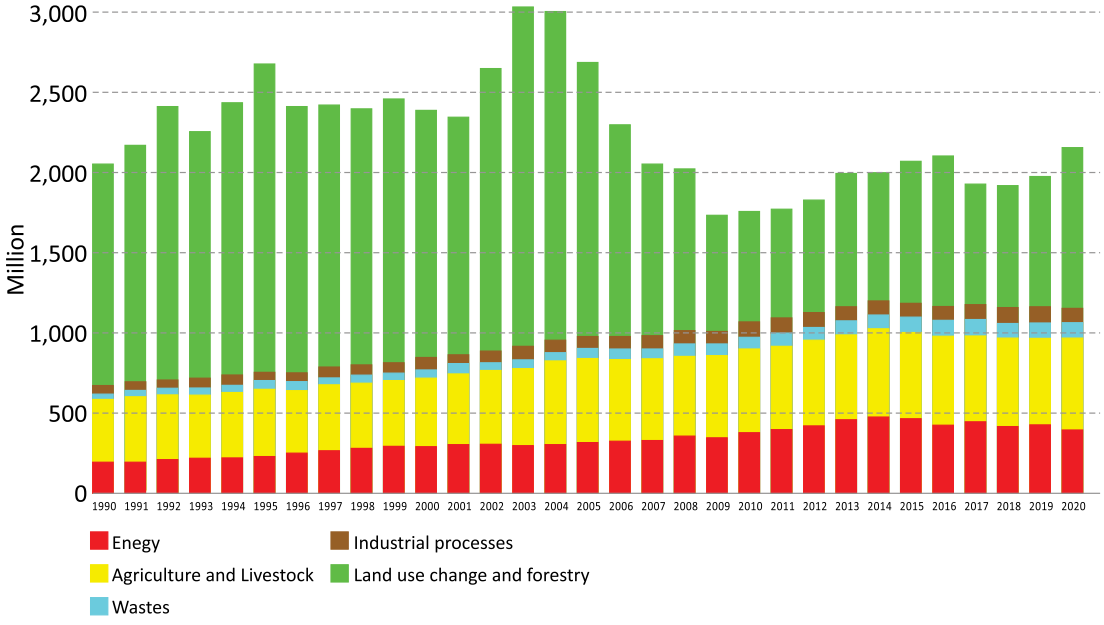
In the second half of 2010 there is a **dismantling of public policies and an intensification of the environmental crisis**. There was a discontinuity of those programs that had been working, even if with partial success. This can be explained for the economic crisis that struck the country in this decade; or by the vision guiding the action of the State in the period - according to which austerity in public spending would favor private investments and these would generate the economic dynamism necessary to overcome



Percentage of the population (Y axis) in severe food insecurity in Brazil in the five regions of Brazil (X axis).
Source: PNAD and POF – IBGE, VIGISAN and University of Berlin (Galindo et al., 2021).
Reproduced from: Belik (2022).



Population located in agricultural establishments, in millions, in the five regions of Brazil.
Source: IBGE (2019); Reproduced from: Favareto et al. (2022).



Emission of greenhouse gases in Brazil – 1990/2020 (Gt of CO_2 equivalents) (Y axis) in relation to years (X axis).
Source/preparation: SEEG/Climate Observatory (2022).

poverty and exclusion; or, either still by the systematic decision of not prioritize social and environmental agendas. The result was the rapid return of poverty and hunger, falling back the country to the same state of indicators that were seen decades earlier.

In the 2020s, there is an expectation of **the resumption of the State's protagonism in economic, social, and environmental agendas. But how will these topics be addressed**? The major issue is whether the country will invest in economic activities with a low degree of economic inclusion and generate significant environmental impact. It has been done

in the past with the industrial and agricultural policies, leaving the social agenda and the environmental agenda restricted to measures to mitigate the negative effects of the predominant development style. Or, if changes in the orientation of the State action will be able to achieve a new model (of growth, of development, of social organization), in which the fractures between the production of wealth, the inclusion of people, and the environmental conservation can be combined. For this, it is necessary a transition that involves sectors to be supported, the ways to produce, and mainly, the ways to think about the future.

Worldwide, these challenges are also being faced, and in many places, this has been called a **fair transition, sustainable transition, ecological transition,** or other similar forms. In all of them, the need for a new moment is pointed out, and for this to happen, a new agenda is a striking trait. With regard to rural Brazil, the remaining question is to know whether, in the next period, we will continue to bet on two vectors of action on rural environment – one labor-saver and intensive in natural resources, and another based on the expansion of social policies to compensate the negative effects of the first vector, including hunger; or, if it is possible a transition to **a new model of development in rural Brazil, in which, without giving up the production of wealth, it is possible to design incentives and investments to promote greater convergence between private, social and environmental gains**.

The new challenges for Brazilian agriculture

The challenges for Brazilian agriculture in the 21st century are no longer limited to increasing agricultural productivity. The very brief recovery of the trajectory of policies for agriculture and rural Brazil shows that there is a dissociation between the productive, environmental, and social agendas. The demand of consumers, markets and funds is growing for greater commitment to a set of issues that cannot be addressed without an effective change in the pattern of food production and consumption. We need to move beyond the conspiracy arguments, according to which the introduction of socio-environmental criteria for international trade or financing rules would be only disguised as protectionism.

In particular, three specific agendas demand more effective responses. Namely: the climate agenda, fighting hunger and promoting of food security, and the productive inclusion of the most vulnerable population.

The new challenges of Brazilian agriculture require the implementation of three agendas: *(i)* the climate, *(ii)* fighting hunger and promoting the fair food transition; and *(iii)* the productive inclusion of the most vulnerable population.

The climate agenda

The "climate agenda" represents a set of actions aimed at reducing greenhouse gas emissions, in order to promote, on a global scale, the commitment established in Agenda 2030, enshrined in the Paris Agreement in 2015, to limit global warming to 2 degrees Celsius in the coming decades, preferably trying to reach the most desirable target of 1.5 degrees. This should be consolidated in the NCDs (nationally determined contributions – a device defined in the Paris Agreement according to each the countries set its own goals, with the expectation that the aggregate of commitments may lead to the desired reduction in emissions).

Brazil has a specificity in comparison to the other important countries for the global climate agenda: **here, the main sector responsible for greenhouse gas emissions involves land use and agricultural production (not transport or energy generation) – deforestation, agriculture, and livestock**.

For several reasons, **Amazon** is another important topic. It is due to the fact that the biome has a fantastic biodiversity; for its relevance to the global climate regulation; for the relevant presence of indigenous people. It is not enough to argue that the growth of agricultural production in Brazil has occurred predominantly from productivity gains, not from the expansion of cultivated areas. Although this is true, the fact is that the agricultural frontier continues to advance over the Amazon. If it is a fact that Brazilian agribusiness does not need to dismantle environmental policy, then what is the reason for so much resistance among the political organizations of this sector in accepting the strengthening of the state's action in the environmental area or adhering to proposals such as zero deforestation?

The agenda of hunger and fair agri-food transition.

The idea of **agri-food transition** emerges from the diagnosis regarding the relevance of this sector to achieve responses to different problems. The first is the climate agenda, mentioned above. On a global scale, agri-food systems (involving not only agricultural production but also the transformation sector and the forms of distribution

of food products) are responsible for almost half of the global emissions associated with global warming. In Brazil, as it was also mentioned, changes in land use, largely driven by the dynamics of primary production and the form of production in agriculture and livestock are, together, the main vector of emissions. There is no possibility of achieving the goals for 2030 or getting close to some kind of transition to sustainability without a structural and rapid change in this sector.

The second is the food agenda, subdivided into two dimensions. One of them involves the problem of hunger. As it has already been said, after a period of systematic decrease in hunger and food insecurity in the first decade of this century, this situation has deteriorated again in the world and in Brazil in the second half of the last decade. Although the specialized literature points out that hunger involves difficulties of access to food by the poorest (purchasing power, distribution channels), there is also a certain relevance of aspects related to supply: in Brazil, part of the crops dedicated to the basic feeding of the population (rice, beans, and other products), has been gradually replaced by *commodities* for export (soy, especially). Another dimension involves a number of health-related problems - that is, while hunger is growing, there is also a worldwide epidemic of diseases associated with poor nutrition and excessive consumption of ultra-processed foods. It is not a question of giving up the Brazilian competitiveness in the world export of grains. But to try to promote greater productive diversification and the adoption of a new transition in the use of technologies, replacing the high use of chemical inputs with biological inputs and forms of natural resource management that **favor greater conservation and the expansion of opportunities for a better distribution of gains, especially among the most vulnerable segments of rural Brazil**.

On this, the narrative of the **bioeconomy** is increasingly highlighted. Brazil has the technological capacity to lead, on a planetary scale, a new technological revolution consistent with these requirements. Without this, in a world in which businesses increasingly depend on the reputation of their agents, the country will be at risk of losing markets, competitiveness, and legitimacy.

The agenda for economic inclusion

Throughout the world, and even to a lesser extent also in Brazil, an **important part of the people who starve are poor farmers**, who do not have enough land to produce food for self-consumption, nor to produce surpluses that allow them to measure monetary

gains and, with this, gain enough to buy food in satisfactory quantity and quality. Improving the living and production conditions of these populations could, therefore, at one time, allow for improving the supply of healthy food and reducing the rates of hunger and malnutrition among that population. Moreover, depending on the style of production that is experienced (less use of chemical inputs, improved productivity to avoid the need to incorporate new areas today covered with forests for agricultural production), there is also a potential contribution to the climate agenda.

It is simply unreasonable to argue that these poor farmers are unviable. **The data show that the productivity per hectare of large-scale agriculture in Brazil is equal to the productivity of family farming**. Why is this infeasibility alleged only for poor family farmers? Why would the diagnosis that social policies be sufficient for this segment, while large properties that produce nothing and function only as an instrument of patrimonial valorization or political domination remain untouched? On the contrary, with fewer investments proportionally, the responsiveness of this segment of small autonomous producers is large.

At this point, the interdependence between the rural productive inclusion agenda and the agri-food transition and climate agendas must already be clear, since ways to economically include poor farmers can bring productive repercussions for these two other agendas.

However, there is a need for proper management to coordinate actions that are in the spheres of ministries traditionally associated with rural Brazil – Agriculture and Agrarian Development – but also others, such as policies and programs in the areas of Social Development, Infrastructure, Science and Technology, among others. The *Brasil Sem Miséria Program* had experienced an innovation, considering that the policies of immediate poverty alleviation would need to be combined with the improvement of the basic conditions for these farmers, the expansion of the supply of productive policies, and forms to access markets. As we know, this package of policies and programs has never come in a coordinated way to farmers, despite the expansion of resources. And, as it has already been said, strategic areas were left out of the mix of mobilized instruments. That is why it is insufficient to simply repeat the strategies of the past.

Conclusion – for a renewed development strategy for rural Brazil

Two decades ago, one of the largest Brazilian experts on topics related to agriculture, rural development, and sustainability, José Eli da Veiga and collaborators published an article whose title was significant: "Rural Brazil needs a Development Strategy" (Veiga *et al*., 2001). The argument of this expert is that we had experienced an agricultural development strategy, but we had to set in motion a new vision for the future in which **rural areas could also fulfill other functions, such as the expansion of work opportunities and environmental conservation**.

Twenty-two years later, it is necessary to recognize that the country continues with an expressive agricultural development strategy but is limited in its ability to overcome the challenges of the 21st century. The country continues without a rural development strategy because a juxtaposed set of programs and policies does not necessarily mean coordinated and coherent action toward a transition that can be called just, inclusive, and sustainable.

If, as the Indian economist and Nobel Prize in Economics, Amartya Sen says, development must be synonymous of an extension of people's freedoms in doing what they consider the best for their lives – and not pure and simple economic growth, but rather – (Sen, 1988), and if the environmental agenda will be more and more important, then **there is still a huge debt of our agricultural development style toward this** ambition.

This is the time to separate those who cling to the past only to sustain their prominent position in the economic and political order from those who follow the ambition to see their businesses thrive, but doing this without ignoring the unavoidable demands of the present and the next generations. Only in this way will agricultural development make peace with rural development and the climate agenda, and will allow us to leave behind the glaring situation of hunger.

Chapter 10

Family farming and the need to reinvent agricultural extension to eradicate hunger

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[4]*Embrapa General Business Management*

Data from the 2017 Agricultural Census indicate that Family Farming (PA) represents **about 77% of agricultural establishments in the country and employs 10.1 million people** (67% of all personnel employed in agriculture nationally). Of the total PA establishments, 18.7% are administered by women and 1.9% by young people under 25. Family farming produces 48% of the value of coffee and banana production, accounting for 80% of the value of cassava production, 69% of pineapple, and 42% of the bean production. In addition, 31% of the number of cattle heads, 45.5% of birds, 51.4% of pigs, 70.2% of goats, and 64.2% of milk production come from family farming (IBGE, 2017). In 2017, **establishments classified as PA accounted for 23% of the value of domestic agricultural production**, **which is mainly intended for the domestic market.**

The creation of PRONAF (National Program for the Strengthening of Family Agriculture) in 1996 was an important milestone for this public – in which family agriculture became better legitimized by the State. However, even with the creation of public policies aimed specifically at the development of family agriculture, its universe is not homogeneous; on the contrary, it is marked by profound social, cultural, and economic differences. Great differences also appear regarding the incorporation of innovations into productive systems, observing, among others, three major problems:

i) Problems with the adoption of new technologies;
ii) significant differences between regions and producer groups regarding access to modern and more sustainable production techniques;
iii) low rates of use of the main technologies and the use of certain practices and inputs.

In addition to their role in food production, it is increasingly recognized that family farmers play a central role in promoting more sustainable, biodiverse, and inclusive agri-food chains, as well as **guardians of natural resources** (FAO & IFAD, 2019). Family farming systems that adopt sustainable productive intensification practices can increase crop tolerance to abiotic stresses, diversify production, promote food and nutrition security, increase resilience to external shocks, prevent environmental degradation, and reduce greenhouse gas (GHG) emissions. (Angelotti & Giongo, 2019).

Despite the great importance of family farming in food production, **this segment is the one that faces the most problems of food insecurity in rural areas** (Rede PENSSAN, 2022). The survey carried out during the COVID-19 pandemic by the Rede PENSSAN

indicated that **38% of family farmers faced the most severe forms of food insecurity** (moderate or severe). The situation was even more worrying in the north and northeast regions where, respectively, 54.6% and 43.6% of family farmers faced moderate or severe food insecurity. In the south and southeast regions the problem appears in lower intensity, although still very worrying, with 13.8% and 22.1% of family farmers, respectively, facing moderate or severe food insecurity (Rede PENSSAN, 2022).

Food insecurity data in family agriculture also indicate a remarkable characteristic of this segment. Family farming in Brazil is extremely heterogeneous, presenting a wide variety of forms of organization, different socioeconomic and historical conditions, cultivating different species, adopting different agricultural practices, and differentiated access to credit and technical assistance, besides being developed in different biomes, from the Amazon through the Caatinga, Cerrado, Pantanal, Atlantic Forest, and Pampa.

Considering this great heterogeneity, it is necessary to advance in the knowledge of the different realities experienced by family farmers for the design and implementation of actions directed to specific audiences in order to provide better results in the promotion of food security, income generation, and improvement of the quality of life of this population. This deepening in the knowledge of the reality of the different subgroups of family farmers, as well as identification of solutions to the problems faced by them, demands different areas of knowledge and actions involving multidisciplinary teams.

In this scenario, the **Technical Assistance and Rural Extension** (ATER) services have a central role in overcoming poverty and food insecurity in the field, especially in the context of family agriculture (Zambra *et al.*, 2018). Providing family farmers access to ATER in a wide, continuous, and quality way is an essential strategy for the sustainable development of this segment, with social inclusion, income generation, promotion of food and nutrition security, and improvement of the quality of life. Census data show that **family farmers who receive technical assistance and rural extension have an average income considerably higher than those who do not have this service** (IBGE, 2017).

From the historical point of view, the first institutionalized actions of ATER in Brazil occurred, even in an incipient way, in the imperial period, within the imperial agricultural schools. However, the model that was consolidated in the country is derived from the American experience and was created in the late 1940, focusing on the provision of rural

credit lines associated with technical assistance through the Credit and Rural Assistance Associations (ACARs) (Pereira & Castro, 2021). Since the 1960s, there has been a great expansion of the credit associated with the service of ATER, favoring the incorporation of many innovations to the production systems, being decisive for the great transformation in the rural environment, arising from the modernization of Brazilian agriculture (Castro & Pereira, 2017). However, this modernization did not include all Brazilian farmers, leaving behind this process millions of rural establishments, especially those of family farming.

Currently, ATER in Brazil is promoted by different players. The federal government coordinates public policies at the national level and promotes actions through public calls, via the National Agency for Technical Assistance and Rural Extension **(Anater**). In addition to the actions developed in the federal sphere, Ater's service provision takes place at the municipal level, through technicians linked to the municipal departments of agriculture, environment, and social assistance, in addition to the performance of Ater's official institutions in the states, linked to the Brazilian Association of State Entities of Technical Assistance and Rural Extension (Asbraer). S system, cooperatives, private technical assistance companies, and NGOs, among others, are also important actors in the provision of ATER in certain regions.

The official rural extension services in the states have an extremely low number of extensionists, estimated in 2017 at only 12,766 extensionists (ASBRAER, 2017). Moreover, despite the importance of ATER for the development of Family Agriculture, much of this public does not have access to this service. According to data from the Agricultural Census of 2017, **only 18.2% of Brazilian family farmers have access to ATER services**, and access to this service varies considerably according to the region: 48.9% in the south, 24.5% in the southeast, 16.4% in the midwest, 8.8% in the north and 7.3% in the northeast.

All these numbers, combined with the reality of food and nutrition security observed in the field, have shown that performing the service **in the traditional ATER molds, that is, in an exclusively face-to-face manner, has not been shown to be viable, either by geographical distribution or by the quantitative of family farming properties**. In this sense, regarding access to ATER services, new strategies and initiatives have gradually emerged incorporating **information and communication technologies (ICTs**), aiming to increase the capillarity of this service, improving the quality of life of rural families.

On-site service, in the traditional way, is essential, but can count on the support and reinforcement of other strategies and tools that favor the expansion of the quantity of family farmers served in a sustainable, effective, and efficient way. Within the ATER scope, the use of digital tools has certainly complemented and improved their actions against producers, passing through geographical barriers, and merging remote and face-to-face assistance. According to Zuin *et al.* (2022), this new interactional reality in the field allows, in addition to all the benefits linked to improving food production and safety, to reduce the cost of the ATER service.

However, it is important to highlight that the use of ICTs in ATER's actions in the rural environment are complementary facilitators of face-to-face actions and do not replace them. **Personal contact between the extensionist and family farmers is considered important in activities that demand experiences and build trust relationships**.

As for its impact, the use of ICTs for the care of rural producers presents promising results in specific cases, such as in solving problems of production chains and defined producer profiles, as well as in facilitating the process of commercialization of products, reducing the dependence of intruders. However, in order for the remote ATER, that is, using ICTs, to be effective, it is necessary to consider the capacities and competencies of rural producers in relation to the use of digital tools, such as the degree of literacy, age, and connectivity infrastructure, access to equipment, among other factors.

In addition, there is another important element to be considered in this scenario of ATT through ICTs in Brazil, which is that of low connectivity in rural areas. According to recent research, **a considerable part of the Brazilian rural population still does not have access to the Internet**, and the average connection speed is considered low. This highlights the limited connectivity infrastructure in rural areas of Brazil, which makes it difficult for many farmers to access information and services essential for the modernization and competitiveness of agricultural activities. The data also point to regional disparities, where remote and difficult-to-access areas, such as the Amazon region and rural areas of the Northeast, present a greater lack of connectivity (Rocha Junior *et al.*, 2021).

If, on the one hand, these data show a challenging situation of the low connectivity in rural areas of Brazil, the practice in the field already shows that the frequent use of

messaging applications, social networks, YouTube, among others, is a challenge, by the extensionists and farmers it is a reality in most Brazilian territories (Zuin et *al.*, 2022).

In this sense, it is urgent to establish a national strategy that incorporates ICTs to facilitate, scale, and improve the efficiency of extensionists' work. This strategy should also promote investments in digital infrastructure and access to quality internet to promote the sustainable development of the agricultural sector.

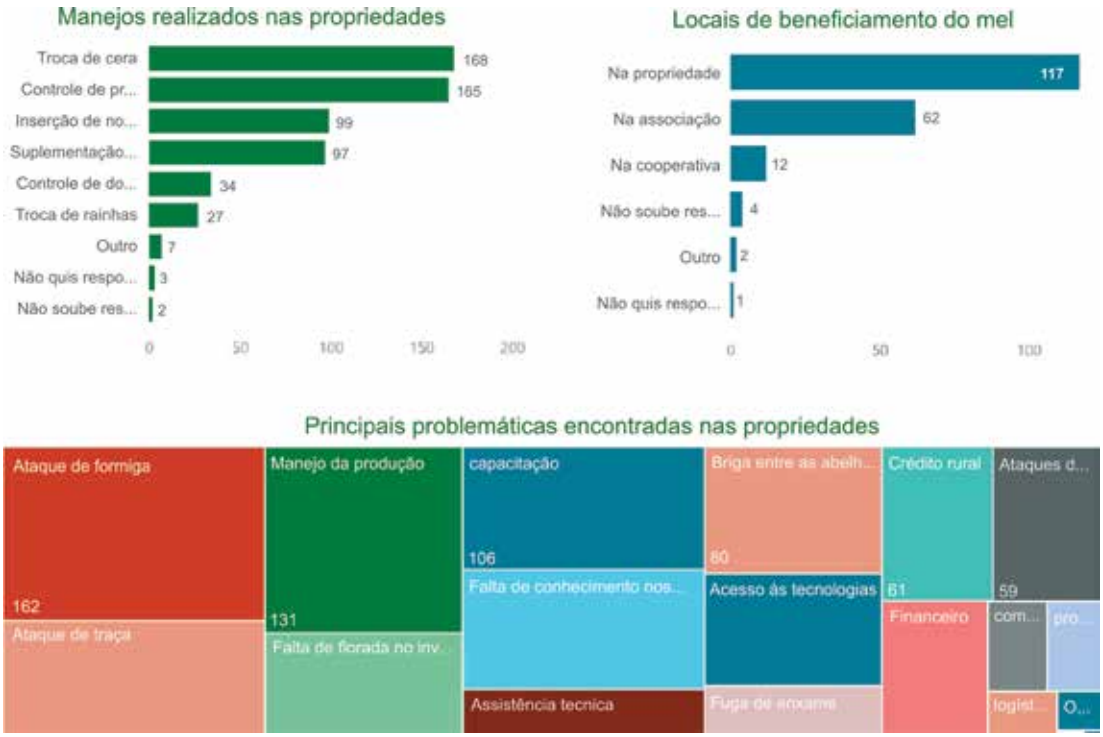
Pillars for a New Family Farming Assistance (MAPA, 2020).

- Organization and sharing of information/knowledge about research and extension in agricultural areas.
- Modernization of Information Technology (IT) infrastructure of state public institutions of Technical Assistance and Rural Extension.
- Sharing and/or development of systems/applications aimed at improving productivity, quality of agricultural products, and optimizing resources.
- Training of the extensionists of the Public Technical Assistance and Rural Extension entities to use the mobile resources of Information Technology in order to strengthen the actions of Technical Assistance and Rural Extension.
- Creation of Information and Technological Management Centers for Family Agriculture.

Finally, it should be mentioned that several initiatives of remote and digital ATER have already been carried out by public and private entities at the federal, state, and municipal levels in the country, as is the case with the Ater Digital program – launched in 2020 by the Ministry of Agriculture, Livestock and Supply. These initiatives have supported the construction of a new paradigm of providing the ATER service by facilitating and improving communication with people living and working in rural areas.

As an example of these actions, a thematic pilot study was established under the ATER Digital Program – aiming at the validation and testing of remote methodologies for the provision of the ATER Digital service. This work was done in partnership with IFAD (International Fund for Agricultural Development), Embrapa Meio Norte and Startup Maneje Bem, with the objective of making a diagnosis of sociodemographic characteristics, productive profiles, aspects related to access to technology, as well as ATER services with beekeepers of cooperatives and associations of Piauí. From this information it becomes possible to provide a service of ATER highly adapted to the reality of each producer.

General results of the diagnosis carried out within the scope of ATER Digital.



Diagnosis of productive aspects of beekeepers in the pilot study carried out by the ATER Digital program.

Data	Produtor	Técnico
05/01/2022	BR-103 David	Erica do Vale

Etapa	Pergunta	Resposta
Produção	Produtividade média anual (Kg/colmeia/ano)	Ainda não respondeu
Produção	Qual associação?	Ainda não respondeu
Produção	Quantas colmeias em produção?	Ainda não respondeu
Produção	Quantas colmeias foram perdidas?	Ainda não respondeu
Produção	Principais problemáticas encontradas pelo produtor na apicultura	Ataque de formiga, ataque de traça, ataques de pragas em geral, capacitação, briga entre as abelhas e morte, comercialização, crédito rural, falta de conhecimento nos manejos, falta de florada no inverno, financeiro, manejo da produção
Produção	Município onde estão inseridas as colmeias	Bela Vista
Produção	Meses em que faz a colheita	Dezembro, janeiro, fevereiro e março
Produção	Locais de destino da produção	Encaminha a produção para a cooperativa
Produção	Qual a espécie de abelha da produção	Europeia
Produção	Quais produtos o produtor extrai da apicultura	Mel
Produção	Onde é feito o beneficiamento do mel?	Na associação

Individualized producer diagnosis provided in the ATER Digital program under the pilot study.

The economy assisting in the design of public policies, bioeconomy as a new strategy for food security and the role of the private sector

Chapter 11

Economic aspects of food security, poverty and food production: Distinct but interconnected issues

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If food production in a country, region, or community is insufficient to meet the needs of its population, this deficit will be either covered by food imports or, necessarily, there will be hunger. In the case of Brazil, **national production exceeds by 32% the needs of the population** (FAO, 2022c), with this surplus growing over time. Over the last two decades, per capita food production in Brazil has increased by over 2% per year (FAO, 2022b).

An alternative way of confirming this Brazilian surplus in food production is to compare the gross value of Brazilian food production, R$789 billion in 2022 (Brasil,[1] 2022a), with the cost of feeding the entire Brazilian population of 213 million (IBGE, 2022a), using the cost of a food staple basket capable of meeting a person's nutritional needs, estimated at R$ 664/month[2]. Considering that the consumer price is 2.5 times the price paid to the producer, it is estimated that a **production of R$ 679 billion would be sufficient to feed the entire Brazilian population**. A surplus, therefore, of 16%, when estimated in this way.

On the purchasing power side, a corresponding analysis shows that a family with the average Brazilian per capita income is able to acquire 11 food staple baskets capable of meeting their nutritional needs[3] (IBGE, 2020a). Therefore, the average Brazilian family needs to allocate only 9% of its budget to meet its energy needs. This finding aligns with POF 2017-2018, which finds that, on average, food expenditure represents only 12% of the household budget in Brazil (IBGE, 2020a).

Unfortunately, the reverse is not true. Food production in a country, region or community can far exceed the population's needs, and yet a significant portion of the population may still have unmet their nutritional needs. In fact, **hunger and malnutrition do not necessarily result from insufficient aggregate availability of food, they can also perfectly result from the lack of access by some families to available food**.

[1]As not all agricultural production is directed to human food, the estimate used in the text subtracts from the value of agricultural production the whole value of cotton and tobacco production and 80% of the value of soybean and maze production.

[2]The value of this food staple is the average value for Brazil of the food staple that ensures the minimum caloric requirement, obtained from *Barros et al.* (2004), adjusted for inflation by the INPC and converted into a food staple that ensures a nutritionally adequate diet of a person, using the World Bank (2020).

[3]According to our estimates based on POF 2017-18, the Brazilian per capita income was R$ 1,809 per month in values of 15th of January, 2018, that amounts to R$ 2,378 in mid-2022 when the cost of the food staple basket, capable of adequately meeting the energy (caloric) needs of a person, was R$212 *Barros et al.* (2004), which therefore amounts to only 9% of the per capita income.

As highlighted, food production is increasing in Brazil and far exceeds the nutritional needs of the population. Hence, the only possible reason for hunger and malnutrition in Brazil is the lack of access of some to the available foods.

In a market economy, sufficiently high-income levels ensure access to nutritional needs. What would be this minimum level of income required depends on food prices and the other expenses that families need to carry out. As food prices vary geographically, the minimum income that ensures access to nutritional needs should also vary spatially. According to DIEESE (2023a), comparing city-state capitals, the cost of a food staple is 40% higher in São Paulo than in Aracaju. The fact that non-nutritional needs vary among families, leads to the fact that the minimum income required to meet nutritional needs should also vary among families in the same locality.

In summary, in a market economy, **purchasing power and food insecurity go hand in hand.** A sufficiently high income certainly ensures that the nutritional needs of a family are met. However, a sufficiently low family income, in the absence of the intervention of other actions, will not allow the nutritional needs of a family to be met. Due to spatial variations in prices and differences in needs among families, **it is not possible to define a single value for this minimum income**.

Due to the high inequality in Brazil, a significant portion of families simply do not have the purchasing power necessary to acquire the staple foods they need to meet their nutritional needs. In part, programs aimed at the transfer of income, such as **the *Bolsa Familia* Program and the BPC**[4], partially alleviate this lack of purchasing power, by allowing many families to rely on the resources they need to meet their nutritional needs. But even after all public and private transfers have been considered, we find families with a clearly insufficient per capita income to guarantee their nutritional needs.

Although there is no universal minimum income capable of ensuring the satisfaction of the nutritional needs of any family in any locality. However, attempts have been made to **estimate an average reference value for this minimum**. According to *Barros et al.* (2004), **the cost of a staple food basket that fulfills the energy requirements would**

[4]The first is a program that transfer a monthly fixed value for poor families, adjustable to family size. The second, BPC is a minimum wage transfer for poor individuals/families, over 65 years or with disabilities.

cost R$ 212. As among the poorest 5%, food expenditure is close to half the per capita family income (POF 2017-2018) (IBGE, 2020a)**, per capita family income would need to reach R$ 424 so that a typical family can have the purchasing power necessary to meet their nutritional needs.**

According to the 2017-2018 Family Budget Survey (POF)[5], 10% of the Brazilian population lived in families with a per capita income below this level. More specifically, the per capita income of this group was R$ 279 per month, leading to the need to transfer an average of R$ 145 per capita per month to each of these families to achieve a minimum of R$ 424. It follows that the aggregated value of the income insufficiency of these families, which is equivalent to the additional transfers necessary to assure everyone a minimum per capita income of R$424**, would be of the order of R$ 37 billion per year** (IBGE,2020a).

This estimate that, in 2018, 10% of the Brazilian population lived in families with a lower per capita income than would be necessary to meet their nutritional needs is consistent with the estimate of POF 2017-18, that 14% of the Brazilian population lived with moderate or severe food insecurity (IBGE, 2020a). Food insecurity is a perception of families measured based on the Brazilian Food Insecurity Scale (**EBIA)**, a reputable instrument, which even allows wide international comparability. It is worth noting that food insecurity measures not only whether a family, currently does not have the resources necessary to acquire the food it needs, but also whether, at some point in the recent past (near future), they have felt (or will feel) that they lack the resources necessary to meet their nutritional needs. For this reason, and given the volatility of a family income, it is expected that the prevalence of food insecurity exceeds the percentage of families momentarily with insufficient income.

During the pandemic period, the per capita income of the poorest families declined while the price of food grew faster than the average. In 2021, the income of the poorest 10% was 12% lower than they received in 2019 and the price of food grew 16 percentage points above inflation (IBGE, 2022b; IBGE, 2023b).

[4]It is worth noting that POF 2017-2018 is the national survey with the best estimates for family income, including in income both monetary receipts and non-monetary components, as well as the amount of rent imputed to those who live in their own housing and production for self-consumption and the receipt of donations of food and other goods.

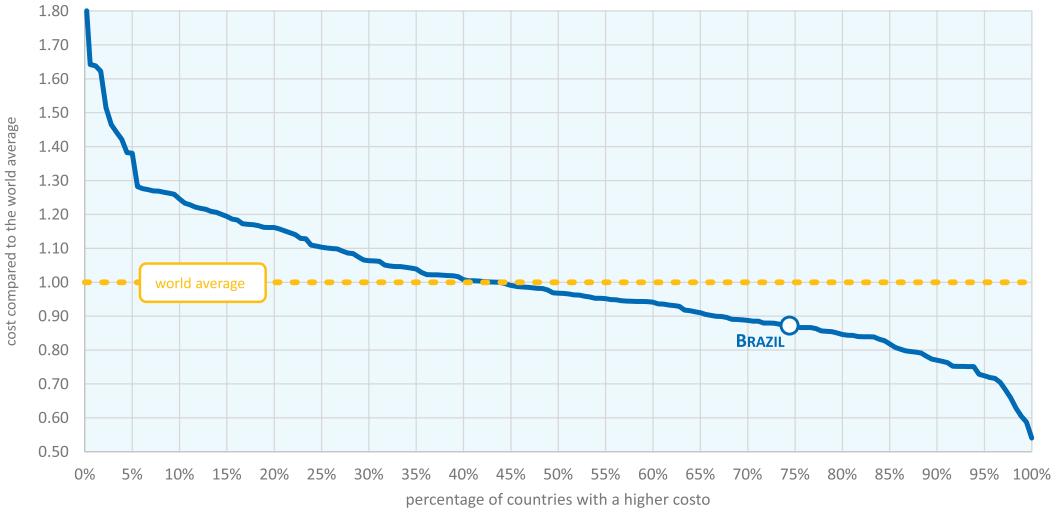
Due to this combination of factors, the purchasing power of families has plummeted, leading to a higher incidence of hunger and food insecurity. In fact, according to FAO in 2021, 29% of the Brazilian population was in a situation of moderate or severe food insecurity (FAO, 2022c). More recently, in 2022, the II VIGISAN estimated that 31% of the Brazilian population was in this situation (Rede PENSSAN, 2022), which contrasts with the production surplus of about 30%.

> The extremely unequal distribution of purchasing power in Brazil leads to the paradox of a surplus in food production close to 30%, with about 30% of the population living in a situation of moderate or severe food insecurity.

It is worth noting that, in the recent past, Brazil had already managed to reduce a percentage of the population in situations of moderate or severe food insecurity to below 10%. This occurred in 2013 (estimate based on PNAD-2013) when the degree of Brazilian inequality was close to its minimum historical value, reached in 2014-15 (IBGE, 2016).

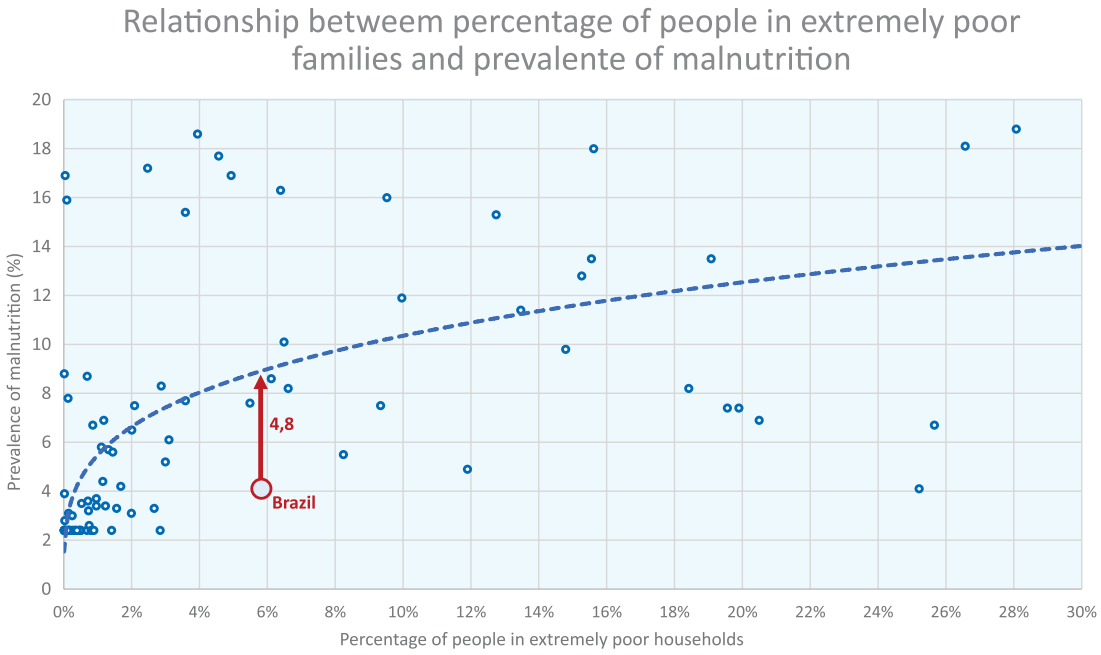
The surplus in **food production** in Brazil, although it does not guarantee food security for all, can have an **indirect utility for fighting hunger and food insecurity through a reduction in the price of food.** In fact, according to World Bank estimates (2020), food is cheaper in Brazil compared to the global context. **The cost of a healthy diet in Brazil is below the corresponding cost in 74% of the countries, being 13% lower than the world average and 21% lower than the average for Latin America and the Caribbean** (World Bank, 2020).

COST OF A HEALTHY DIET PER COUNTRY COMPARED TO THE WORLD AVERAGE (MOST RECENT YEAR WITH INFORMATION AVAILABLE)



Source: WORLD BANK (2020).

Thus, we should expect that the degree of food insecurity in Brazil should be lower than in the average of countries with the same degree of poverty, as insufficient income. And, in fact, faced with international experience, the degree of Brazilian malnutrition, measured by the percentage of people who consume insufficient calories for an active and healthy life, is 5 percentage points lower than what should be expected given the degree of income insufficiency of the Brazilian population (FAO, 2022a; World Bank, 2021).



Relationship between percentage of people in extremely poor families and prevalence of malnutrition.
Note: The prevalence of malnutrition is the percentage of the population that consumes insufficient calories to cover the needs required for an active and healthy life. Source: World Bank (2021); FAO (2022a).

A properly focused income transfer program with sufficiently generous transfers could overcome malnutrition to the extent that food is widely available in the country. As we have seen, if we adopt R$ 424 per month as the minimum per capita income necessary to ensure access to an adequate diet, the aggregate value of the necessary transfers would be R$ 37 billion per year.

This need for resources may seem small in relation to the Brazil'sl GDP (0.4%), or in relation to the total public revenues (1.3%) (Brasil, 2023c; IBGE, 2023c) and, even in relation to the R$ 175 billion predicted for the *Bolsa Família* Program for 2023 (Brasil, 2022b). However, it should be noted that this estimate was obtained after the incorporation of all public and private transfers, monetary and in-kind (including the donation of staple foods), received by the family and, therefore, represents only the additional amount necessary, not the

total value of public transfers. It is worth mentioning that this estimate was made based on POF 2017-2018 and, therefore, prior to the large increase in resources allocated to the *Bolsa Família* Program. If these additional resources have been applied in a well-focused manner, it would certainly be financially possible to ensure that no Brazilian family would need to live with income (monetary and non-monetary) per capita less than R$ 424 (twice what would be necessary to ensure their food needs), although the poverty line adopted by the new program is only R$ 218 per person per month.

There are, however, two challenges to guaranteeing all Brazilian families the purchasing power necessary to achieve their proper food security. On the one hand, the available resources would certainly be enough if we could achieve perfect focus. That is, it presupposes being able to identify exactly all those with purchasing power below the minimum income and also all those with purchasing power above the minimum income. In addition, it requires us to be able to accurately determine the income deficit of each of the families with purchasing power below the minimum income. Estimates based on the experience with the Bolsa Familia indicate that about half of the transfers end up benefiting families outside the program profile (IBGE, 2022b).

On the other hand, it should be emphasized that the minimum income considered is an average. Many families have other needs related to health, and housing, among others, that result in an income necessary to meet their nutritional needs, much higher than the average set as minimum. According to POF 2017-18, much more than half of the people in families with severe food insecurity are among those with per capita income greater than R$ 424 per month (IBGE, 2020a[6]). In other words, due to heterogeneity among families with respect to other basic needs, per capita income, even when perfectly recorded may not represent a good indicator of the family's ability to meet their nutritional needs. Many families with income above the minimum for a typical family suffer from some form of severe food insecurity.

Thus, so that focused income transfers are sufficient to eradicate malnutrition, they will have to use a low-income cut-off far above the necessary minimum obtained,

[6]This result is worrying, it reveals that even when measured based on high-quality research such as POF 2017-18, there is little relationship between the purchasing power of the family and its perception of food insecurity. Among the possible explanations, we highlight: on the one hand, the high volatility of income of the poorest families, even when monetary and non-monetary components are included; on the other hand, considerable noise in the measurement of nutritional insecurity, in particular due to the subjectivity of the responses.

assuming that half of the income can be allocated to food. It is worth noting that adjustments in minimum income imply that the necessary resources to grow much more than proportional. For example, if the goal is to raise the minimum per capita income by 50%, the population included will double and the value to be transferred to each family should grow by more than 60%, leading to the value of transfers tripling.

Therefore, it is clear that, on the one hand, the guarantee of a minimum income is an indispensable and effective instrument in combating hunger and food insecurity. On the other hand, it is also evident that the solution to food insecurity of those with income above the minimum requires alternative strategies.

The fact that many can satisfy their nutritional needs even with income levels much lower than what would be considered the necessary minimum suggests to the existence of alternative strategies in operation. In fact, even among the poorest 5% (understood as those with lower per capita income) more than half declare not to face even moderate food insecurity (IBGE, 2020a). This resultmay indicate that **community social protection networks are being effective in complementing government income transfers.** These local networks have a great advantage in relation to government networks, as they have a greater ability to identify families at risk of malnutrition and food insecurity, regardless of their typical income level.

Thus, an effective strategy to combat food insecurity **should combine some expansion in targeted public income transfers with local solidarity networks (to be supported with public resources)** capable of assisting those who, even typically earn income above the minimum, still remain with their nutritional needs not fulfilled. For everyone, but in particular, for those who combine food insecurity with income above what would be the minimum necessary, it would be important to have food education programs that promote better use of food expenditure by families. Therefore, any public policy aimed at eradicating food insecurity should also promote governmental actions that **strengthen community actions and food education**. This strengthening of community initiatives, however, cannot be understood as an absence of the State, nor that it leads beneficiaries to no longer perceive food as a universal inalienable social right and an obligation of the State.

An effective strategy to combat food insecurity should be to combine government social programs, with expansion in targeted public income transfers, with the increasingly relevant role of local solidarity networks, which should also be supported by public resource

A properly focused income transfer program with sufficiently generous transfers could overcome malnutrition to the extent that food is widely available in the country.

Chapter 12

Potential for economic and social return to the country by assertive policies to combat hunger

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It is still somewhat embarrassing that, even in 2023, scientists met to discuss the role of science in fighting hunger. The same *homo sapiens* which was capable of creating technologies that not even the most hallucinated science fiction writers could imagine, make possible solutions to solve problems whose complexity escapes the understanding of most people, develop the urban habitat, in which in 2021 lived 56% of the world population (UN-Habitat, 2022), failed entirely in relation to overcoming basic problems that accompany human evolution from the earliest times. Food insecurity and hunger, poverty, extreme inequality, wars between nations, intolerance of all kinds, and civil and religious conflicts, to mention just a few who continue to mobilize efforts of the international community, national governments, and civil society in most countries.

Science seems to have been more effective in addressing problems whose solutions are fundamentally through technological development, and less when the challenge involves, in addition to technology, social, economic, cultural, cultural, policies and institutional dimensions. This is the case of hunger, a problem that involves multiple determinants in all spheres, with very serious consequences for individuals, communities, and countries. How can we accept that around 828 million people were starving in the world by 2021? We are talking about hunger, defined by the United Nations Food and Agriculture Organization as the pain or discomfort that stems from the insufficient consumption of nutrients responsible for the supply of energy to the human body, not the food insecurity situation that precedes hunger. In addition to the share of the population suffering from hunger, in 2021 another about 2.3 billion people worldwide, 29% of the global population, were in moderate or severe food insecurity. The estimate presented in the report is that 45 million children under the age of five years old were languishing, the deadliest form of malnutrition, which increases the risk of death of children by up to 12 times. In addition, 149 million children under the age of five had stunted growth and development due to the chronic lack of essential nutrients in their diets.

Nothing more fair than to remember, on this subject, a great Brazilian scientist, Josué de Castro, who in his The Geography of Hunger, published in 1946, indicated that among the mistakes of civilization, perhaps the most serious would be to leave millions of people starving, not only total hunger, but also the most serious one the real famishment that English-speaking people call starvation, a phenomenon, in general, limited to areas of extreme poverty and exceptional contingencies, such as the much more frequent and serious phenomenon, in its numerical consequences, of partial hunger, of the so-called

hidden hunger, in which, due to the permanent lack of certain nutritional elements, in their usual regimes, entire groups of populations are slowly dying of hunger, despite eating every day (Castro, 1984).

Although Josué de Castro, in his 1946 book, had already associated the tragedy of hunger with underdevelopment, inequality, and poverty, hunger was still, for many decades, treated as **a Malthusian challenge, which led to the concentration of efforts to increase food production capacity**. And in this field it is possible to point out important results and highlight the contribution of science. **Food production has grown faster than population growth, increasing per capita global food availability**. In 1960, global food production was 2300 calories per capita, distributed very unevenly among countries; in 1990, it exceeded 2700 calories per capita; in 2015, it reached 2940; and in 2020, it should have exceeded the 3000 calorie mark (FAO, 2022a). It is important to highlight that the sources of this growth were gradually shifting from the increase of land used to the increase of productivity associated with the introduction of new resources to production, the result of investments in R&D that have been supporting for decades a substantive process of innovation in agriculture based on the expansion of the frontiers of knowledge, science and its applications (Fuglie, 2018). **Brazilian agriculture, whose production grew by about 90% between 1995 and 2020, was driven by technological innovations introduced that resulted in increased total factor productivity**. **In the same period, the incorporation of new lands grew by 32%** (FAO, 2023).

Although the world has considerably reduced poverty from 36% in 1990 to 10% in 2015, in 2020 more than 3 billion people could not afford a healthy diet, 112 million more than in 2019, reflecting the rise in food prices resulting from the economic impacts of the COVID-19 pandemic and, more recently, the war between Russia and Ukraine.

Although food availability is sufficient to feed the world's population, **these are important evidences that people cannot access to safe, nutritious, and sufficient food** (Roser *et al*., 2019; Chilkoti, 2022; FAO, 2022a). Regardless of the explanation, the embarrassing fact is that hunger and food insecurity persist, reaching billions of people. One could argue that science is doing its part, contributing to increase production, but we would be limiting the scope and reach of science and ignoring that its role goes far beyond the generation of technology. The resilience of food insecurity and hunger as global phenomena, which today are manifested even in many rich countries with a high

level of development, indicates that science has failed to better understand the topic and offer solutions that turn into policies and effective actions to reduce and overcome the tragedy. A colleague, a scientist of great prominence, says, in a joking tone, that "science is infallible; scientists are the ones who fail." The fact is that we have failed, and we need to gather efforts to contribute to addressing food insecurity and hunger in the world. In this context, we align below some points that perhaps deserve our reflection on the role of science in this field.

- Food production has grown faster than population growth, increasing per capita global food availability, although there are large differences between regions in productive capacity and susceptibility to unfavorable climate events.
- It is verified that the greatest limitation lies in access to food by several segments of the population.

Holistic approach of hunger Science is compartmentalized by areas of knowledge, specific subjects, which translate into specialties whose efforts have increasingly been focused, dividing into subspecialties focused on increasingly specific areas. Despite the advancement of transdisciplinarity in the dynamics of applied research in many areas of science, specialization still prevails, leading to limited views of multidetermined problems, with the natural overvaluation of the areas of knowledge of the researchers involved. Recognition **that hunger is a problem with multiple causes, which can only be understood in fact by a more holistic approach, which includes multiple perspectives and aspects, different temporal horizons, different geographical areas and even the different views and meanings of the actors involved**, it has not been materialized in most scientific researchers on the subject, which are still marked by the traditional "departmentalization/ specialization" that characterizes scientific institutions, in particular, universities (Hughes, 1968; Fazenda, 2000; Lowe and Butryn, 2007). It is, therefore, current and relevant, the initiative of the Brazilian Academy of Sciences when proposing to address the topic of hunger in a multidisciplinary way. In this sense, the most effective fighting hunger begins with a deepening of the diagnosis of the problem, which goes beyond the superficial recognition that hunger is a phenomenon with multiple causes, and reveals how they operate in realities that differ radically, sometimes in the interior of the same country or city, as in Brazil, marked by strong regional inequalities, or in Brazilian cities, with rich neighborhoods, inhabited by families whose main health problem is associated with excess of food, neighbors to poor communities, marked by food insecurity and, in many cases, by hunger.

Approach and intervention scale: Better diagnoses are essential for the success of treatment . A second point we would like to raise is the result of the previous one, which places the need to understand food insecurity and hunger where they manifest themselves, together with the populations suffering it, which implies studies on different geographical and population scales. Hunger has already been analyzed as a result of the lack of food, a diagnosis overcome by evidence of growth in production/supply. **In the context of the recognition of complexity and multicausality, the emphasis shifted from supply to access to food.** And this diagnosis is well supported by analyzes and aggregated data, which in fact prove, scientifically, the extraordinary growth of food production, the result of increased productivity, the contribution of Science (Chilkoti, 2022). These diagnoses are always accompanied by the caveat that global averages hide large variations between countries and within countries, but not always the caveats lead to adjustments in diagnoses. The narrative continues to prevail that the problem is not of production/supply, but of access.

Is it really like that? Here, perhaps, fits the classical answer attributed to economists: It depends. And it depends mainly on the scale and temporal arc of the analysis. **For most countries of the world,** this diagnosis is false, **food production has not grown more than the population**, and the supply problem may be the most serious determinant of food insecurity; in others, the restriction of supply is associated with climatic events, with droughts and or floods that cause severe disruptions of productive capacity (FAO, 2022a). In such cases, the access problem can have its roots in the sphere of production and supply.

We want to call **for the need to overcome generalizing diagnoses, which may have their validity for some countries and periods but are not suitable for others. The problem is that general diagnoses tend to exert an excessive influence on the strategies adopted by international organizations and countries, leading to policies and actions that do not produce the expected impact.** This is an intervention that should not admit failures, since it is dealing with a problem – hunger— that reduces the humanity itself of the human being. **Science plays an important role on reducing errors and increasing the effectiveness of interventions to combat food insecurity and hunger.**

To overcome the wars of narratives that do not contribute to the confrontation of the problem. We are not among those who deceive themselves with the neutrality of science; nor do we think that science is the bearer of truth, or has the final word about

right and wrong in matters whose validation passes through appreciation and values about which science has very little, or nothing, to say (de Oliveira, 2008). But we think that **science has a relevant role in questioning current, sometimes dominant narratives that produce misguided diagnoses and policies that do not contribute to solving the problem**. This is not an easy question since the narratives are the result of the work of scientists; many have been valid in the past or for some specific situations but are not so for the present and much less for the whole population/situation. Moreover, many narratives that may have ceased to be true, continue to be widely propagated, with direct contribution or connivance of fellow scientists. They are taught in universities as if they were true, resistant to the time and transformations that mark the organization and life of society.

The delicacy of the point is that, although colleagues manifest themselves in scientific works of individual or collective authorship, the narratives, regardless of the validation of the validity, are disseminated as "scientific", as a manifestation of science in the eyes of the layman. An emblematic example of the "narrative war" is the role of family farming in food production. In late 1990, Carlos Guanziroli and Silvia Elizabeth Cardim coordinated a research, under FAO sponsorship, on Brazilian family agriculture (Guanziroli & Cardim, 2000). This pioneering study, based on the 1995/96 Agricultural Census, indicated that family farmers played a much more relevant role than was attributed to "small producers", as they were so far treated in the context of public policies and academic work. In some products, particularly in the basic items of the Brazilian food staples consumption, the participation of family agriculture in the total production – measured by the Gross Production Value (VBC), and not by physical production— was quite high: Cassava, 84%; beans, 67%; pigs, 58%; banana, 57%; milk cattle, 52%; maize, 49%; grape, 47%; poultry and eggs, 39%; rice and soybean, 31%; orange, 27%, and beef cattle, 23%. A high and surprising participation, to the point that the authors, enthusiastic about the result, entitled the work as "New portrait of family agriculture: Brazil rediscovered". They were even discovering a Brazil that was hidden by the dominant analysis of latifundium-minifundium or conservative modernization, which overshadowed the role of this player, represented by no less than **4,139,369 million households, 85.2% of the total recorded by the Agricultural Census of 1995/96**.

This discovery, politically reinterpreted in the context of legitimate disputes of social groups, gave rise to the narrative that family agriculture accounted for 70% of food

production in Brazil, contributing to a second narrative, that opposes family agriculture to agribusiness, the first food producer that guarantees the food security of the Brazilian and the second focused on commodity production to serve the foreign market. From so dominant, it becomes difficult for a professor to contest it; even if evidence is shown.

In 2014, Rodolfo Hoffmann, one of the most respected Brazilian statisticians, wrote a technical note to answer a simple question: "Does Brazilian agriculture produce 70% of the food consumed in Brazil?" The answer was adamant: **"the monetary value of all family farming production corresponds to less than 25% of the total expenditure of Brazilian families on food"**. The technical note details the entire methodological procedure adopted to reach the answer, from the participation of family farming production in the total produced, based on the Agricultural Census of 2006, to the use of the Family Budget Survey (**POF**), for 2008-2009. It ends the technical note with a personal statement:

"As the grandson of German immigrants who raised their children in Brazil on the basis of family farming, nothing more distant from the intentions of those who write than reducing the importance that the reader attaches to family farming. But the assertion that 'family farming produces 70% of the food consumed in Brazil' has no basis and, worse, it has no sense. The recognition of the importance of family farming in Brazil does not need fictitious data" (Hoffmann, 2014)

Hoffmann is right, the importance of family agriculture does not need fictitious data to affirm its importance since, as true data revealed by the 2017 Agricultural Census (IBGE, 2017) confirm beyond any doubt its utmost importance and its participation in the value of the production of several items that integrate the Brazilian consumption food staple remained expressive: cassava (70%), pineapple (67%), onion (58%), pumpkin (58%), watermelon (48%), black beans (42%), garlic (21%), wheat (18%), melon (15%), maze (12%), English potato (12%) and rice (11%).

We do not know any scientific work that has questioned the Technical Note, but we know several that have completely ignored it. The 70% statement continues to be published on *official* websites of public institutions, social movements and, worst of all, in scientific articles published in good scientific journals. The problem is that this false narrative does not contribute either to strengthening the role of family farming as a food producer, let alone to combat hunger and ensure food security in Brazil. Whatever the

intended goal to maintain the narrative, it is convenient to start with correct diagnoses, which are more likely to translate into more effective public policies and better results.

The role of science in this field is crucial to debate and clarify thorny issues, difficult precisely because they involve values that go beyond the possibility of scientific evaluation, involve legitimate political projects, visions of the future, and even desires, and try at least to order the discussion, based on possible evidence, that can lead to simple conclusions like Professor Hoffmann. Defending a thesis, a vision of the future, or a desire does not require fictitious data or distorting reality, much less covering it with unsubstantiated claims.

When it comes to food insecurity and hunger, it would be very convenient to reopen some debates, such as the effective role of Brazilian agribusiness, without the mystification of the "Agro is Pop" nor the criminalization of the "Agro of Evil", destroying the environment, *commodities* exporter, income concentrator and responsible for rural poverty; or the role of modern biotechnology in the expansion of agricultural production in Brazil, which may have had relevant impacts both on the Brazilian food supply and negative impacts on the environment. **The role of scientist and science is to ask relevant questions, and seek to answer it with the possible objectivity, and not contribute to propagate narratives that reflect more the scientist's desire for reality than reality itself.**

Role of public policies on food security and hunger combating. The analysis of the evolution of hunger in the world in the two decades of the 21st century reveals a disturbing cause that has affected hundreds of millions of people: political instability, civil conflicts and wars, which impact food production and distribution and have caused international migration movements on an unfounded scale (Chilkoti, 2022; FAO, 2022a).

No war or civil conflict is needed to affect the food security of lower-income families living in 'unsafe' food security situations, which are susceptible even to minor changes in the context in which they live in. **Economic crises**, which throw millions of families into unemployment, disoccupation and or unemployment, **produce situations of food insecurity and hunger that cannot be neglected, taken as conjunctural .** Brazil is a good example: it came out of the hunger map in 2014, but it was not long to return, as revealed by the Rede PENSSAN (2022). In fact, the data from IBGE food security research

and the studies of Rede PENSSAN show a sharp increase in food insecurity between 2013 and 2017-2018 and 2020, as a reflection of the crisis of the Brazilian economy from 2014, that raised the unemployment rate from 6.3% in the last quarter of 2013 to 13.9% in the first quarter of 2017.

Events such as the COVID-19 pandemic, which paralyzed a significant portion of economic activity, in Brazil and worldwide, caused even more severe and dramatic impacts on the living conditions of the population and threw millions of families into food insecurity and hunger. At the height of the pandemic, the unemployment rate in Brazil grew to 14.9%, representing more than 13 million unemployed people. Adding the disheartened and the underemployed, a contingent of almost 30 million people who had their capacity to access food by regular means reduced or entirely compromised (DIEESE, 2023b).

- Economic crises, which throw millions of families into unemployment, disoccupation, and or underemployment, lead to hunger situations, and policies to combat poverty, focusing on income, are fundamental.
- However, it is necessary to establish immediate intervention policies because hunger does not wait to cause irreversible pain and damage, especially in children, the elderly, and the vulnerable.
- Safe scientific methodologies can contribute to the monitoring of risk situations, pointing out the need and modality of intervention.

Conflicts, crises, events such as the pandemic, climate events, and natural tragedies reinforce the importance of public policies and the action of international organizations to face situations of this type, which disorganize the economy in general, production and access to food, generating food insecurity and hunger. The evidence indicates that it is not about designing policies to combat poverty, focusing on income, which is very important, but insufficient to deal with situations of food insecurity and hunger caused by disruptive events and or economic crises. Policies with immediate intervention capacity are needed because hunger does not wait to cause pain, discomfort, and irreversible damage, especially in children, the elderly, and the vulnerable.

The world's hunger situation in 2023 makes it clear that efforts, strategies, and policies to end hunger have not been so successful. The recognition that food insecurity and hunger are determined by many factors, of different natures, from poverty, and social inequality to wars, economic crises to the inefficiency of agri-food systems, inadequate

management of natural resources, climate change, and worsening of natural phenomena, as floods and severe droughts, it confirms the need to review strategies and policies for promoting food security and combating hunger, from the issue of food stocks with the aim of ensuring food security to that of public income transfer policies.

Science has a very important role in this area, whether contributing to the design of these policies, or to the monitoring of risk situations based on safe, effective, and accessible methodologies, which will point out the need and modality of intervention.

The sustainability of the food consumption pattern and food production to eliminate hunger. A relevant question, that has been asked worldwide, is whether it is possible and desirable to feed the world on the basis of the consumption pattern and the food systems that have been consolidated in high-income countries, and that tend to be copied-globalized as countries grow and develop (for example, EAT platform, 2023). Despite the cultural differences that characterize food, it is undeniable that poverty reduction/increase in income level is accompanied by changes in consumption habits that tend to reproduce dietary patterns associated with higher income groups. particularly the consumption of animal proteins and processed and ultra-processed foods. Science plays an important role in answering this question, taking into account that food plays an important cultural and symbolic role for people, communities, ethnic groups and nations, and the economic importance of the food production chain for different regions and countries.

The available evidence leaves no room for doubt: humanity feeds badly. In addition to and alongside hunger, many countries face the dual problem of malnutrition, which refers to deficiencies or excesses in nutrient intake, imbalance of essential nutrients, or impaired use of nutrients. The double burden of malnutrition consists of both malnutrition and overweight and obesity, as well as non-communicable diseases related to food. Obesity is increasing in all regions of the globe, from 12% to 13% between 2012 and 2016, the last year for which data are available (Roser *et al*., 2019; FAO, 2022a; WHO, 2022).

Diets around the world are far from healthy and have not improved over the past 30 years. The intake of fruits and vegetables is still about 50% lower than considered healthy and the intake of legumes and nuts is more than two-thirds below the recommended two servings per day. On the other hand, the consumption of red and processed meats

reached almost five times the recommended maximum of one serving per week, while the consumption of sugary drinks, which are not recommended in any quantity, continues to increase (GNR, 2022; WHO, 2022)

Despite some variation between regions, no region on the planet meets the recommendations for healthy diets. Low-income countries continue to have the lowest intake of essential health foods, such as fruits and vegetables, and the highest levels of low-weight, while high-income countries have the highest intake of foods with a high impact on health and the environment, including red meat, processed meat, and dairy products, and the highest levels of overweight and obesity. In Brazil, about 2% of children under five years old have a weight deficit, while 8% are overweight. In the context of malnutrition produced by food insecurity, the most vulnerable groups do not have access to a minimum of three meals a day, while groups that still have access to food consume ultra-processed and sugary foods. Between 2008 and 2017, consumption of ultra-processed foods increased, on average, 5.5% per year (Louzada *et al.*, 2023); more worrying is the information that more than 80% of people in the age group from 2 to 19 years old consume ultra-processed products.

The other dimension of the question refers to the compatibility between the production pattern and the production system and environmental sustainability, notably climate change. Is it possible, for example, to expand meat production to meet the growth of projected demand from current standards and, at the same time, to respect the restrictions placed by the imperative of containing the emissions of gases that threaten the planet? This same question could be asked for other prominent products in the production of food and products that integrate the dominant diets, such as soy and maze.

One of the roles of science is to continue contributing to the generation of innovations that contribute to raising the total productivity of the factors used in food production and, at the same time, reduce and eliminate negative environmental impacts. But this contribution may not be enough. The Lancet Commission study indicates the need for a major food transformation *(*The 21st-century great food transformation), **giving rise to an agri-food system capable of producing healthy food, enough to eliminate hunger and balance the dimensions of human, animal and environmental health** (Lucas & Horton, 2019). Eventual changes in production systems have costs and benefits, unevenly distributed. A country like Brazil, highly competitive and prepared to produce food, fiber

and bioenergy and meet a growing part of the world's demand, would be strongly affected by dietary changes that significantly reduce meat consumption, for example. It is a debate that needs to be done, involving more than one group of scientists and experts convened by an institution. Science and scientists need to produce more knowledge about this matter, but they also need to leave the laboratories and classrooms, take the stage and lead debates with society as militant scientists of a greater cause – eliminate hunger and preserve the planet.

Final Considerations

The reflection on the topic of food insecurity and hunger transcends the limits of science and is permeated with polemics associated with the political positioning of interlocutors, worldviews, and beliefs, involving solid and false evidence in contexts in which it has been increasingly difficult to separate from each other. The COVID-19 pandemic revealed both the importance of science, and the difficulty of scientists' communication with society, as well as the difficulties for the ordinary citizen to separate good from bad science, the serious doctor, who honors the oath of Hippocrates, the charlatan, the true scientist of the one who did not hesitate to align himself with obscurantism to enjoy a minute of glory. Unfortunately, science does not have a scientific methodology to address this type of situation, and the only recipe is to preserve the space for debate, in the expectation that in this case, the Gresham Law will not apply, according to which the bad currency expel the good from the market, and let false science be quickly unsolved by the true, and the bad scientists demoralized by the true ones.

It is evident that hunger is multidetermined and that diagnoses must be deepened on scales compatible with the formulation of policies that are more effective and effective. It seems to be that both hunger and health problems are related to the inefficiency of the food system. There are failures in the whole process of food production and consumption, starting with land use. Between the farm and the table, the world loses about a third of the food produced while they are stored, transported, processed, packaged, sold, and prepared. In the end, 1.3 billion tons of food is lost or wasted every year. It is not permissible to solve one problem and create another by stimulating the production of more food to waste it. It should be noted that this estimate does not include excess food consumption, responsible for the obesity epidemic, whose importance has been neglected.

There is no doubt that world food production has advanced significantly, based on innovations based on the development of science and technology. This progress has not been free from negative side effects. Some may have been necessary, others may have been avoided by a more effective intervention of science and scientists in the affairs of society. Evidence suggests the importance of public policies to encourage and enable sustainable food production and the consumption of healthy and nutritious foods, making diets healthier, less expensive, and more accessible to all. This is not by chance that the second goal of Sustainable Development proposed by the UN is to end hunger, achieve food security, improve nutrition, and promote sustainable agriculture. After all, ensuring that all people have access to quality food is essential for building a fairer and more balanced future for the planet and its inhabitants, which implies environmentally sustainable agriculture. These are challenges that a country like Brazil, considered as the 'strategic source of food for humanity' and the 'environmental power of the planet', needs to take seriously.

Brazil's return to the hunger map reveals that the country has not yet been able to effectively address the problem of poverty and inequality, which now needs to be equated along with the new challenges posed by climate change and society's demands for equality, equity, health, education and safety.

... an agri-food system capable of producing healthy food, enough to eliminate hunger and balance the dimensions of human, animal and environmental health (Lucas & Horton, 2019)

Chapter 13

How can bioeconomy in the Amazon contribute to the food security of native peoples and traditional communities?

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Introduction

Amazon biodiversity is recognized worldwide for its contribution to **socio-biodiversity** (Joly *et al.*, 2019). Indigenous peoples have inhabited the region for many centuries and contributed to **the domestication of plants and animals from the Amazon** prior to the European conquest (Clement *et al.*, 2015). The anthropogenic forest is associated with large human groupings, as shown by recent research that analyses the "black earth of the Indian" (Furquim *et al.*, 2023). It is estimated that there were 8 million people in the Amazon before 1492 and domestication included landscape and food, as well as agricultural cultivation (Posey, 1985; Clement *et al.*, 2015; Levis *et al.*, 2017).

Today, negative impacts directly and indirectly related to the exploitation of Amazon resources in mining, illegal logging and predatory livestock rearing are increasingly evident (Bebbington *et al.*, 2018). The forest conservation index was at 95% until 1970, when political issues led to forest devastation (Margulis, 2003). Many species and/or varieties of plants have been decimated and definitively lost as a result of these processes (Neves, 2022). Given this scenario, discussion about the interface between anthropology and bioeconomy is essential. This is the main focus of this text.

Native peoples as a source of learning. In their natural environment, traditional peoples have been guaranteed sufficient, safe, and nutritious food for their communities, necessary for a healthy and active life. With sustainable interaction with resources, they achieved food security throughout history and, today provide multiple lessons: phenological knowledge of local plants and animals respecting reproductive periods; a balanced and nutrient-rich diet with a diversity of foods, including fruits, vegetables, fish, and meat; and access to medicinal plants to treat diseases and infections (Neves, 2022).

The coexistence of native people with this exuberant nature produces **a biocultural connection** (Hill *et al.*, 2019), orally transmitted between generations. Over time, they have manipulated several forest organisms, mainly plants, aiming to increase productivity in specific regions or even improve palatability or food quality, such as pupunha (*Bactris gasipaes*), potato *(Solanum tuberosum)*, cassava *(Manihot esculenta*), among others (Clement *et al.*, 2015).

Bees hold an important role in socio-biodiversity, not only because they produce valuable sugary food, but also because of the divine and social traditions that govern societies that are often linked to them (Quezada-Euán *et al.*, 2018). In addition, the other products of their colonies were appreciated: the cerumen, a mixture of the bee wax and plant resin produced by the bees as build material in their nests, is used to waterproof baskets, fix ornaments and, when burned, purge evil spirits; propolis, resin collected in the trees, is used as food and as a medicinal resource (Posey & Camargo, 1985; Quezada-Euán *et al.*, 2018; Hill *et al.*, 2019).

Stingless bees for honey production. Photo: Ayrton Vollet Neto.

The diversity of communities of indigenous peoples in the Amazon is significant and is distributed throughout the different microregions of the biome (Cunha *et al.*, 2021). Each microregion has specific characteristics, and each community has unique cultures that produce a profusion of bioproducts. However, a range of challenges and factors have caused communities to **abandon bioproducts, thus reducing the autonomy, security, and food self-determination of traditional communities** (Santos, 2023).

Monocultures aimed at the export and trade of seeds and consumption via international chains of industrialized products and supermarkets are examples of the

reduction of food self-determination currently experienced by Amazonian social groups (Schor *et al.*, 2015; Schor *et al.*, 2021). The traditional diet, based on local resources has increasingly been replaced by the consumption of undiversified industrialised products.

Flour Production Photo: Project Tipitix / Ana Lu Rocha.

A study on the eating habits of the Xavante from the Etenhiritipaha village of the Pimentel Barbosa indigenous land in the state of Mato Grosso, Santos (2023) identified that there is a tendency to **abandon traditional hunter-gatherer** activities because of a range of external limiting factors including land demarcation, the traditionally active population becoming increasingly sedentary, the advance of the agricultural frontier, the decrease of fauna for hunting and wild species for gathering; access to new technologies and new markets; the disinterest of younger generations, among others. This change represents increasing danger, because there is increasing reliance on industrialized food, with a resulting increase in dependence on external resources, reducing the autonomy of the group and compromising its food security and sovereignty. In this sense, it is

essential to preserve all aspects of food culture that remain organized and present as a guarantee that the situation of transition and readjustment to the new context and reality does not become a situation of dependence on governmental institutions and aid, avoiding a process of acculturation (USP, 2023).

Therefore, access to food is not sufficient to ensure nutritional quality and recognition of food as an element of cultural identity, linked to the inhabited space and the cultural norms to which it is subjected (Campos & Campos, 2007; Schor *et al*., 2015). Food sovereignty, related to the self-determination of food production and consumption is linked to the culture and way of life of a particular social group based on the right to access resources and means for production or for the acquisition of food (Chonchol, 2005; Schor *et al*., 2015). Therefore, the focus on food security is an insufficient basis for the establishment of an inclusive bioeconomy in the Amazon.

Inclusive bioeconomy in the Amazon. To build a proposal focused on **inclusive bioeconomy,** it is essential to observe which productive chains are most important to the eating habits of different social groups, and which foods are traditionally managed and consumed, in order to strengthen their production. Regarding the potential for use in a bioeconomy with social objectives in the Amazon, the region is rich in natural resources, including plants, animals and microorganisms, which can be used in the production of food, medicine, cosmetics, etc.

The concept of bioeconomy in the Amazon is related to the respect and maintenance of interaction between Amazonian societies and nature and environmental conservation. It is driven by the emergency in the conservation of the planet's biotic and climate balance, with ecological restrictions becoming a priority over economic growth. Currently, the determining criteria for an inclusive bioeconomy in the Amazon can be grouped into the following sets of factors:

i) **To conserve and protect the natural resources** of the Amazon, which are fundamental to an inclusive and sustainable bioeconomy. The Amazon's natural resources are constituted by a geo-evolutionary process that contributes to the diverse geological layout of the region and includes extreme environmental conditions, but also adds an unparalleled biological diversity on the planet. This diversity provides the basis for an inclusive and sustainable bioeconomy.

ii) **To respect local communities**: traditional Amazon communities have intimate knowledge of the region and its natural resources. Respecting this knowledge and involving them in building an inclusive and sustainable economy is essential. The knowledge held by traditional communities should be recognized, added to contemporary knowledge and valued in the sharing of benefits.

iii) **To adopt appropriate technologies** to promote a bioeconomy that efficiently uses the biological resources of the Amazon, without causing damage to the environment or people's health. Development of technologies that can ameliorate or mitigate the main bottlenecks in value chains related to food production, from the Amazonian biodiversity has made slow progress. Importing technology did not produce initial success as expected; appropriate technology needs to be developed specifically.

iv) **To preserve cultural diversity**: the Amazon has a variety of ethnic groups, with their own languages, customs, beliefs and cultural practices. In addition to the native peoples, the region also houses non-indigenous populations, such as riverside communities, quilombolas, rubber tappers, fishermen and extractors of non-timber forestry products, among others, who have their own traditions, customs and lifestyles.

Decisive actions for an inclusive bioeconomy in the Amazon

Conserve and protect the natural resources of the Amazon. Unique geo-evolutionary processes have resulted in a wealth of natural resources that provide the basis for an inclusive and sustainable bioeconomy in the Amazon.

Respect local communities. The Amazon's traditional communities, including indigenous and non-indigenous populations, such as riverside communities, quilombolas, rubber tappers, fishermen, and extractors of forest products have intimate knowledge of the region and natural resources that must be respected, recognized and used in partnership for the construction of contemporary knowledge.

Adopt appropriate technologies. Appropriate technologies that solve or mitigate the main bottlenecks of value chains related to food production from Amazon biodiversity must be developed in a way that combines traditional knowledge and innovation.

Potential for Bioeconomy in the Amazon. The development of Amazon value chains requires measures that increase their potential and value local culture and the well-being of populations. **Fishing**, for example, relevant to food security, to local

and regional economies, **is hampered by a lack of technical assistance, lack of access to credit and infrastructure**, such as logistics and access to energy and storage and processing facilities. This leads to a significant loss of income for fishermen (Abramovay, 2022).

Community fisheries agreements are crucial in the shared management of lakes in order to maintain artisanal fishing. The use of **participatory methodologies such as citizen science** can make these agreements viable by incorporating knowledge of the local population. The pre-existing local chains are strengthened by **adopting innovation based on knowledge of nature**, which is a result of the interaction between local populations who have used forest resources for centuries, and the different actors involved in the process.

In this way, if we intend to develop sustainable value chains in the region, bioeconomy can help promote them through the processing and marketing of products, ensuring environmental sustainability and social equity. Such a stance may contribute to an increase in local communities' income and nutritional improvement.

Contributing to the reflection on sustainability and bioeconomy in the case of Pará, the economic evaluation of pollinators for the products of the Amazon forest was estimated to be one-third of the agricultural production of the state (Borges *et al.*, 2020). The major threats to the maintenance of pollinators and plants that serve as food are land use modification and climate change (Galetto *et al.*, 2022). Recent analyses using the premises of the Intergovernmental Panel on Climate Change (IPCC) indicate that planned changes will greatly impact food production and other benefits of nature for people (IPCC, 2022).

In tropical forests, pollination is necessary to maintain or increase diversity in about 90% of flowering plants (Ollerton *et al.*, 2011) and impacts the food chain in the Amazon (Paz *et al.*, 2021), where there are many edible plants. Among the 161 species evaluated, 54% depended on bees and 14% on beetles. Pollinators are essential for the production of açaí (*Euterpe oleracea*), Brazil nuts (*Bertholletia excelsa*), cocoa *(Theobroma cacao*), babassu *(Attalea speciosa*), guarana *(Paullinia cupana*), cupuaçu *(Theobroma grandiflorum*), bacuri *(Platonia insignis)*, buriti *(Mauritius flexuosa*), andiroba (*Carapa guianensis)*, copaiba (*Copaifera langsdorffii)*, among others. The environmental service

of pollination makes the fruits more perfect, larger in size, with a longer shelf life and of greater nutritional value. Therefore, biotic pollination is very important for human well-being (Potts *et al*., 2016).

The two main strands of bioeconomy in the present context, **production and extractivism, play an important role in social inclusion and in the reduction of hunger**. In the Amazon itself, original populations' interaction with the forest and rivers provides the amount of calories needed for a healthy living standard. This only starts to cause concern with the appearance of the effects of anthropic actions. Among the current anthropic actions in the Amazon, deforestation, mining, and climate change are the most significant (Meirelles, 2014; Meirelles, 2020). The question of gold mining, mainly with the use of mercury, has had an unprecedented impact on the forest-dwelling population (Vasconcellos *et al*., 2022). These actions and their effects impact food availability and quality. Sustainable technologies can help reduce such impacts.

It is also important to highlight the vast set of information that has been incorporated into the genome of organisms over the millions of years of the biome's formation. This information can contribute significantly to the reduction of hunger, such as the adaptation of fish to the extreme environmental conditions, such as hypoxia, acidic water, and high temperatures (Val & Almeida-Val, 1995).

The Amazon also has great potential for **renewable energy** production, from solar, wind, hydroelectric and biomass energy, such as the use of açaí pit, which can be used for the development of sustainable economic activities in the region. These are measures aimed at increasing the income and the availability of food for local communities, but they do not exhaust the possibilities.

Contribution of Science, Technology & Innovation. Science, technology and innovation can contribute to the development of sustainable processes, such as the use of biological resources in the Amazon. This happens in the production of food, bioproducts, biofuels, and building materials from renewable natural resources. **Research and innovation allow the development of new products and processes**, as well as contributing to the connectivity of biodiversity and ecosystems in the region. They also allow **a greater supply of regional foods**, as well as the improvement of the processes of social inclusion and income generation. Therefore, robust information

produced by science that generates sustainable technologies is of vital importance for the improvement of the quality of life and income generation of the forest-dwelling communities of the Amazon, in addition to contributing significantly to the reduction of global hunger.

Paying attention to land use, forest conservation and regional culture is vital to face new challenges such as climate change. Implementation of modern techniques of biology, agronomy, and forest engineering to select organisms that allow assisted and controlled production in increasingly hot and dry environments should be undertaken urgently. Many species of fish in the Amazon, for example, are already experiencing their upper thermal limits. This can result in the reorganization of fish populations, or even the disappearance of some species of commercial importance, imposing constraints also on the human populations of the Amazon.

Technical training may also contribute to the strengthening of local communities through **training and programs aimed at the sustainable management of the natural resources of the Amazon**. Environmental monitoring and control are necessary through remote sensing technologies, monitoring of air and water quality, among other measures. Promotion of the circular economy should also be encouraged.

Public policies and priorities for action: recommendations. Beneficiaries of all public policies and an effectively inclusive bioeconomy, native peoples have a decisive role to play in preserving the largest tropical forest on the planet. They are their most qualified guardians to keep it alive, a key condition of Brazil's environmental strategy presented to the world.

The priority should be to **stimulate and enhance regional agri-food networks**, capable of offering diversified products inserted in seasonal dynamics, consistent with reproductive periods and with sustainable management (Campos & Campos, 2007; Altieri, 2012). It is, therefore, necessary to "**move toward socially just, economically viable and environmentally healthy agriculture**" (Altieri, 2012). Therefore, Amazonian socio-economic products can nourish people and animals, preserving the environment and ensuring food safety and self-determination of various social groups.

The "Report of the University of São Paulo on Public Policies to Combat Food

Insecurity and Hunger" (USP, 2023), coordinated by Silvia Helena Galvão de Miranda and Marcelo Cândido da Silva is a central contribution to the literature for social needs worldwide. Among recommendations formulated in report, the essence of three priorities promoting food safety are highlighted:

i) **To encourage the valuing of agricultural practices of traditional communities in the management of biodiversity**, ensuring greater visibility to ongoing experiences, to replicate the most successful. These production niches have been considered by international specialist bodies as decisive for food security in the 21st century.

ii) **To educate for complete citizenship**, disseminating greater public awareness of the right of access to food security and the public policies that support it.

iii) **To implement extension programs** aimed at vocational training in federal universities and institutes, with emphasis on training technicians who guide good practices in family farming.

With reference to the contamination of water from mining (Cordani & Juliani, 2019; Andrade *et al.*, 2022), it is recommended:

i) To ensure **monitoring of mercury contamination** of fish and other aquatic products, as well as the analysis of the human risk of exposure to heavy metals from the handling and consumption of these foods.

ii) To develop **multidisciplinary research projects on the food chain** with a focus on health, including physicians addressing the effects of chronic and acute mercury exposure in addition to public health experts who analyze patterns of large populations and sociologists and anthropologists who study the impacts of the main source of that metal resulting from gold prospecting and extraction.

iii) To formulate future scenarios free of mercury exposure and support measures to **improve the sustainability of artisanal fisheries for food safety.** In the short term, to improve the information available as a result of fish quality audits.

iv) To use **the mechanisms provided for in** regional governmental organizations, such as

the Union of South American Nations (UNASUR) and the Organization of the Amazon Cooperation Treaty (ACTO), and non-governmental organizations such as the Inter-American Network of Academies of Sciences (IANAS) and the Inter Academy Partnership (IAP), to participate in this effort and expand its scope.

To enable priorities and recommendations, it is up to national and international funding agencies to promote the construction of robust knowledge on the issues mentioned above concerning the Amazon region and its diversity. It is necessary to focus on a framework that promotes **the establishment of qualified personnel and the development of local skills.** For this, it is **necessary to consolidate the institutions set up in the region, as well as new institutions to be** designed to make science, technology and innovation a means of promoting human well-being and nature conservation.

To conclude, biodiversity conservation is a condition for bioeconomy to fulfill its conceptual premises in the eradication of extreme poverty. The value chains derived from the efficient use of biological resources, with actions that generate food, energy, drugs and fruits, and fair remuneration to traditional communities – are one of the factors for the transition of the Amazon, as a whole, toward a sustainable economic model. We hope that the project of new environmental management in Brazil meets expectations and can hasten the arrival of a new era.

Priority actions
To promote food security
➢ To encourage the valuing of agricultural practices of traditional communities. ➢ To implement extension programs aimed at family farming. ➢ To protect local biodiversity, which maintains environmental services. ➢ To educate for complete citizenship.
To prevent water contamination
➢ To ensure monitoring of mercury contamination. ➢ To develop multidisciplinary research on the food chain. ➢ To improve the sustainability of artisanal fishing. ➢ To use the mechanisms provided for in regional organizations.
To consolidate the C, T & I system
➢ Construction of new knowledge. ➢ Training and retaining qualified personnel. ➢ Consolidation of the institutions installed in the region and design of new.

Chapter 14

In favor of food and climate security, sustainable action in the agricultural sector requires sharing knowledge, technology and innovation

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Food security was central to both the United Nations Climate Change Conference (COP 27), hosted by Egypt in 2022 – and the last edition of the World Economic Forum – which takes place annually in Davos. And not without reason. According to the report "The State of Food Security and Nutrition in the World", published by the UN in 2022, there are more than 820 million people in situations of nutritional vulnerability in the world (FAO, 2022c). And there is a strong intersection between hunger and climate since global warming has a significant impact on the global agricultural production system.

According to the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2023), a body also linked to the UN, **the costs for adaptation and residual damage to major agricultural crops will be around U$S 63 billion if the world remains within the Paris Agreement's goal of limiting global warming to 1.5ºC in this century**. **With heating rising to 3ºC, costs would reach up to U$S 128 billion.** In addition, **the population exposed to water stress, thermal stress, and desertification would range from 95 million to 1.29 billion people**.

Considering that agriculture, forestry, and other types of land use account for 23% of human greenhouse gas emissions (IPCC, 2019), we have an important challenge to reconcile a productive agricultural system that continues to meet the growing global demand for food – expected to increase by 50% in current levels by 2050 (WRI, 2019) – and, at the same time, develop sustainably. In this context, it is necessary, fundamental - I would even say mandatory - that we share knowledge, science, tools, technologies, and good practices to achieve shared goals for the benefit of the future of humanity.

Events such as COP 27 foster this sharing by promoting public debates, which are widely disseminated and unite social actors from different parts of the world so adding the diversity of realities and points of view necessary to finding local solutions that have a positive impact on a global scale. **But we must go further and promote this sharing among academia, companies and the third sector**.

It is worth noting the effort of 13 of the world's largest agricultural traders and processors, including Bunge, which, during COP 27, presented a roadmap for these companies to stop deforestation linked to commodities to contribute to limiting global warming to 1.5ºC.

Bearing in mind that deforestation is a major factor for greenhouse gas emissions, the coordinated action of these companies, which is being facilitated by the Tropical Forest Alliance and the WBCSD (WBCSD, World Business Council for Sustainable Development) (TFA, 2022) demonstrates that the sector has come to the understanding that we have in Bunge for many years: **positive, permanent impacts at scale are only achieved collectively**.

One of the many important points of this sector roadmap is the commitment of the companies to act in the transition to sustainable land use and in the management of *commodities* production, from **investing in initiatives to adopt best agricultural practices and support farmers' livelihoods, as well as accounting for land use-related emissions in their carbon inventories.**

In this regard, we must understand and consider the social and economic dimensions of the transformations toward agriculture of the future from the farmer's point of view. The investments in research, technology, and innovation must be considered, as well as changes in land use with the growing commitment to conserving native forests and biomes. **Agricultural production must be increasingly perceived as a highly sustainable, technological and digital industry, being remunerated as** such. Recent studies (WRI; Bain & Company, 2023) demonstrate that the likelihood of producers adopting sustainable practices increases as the economic return also grows.

Furthermore, agriculture has the potential to contribute to the energy transition, as the industry invests in innovation to produce biofuels - an alternative to fossil fuels, which are the main cause of the climate crises (IPCC, 2023).

It is worth noting that both events, COP 27 and the World Economic Forum, highlighted the need to evolve from the field of intentions to actually plan and act. Concrete initiatives to mitigate emissions, to adapt the production system to climate change, and for countries to joint forces and share knowledge to achieve these common goals are urgently needed.

Not by chance, climate change is increasingly present in corporate strategies, as pointed out by the *CxO Sustainability* Report 2023 study conducted by Deloitte consulting firm, which surveyed more than 2,000 high-ranking executives (Deloitte,

2023). Carried out in 24 countries, including Brazil, the survey reveals that the issue is among the priorities of organizations and is one of the top three main challenges of companies.

Among the interviewees, more than 60% say that the theme "will have a high or very high impact on their organization's strategy and operations in the next three years" (Deloitte, 2023), and 75% confirm that the company for which they work increased investments in sustainability - in Brazil this percentage reaches 85%. The survey also found that the vast majority of participants indicate that companies have been somehow impacted by climate change, and 82% claim to have been personally impacted by them. Such figures prove the urgent need to act in a planned, structured, and shared way.

The fact that all these movements and this mindset are aligned with Bunge's purpose - which is to connect farmers and consumers in a sustainable way and for the sake of food security - gives us confidence that we are on the right track, while also evidencing our responsibility to lead, foster, engage and influence the chain to operate to a high socio-environmental standard.

Our participation in the sectoral roadmap presented during COP 27 reinforces that we will not achieve satisfactory results by acting alone. We have to work together, increasingly close to producers, business partners, governments, and customers, acting as strategic allies to support them in fulfilling their sustainability commitments.

As a company with more than 200 years of history, we wish to perpetuate our legacy. This will only be possible through a clear commitment to sustainability, addressing climate change, and minimizing the business's impact on the planet. In parallel, we need to keep meeting the needs of consumers and communities, ensuring food and nutrition security for a growing population.

Faced with this challenging scenario, all Bunge's decisions are guided by the company's ESG (Environmental , Social , and Governance) guidelines, striving for sustainable growth of grain origination, our *core business*, from a social and environmental point of view. To this end, we have developed businesses, innovations, projects, programs and partnerships to conserve the environment while increasing productivity. It is crucial to produce more using less natural resources.

Given this situation, it is important to remember that Bunge was the first company in the sector to commit to eliminating deforestation throughout the value chain in 2025, in addition to maintaining strict socio-environmental protocols that are followed not only within the company but also by its partners. However, we know that it is not enough to "raise the bar" and impose a conduct. We understand that our role is to engage and instrumentalize the chain, offering tools, means, and knowledge so that everyone can reach the highest standard in ESG practices.

It was from this vision that , **the Sustainable Partnership Program** emerged. Conceived by Bunge and launched in 2021, the initiative was a response to the challenge of increasing indirect traceability – considering that we had already reached 100% of soy traceability in our direct supply chain in regions subject to deforestation in South America. Pioneer in the sector, the program supports grain resellers in the adoption of socio-environmental verification systems, traceability, and monitoring through the sharing of knowledge, methodologies, and tools, enabling them to improve the traceability of their suppliers and, consequently, market a product of proven sustainable origin.

The strategy proved to be correct, with significant take up by resellers and highly promising results: at the beginning of 2023, we announced the traceability of 80% of the soybeans acquired indirectly in areas at risk of deforestation in the Cerrado. In addition to the Sustainable Partnership Program being consolidated as an important instrument toward the company's goal of reaching deforestation-free chains, the initiative also made an important contribution to raising the sustainability and transparency standards of the indirect soy chain in Brazil, influencing the sector as a whole and promoting important systemic transformations.

Bunge's approach to climate issues is broad and takes in everything from the adoption of **Science-Based Targets** SBTi) to measure and reduce GHG (greenhouse gas) emissions, the acquisition of stake in strategic businesses in the value chain, such as grain resellers, and the development of new businesses, such as Origeo, *a joint venture* with UPL, which offers significant support for partner farmers as they develop the agriculture of the future by promoting technical training for the adoption of best agricultural practices and offering solutions, tools, technology, methodology, and inputs for an increasingly sustainable production combined with productivity and profitability

of the business. These choices were always made to improve ESG standards both from the Inside and outside the farm gates.

We understand that the economy of the future is low-carbon and agriculture must also follow this path. From the point of view of **food production, the best alternative is regenerative farming**. In this regard, and to increase our positive influence in the chain, Bunge promotes the engagement of farmers in the application and improvement of low-carbon agriculture, collaborating to realize the agri-environmental power that is Brazil, generating value for local communities, for society, and for the company.

We also participated in the **Low Carbon Soybean Project**, of the Brazilian Agricultural Research Corporation (Embrapa), which works to create a voluntary certification protocol conducted by an accredited third party with criteria and guidelines that parameterize the mitigation of greenhouse gas emissions in soybean based on science. Such an initiative will create possibilities for different business models to be established to differentiate and add value to soybean produced with the integrated use of sustainable practices and technologies that reduce global warming potential.

With a vision that goes far beyond the triad of certifying, tracking, and monitoring – fundamental to eliminating deforestation and decarbonizing our value chain – we have implemented a holistic, purposeful, cooperative, and aggregating approach to realize the purpose of connecting farmers, customers and consumers in a sustainable way - and for the sake of food security. This line of action demonstrates that Bunge has put its climate vision at the center of business decisions, from the way it operates through the investments it chooses to actions aimed at engaging the entire value chain in this front. We believe that companies that want to thrive and contribute to a world with food and climate security must follow this trajectory.

- There is a strong intersection of hunger and climate, as global warming has a high impact on the global agricultural production system.
- Concrete and long-term solutions can only be found with the participation of academia, companies, and the third sector.
- Business initiatives in the agricultural sector are already underway in the world and in Brazil, addressing projects to support farmers and accounting for greenhouse gas emissions related to land use and agricultural practices.

Chapter 15

Joint-responsibility, regenerative agriculture and productive inclusion: a fundamental triad to ensure food security in Brazil

Cláudia Buzzette de Calais

Bunge Foundation

Numbers are people. In any reflection one might make regarding the fight against hunger in Brazil and the world today – or about the roles that governments, civil societies, science or sectors of the economy, such as agriculture, must play to attain a certain objective – it is fundamental that we should remember that the numbers that we quote or cite represent people, millions of real people.

To state that 11.3% of the world's population faces severe food insecurity, as the United Nations did in the report "The State of Food and Nutrition Insecurity in the World" (SOFI) in June, 2023, is to say that around 892.7 million people are going hungry every day. Likewise, to indicate that the same problem has risen to above 9.9 % of Brazilian households is really saying that more than 21 million Brazilians are literally living without enough food to eat. Furthermore, if we widen our view and consider every level of food insecurity, from the lowest level – which, despite this terminology, actually means "insecurity related to access to food in the near future, or when the quality of such food has been compromised" – we need to recognize the fact that half of the country, some 70.3 million people have their capacity of meeting one of the most basic needs threatened - one of the most fundamental rights of human beings threatened. Yet, on the other side of the fence, we follow the reports of food production beating world records every year. Reaffirming the human beings behind such numbers not only serves to highlight the urgency of the matter, as exemplified by the exaltation from the renowned sociologist Herbert de Souza, that **those who are hungry, can't wait (***quem tem fome tem pressa***).** It further serves to remind us that, like everything else that involves people, the **fight against hunger is not just a mere question of calculations or just a case of balancing supply and demand for foodstuffs; neither that little can be solved with simple solutions.**

Food insecurity, as we know, has always been a problem in which there is a history of a range of socioeconomic, political, environmental, and cultural factors. Today, perhaps more than ever, when we refer to hunger, we are talking about a question that reflects regional inequality, racial inequality, and even gender inequality which still afflicts our country. Data from a 2021 study from Food for Justice indicated that food insecurity is more prevalent in households with just one responsible adult (66.3%), and even more accentuated when this responsible adult is a woman (73.8%) or has colored skin (67.8%) or is black (66.8%) (Motta, 2021). The study further identifies higher rates of hunger in rural areas, in which more than 75% of the population faces some degree of food insecurity, as opposed to those in urban areas (55,7%).

While climate change threatens the productive feasibility of regions of the planet and bellicose conflicts paralyze or seriously compromise the input chain, affecting the worldwide production of foodstuffs; in predominantly agricultural countries, like Brazil, the integrated vision of the countryside is urgent. **If there are no incentive programs that guarantee the production of basic food items that come in greater part from small producers and farming families, as well as the diffusion of know-how and new technologies to such farmers, the production and access to foodstuffs will become increasingly compromised**; not to mention the enormous and unacceptable indices of wastage of foodstuff pertaining to handling, storage, transport and commercialization which, just in Brazil, represents around 27 million tons of lost food every year, just in the journey from the farmer's field to the consumer's table (Mercado e Consumo, 2023). Multicausal challenges such as these, therefore, require solutions that come from various fields of knowledge and sectors of society. It is hardly a surprise that the acronym ESG (Environmental, Social, and Governance) has increasingly gained importance within companies, reflecting even in their business strategies for the coming years. **To combat climate change, to act with social responsibility and to pay attention to the corporate governance of companies is crucial** for us to be able to act towards reducing social inequalities and the economic abyss in contemporary society, with a consequent impact upon food insecurity.

In regards specifically to agricultural science and the agribusiness industry, we have known for a long time **that the role of the productive sector is far from simply just producing more.** Given its importance, **agribusiness has the potential to induce deep transformations around the world through actions that sow new ideas in society.** It is something that the Bunge Foundation has been doing for almost seven decades now. Created in 1955 as the social wing of Bunge companies in Brazil, the Bunge Foundation has always worked based on the belief that knowledge is a transformative power and that people are its vectors, the agents of the transformation of such knowledge. Based upon this conviction, the Foundation has spent more than half a century promoting projects that have provided incentives to science, the dissemination of knowledge, and sustainable practices. Currently, the Bunge Foundation is also going through a phase of working more closely aligned to the business chains of Bunge, prioritizing projects that, in the agricultural universe, are based upon the pillars of inclusive production and the promotion of the low-carbon economy, through concepts and practices of regenerative agriculture; two points that, not surprisingly, have an important relationship with the fight against hunger and the promotion of food security.

- The fight against food insecurity is a challenge that needs integrated science-based actions involving and between businesses, governments, and the Third Sector, with optics that cater to social requirements.
- Agribusiness has the potential to induce deep transformations around the world through actions that sow new ideas in society.
- This article shows, by means of a case study from the Bunge Foundation, how it is possible to work together in order to face the global challenge, bringing a perspective of complementary actions between agribusiness and farming families.

On the subject of productive inclusion, it is necessary to remember that, whilst large agricultural companies stock the world with commodities, animal feed and biofuels, **the small producers are, effectively, those responsible for the production of the majority of the food that reaches the table, breakfast, lunch and dinner**. In 2019, FAO launched the program called "Decade of the Family Farmer — 2019-2028". This happened due to the relevance that 80% of all the food in the world, in terms of value, comes from family properties; in Brazil, family properties represent almost 80% of the total rural establishments (Summit Agro, 2021), however, even with the significant share in production, they have difficulties to continue planting. Such are the difficulties that it is making it impossible for producers to make a living from their production, leading many to rent their lands to large landowners.

Nevertheless, despite how it might seem, the agribusiness and small rural properties that live off family farming, are not antagonic. On the contrary, preliminary results from the initiatives of the Bunge Foundation, such as the development of actions of social inclusion, professional capacitation, incentives for regional economic circuits, and the promotion of sustainable planting techniques, show that these two concepts can complement each other, with mutual benefits. In one of the Foundation's projects in Canarana (Mato Grosso), for example, the association of agricultural crops of soybean, cotton, and maize, among others, with family production of honey brought significant results. The partnership, which sought to generate employability and income for small regional producers, enabled not only the training of qualified labor but also further the commercialization of honey and the offer of an increasingly valuable environmental service for the large producers: the pollination by bees, which, according to Embrapa, increased the productivity of the soybean crop by up to 12%, apart from improving the planning of chemical applications, due to its being a bio-input.

The Bunge Foundation, Canarana (MT). Photo: The Bunge Foundation.

The women and youngsters of small rural properties surrounding the large properties are being trained in different courses, such as piloting drones and geo-referencing which, apart from better qualifying them for controlling production of their small properties, further qualify them as service lenders in the larger rural properties. Technical knowledge exchanged and multiplied in favor of greater and better production of foodstuffs in which agribusiness and family farming complement each other. Original native people (indigenous people) also make up part of this project because we understand that they are the great true guardians of the existing forest. In this sense, the indigenous people in the Caranana (MT) region are being trained and receiving equipment, such as drones, computers and tablets, to enable better territorial management and ensure the maintenance of the standing forest, monitoring possible points of deforestation and forest fires.

Another subject that we have invested a lot in is the discussion surrounding the regionalization of foodstuff. The diffusion of both information and knowledge among producers regarding local food, their season and importance within the local economy

has helped the development of new chains that, in consequence of this, have increased food production, inhibited food stocks running low and further helped control the sudden rises in prices. The result is the guarantee of access to regional foodstuff, providing food security.

In parallel to this, the Foundation has worked in order to provide access for family farmers to the necessary technologies so that they might implement processes of Low-Carbon Emission Agriculture (ABC - *Agricultura de Baixa Emissão de Carbono*) for soil, water and non-deforestation. By means of the dissemination of these concepts and regenerative-agriculture processes, we seek to support them in the development of techniques that can increase their production and, at the same time, combat climate change, which presents one of the largest threats to the production of foodstuffs itself. Thus, we shall be able to ensure both their dignity and permanence on the land, as well as guaranteeing the production of food for the Brazilian table.

Training in apiculture for small producers: Semêa Project of the Bunge Foundation, Canarana (MT).
Photo: The Bunge Foundation.

All the work of disseminating the concepts and practices in regenerative agriculture and carried out by a group of agricultural technicians that work in resale and serve the region, in the Municipal Secretariat for Agriculture EMPAER (Empresa Mato-grossense de Pesquisa, Assistência e Extensão Rural). These technicians were trained by researchers specialized in low carbon agriculture. They are responsible for passing on this knowledge and know-how to the small producers, as well as accompanying them in their crops and harvests. All this exemplifies the importance of the integration of the first, second and third sectors being directed by the academic world in the search for ever more sustainable production.

Currently, the actions developed by the Bunge Foundation are having an impact on the production of 53 small producers, spread across 11,084 hectares, and this model must now be replicated for other regions of the country. These initiatives, albeit good examples, are just a portion of everything that must and can be done in order for us to really ensure food security for people, regardless of gender, ethnicity or where they live.

Apart from continually improving in activities developed for agribusiness, efficient public policies and social projects implemented by the Third Sector, we further need a change in the mindset of every citizen in Brazilian society. It is simply not acceptable that our country, one of largest producers of foodstuffs in the world, has more than half its population, nearly 125 million people, living with some level of food insecurity. Neither is it acceptable that we continue to live without considering ourselves as being co-responsible and part of the problem of hunger; indeed, we are a fundamental piece of the puzzle towards resolving this question. **Our practices in the social field show that the partnership between Brazilian agribusiness, the family farmer and traditional peoples is both totally possible and complementary and that only together will we be able to ensure food security.**

“Our practices in the social field show that the partnership between Brazilian agribusiness, the family farmer and traditional peoples is both totally possible and complementary and that only together will we be able to ensure food security.

Knowing, educating and communicating are key parts of food and nutrition security

Chapter 16

Changes in the feeding behavior of Brazilians aiming at healthy and sustainable consumption

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Diet is a fundamental determinant of health and influences public health directly due to its impacts on nutrition and indirectly through its impacts on the environment. However, food is not limited to an act that satisfies biological needs: More than that, it **represents social and cultural values, wrapped in symbolic aspects that materialize tradition in the form of rites and taboos.** Access to food in modern society, predominantly urban, is determined by the socioeconomic structure, which mainly involves economic, social, agricultural, and agrarian policies. Thus, the food practices, established by the condition of social class, engender cultural and psychosocial determinants (Garcia, 2003).

Brazil, even within a context of economic, political, and social turmoil, has changed substantially in the last fifty years, causing important changes in the nutritional situation and food consumption, inserting itself, as a large part of modern societies, in the historical processes of nutritional, demographic and epidemiological transition. Accelerated urbanization, income, growth, labor market transformations and technological development have been powerful drivers of food demand and dietary changes.

Brazilian food consumption: from discovery to 21st century

The Brazilian nation, when discovered by Cabral, was inhabited, according to estimates, probably by about 3 million indigenous people, who had their resistance plate in cassava. Maze, also part of the menu, was the only cereal existing in Brazilian lands: popcorn is a Brazilian culinary contribution to the world. Other roots such as yam, sweet potato, and wild plants such as sawblade, palm, and caruru complemented frugal feeding. Game meat and fish also composed the menu, eaten raw or cooked in a rudimentary grill, without being eviscerated or cleaned. This cuisine did not excite the Portuguese, who brought, during the colonization, the first herds of dairy and beef cattle, starting homemade cheese production. Chicken also came in the squadron of the discoverers. During the colonization, sugarcane sugar, which gained importance in Brazil, was mixed with tropical fruits to make jams: pineapple, papaya, banana, and coconut.

The daily table in the colonial period was poor and saltless. There were no butchers, fairs or markets. Meat and salted fish were consumed and legumes were rare. The wealthiest Portuguese received much of their food from Portugal: wheat bread, olive oil, vinegar, wine, olives, preserved meat and nuts.

But, in addition to the mills, which made the national sweets flourish, the presence of black slaves brought great influence on national cuisine. They perfected indigenous and Portuguese dishes and introduced black beans from Africa. Cassava, especially cassava flour, was the basic food of that time. In the homes of all regions of the country there was the habit of at least one main daily meal, usually lunch. With the end of slavery, European immigrants came to the country, who introduced new modifications in the diet scenario, such as Italians, with legumes and homemade vegetable products, breads, and pasta.

Brazil had 47 million inhabitants after World War II, mostly living in the countryside. From there to here, the urbanization was intense. Today, 84% of inhabitants live in cities. A product of this urban *modus vivendi*, contemporary commensality is characterized by the scarcity of time for food preparation and consumption; by the presence of products generated with new techniques of conservation and preparation, which add time and work; by the wide range of food items; by moving meals from home to establishments that sell food – restaurants, snack bars, street vendors, bakeries, among others; by the increasing supply of transportable preparations and utensils; by the supply of products from various parts of the world; by the advertising arsenal associated with food; by the flexibilization of times to eat combined with food diversity; by the increasing individualization of food rituals.

Consumption and availability of food in Brazil

Because Brazil has invested in conducting surveys with great territorial scope, it is possible to analyze, from the set of information produced, the consumption or availability of food over the last decades.

The pioneering study was conducted between 1974 and 1975, the National Family Expense Study (**ENDEF**), with the aim of collecting relevant data on family budgets and food consumption. The Family Budget Survey (**POF**) followed, which has been carried out regularly in Brazilian metropolitan regions and through them, it has been possible to evaluate the secular trend of food availability in the country (Levy-Costa *et al*., 2005; IBGE, 2011). In POF 2008-2009, a module was introduced that evaluated the individual consumption of food, the National Food Survey (INA), with repeated measures, which allowed us to estimate the distribution of the usual intake of food and nutrients for the first time in Brazil. This module was reperformed on POF 2017-2018.

In the POF of 2017-2018, the highest consumption frequencies were observed for coffee (78.1%), rice (76.1%) and beans (60.0%), followed by salt bread (50.9%) and oils and fats (46.8%). Comparing the frequency of consumption according to sex, men presented lower frequencies of consumption of all vegetables, legumes, and fruits, with the exception of English potatoes, and women presented higher frequencies of consumption for cookies, cakes, sweets, milk and derivatives, coffee, and tea. The foods with the highest average daily consumption per capita were coffee (163.2 g/day), beans (142.2 g/day), rice (131.4 g/day), juices (124.5 g/day), and soft drinks (67.1 g/day).

Comparisons by income quarters showed that, for rice, cassava flour, maze, and maze-based preparations, green beans/black-eyed, pasta and pasta-based preparations, coffee, and poultry, the frequency of consumption was higher in the lower income quarter than in the higher income strata. For most fruits, vegetables, and legumes, there was an increase in consumption frequencies and *per capita* consumption values with income classes, reaching differences of up to eight times greater between the last quarter compared to the first quarter for the frequency of consumption of pineapple and papaya and up to ten times higher for the average consumption of cucumber and pineapple. The *per capita* consumption of negative markers of diet quality, such as consumption of sweets, pizzas, fried and baked savory and sandwiches, was also higher in the highest income category. An eight times higher consumption of green beans/black-eyed and almost five times higher of sausage was found in the smallest quarter compared to the highest quarter income category.

Standard of food consumption

In the individual food consumption modules, inserted in the Family Budget Research conducted in 2008-2009 and 2017-2018 by IBGE, there was the maintenance of dietary patterns in the Brazilian adult population. A traditional pattern is characterized by the consumption of rice, beans, and meats, a second by bread, oils, and fats, and a third by soft drinks, pizzas, and savory snacks. In none of the identified patterns, there was an important participation of fruits, legumes, and vegetables. There was also variation in adherence to standards according to sociodemographic characteristics and housing macro-region (Antunes *et al*., 2021).

The planetary diet

According to the United Nations Food and Agriculture Organization (FAO) and the World Health Organization (WHO), sustainable healthy diets are "**dietary patterns that promote all dimensions of the health and well-being of individuals; have low pressure and environmental impact; they are affordable, cheap, safe and equitable; and they are culturally acceptable**". They are most often defined as vegetable-based diets and described as a diet composed of a variety of fresh and minimally processed foods, sustainably produced vegetable fats, small amounts of minimally processed animal foods, tap water as a primary choice of drink and very little wasted food.

In 2019, the prestigious Lancet journal released a report called "EAT-Lancet on Healthy Diets of Sustainable Food Systems" (EAT, 2023), advocating the need for substantial changes in diet and sustainable food production, to meet the challenge of providing, for a growing global population, the need for substantial changes in diet and sustainable food production, to meet the challenge of providing a growing global population with the need for sustainable food. healthy diets from sustainable food systems, proposing a reference diet, simultaneously healthy for human and planetary health, called the **Planetary Health Diet** (PHD) (Willett *et al.*, 2019).

To verify adherence to the planetary health diet proposed by the EAT-Lancet, an indicator was developed, the Planetary Health Dietary Index - PHDI (Cacau *et al.*, 2021), which contains 16 components and provides a score ranging from zero to 150 points. Applied to the Brazilian population, using data from the individual module of the POF, it was verified that **the Brazilian population has low adherence to a healthy and sustainable food pattern**. The average score reached was 45.9 points, representing about 30% of the maximum score. Women, older age groups, and those with higher income have higher scores, although also low (Marchioni *et al.*, 2022).

Food Insecurity and Food Consumption

Food insecurity and hunger have always been a chronic problem in Brazil that has been worsening since 2018. The number of Brazilians living in food insecurity increased from 57 million to 116.8 million in December 2020, according to the Brazilian Network for

Research on Food and Nutrition Sovereignty and Security (Rede PENSSAN, 2021) of this total, 19 million go hungry and 43.3 million do not have access to the sufficient amount of food. That reveals the importance of reviewing public policies and carrying out their follow-up to make necessary corrections to make them effective for their goal: mitigate food insecurity and hunger (IBGE, 2020a). In 2021, there were already 125.2 million people in food insecurity, with more than 33 million in hunger situation (Rede PENSSAN, 2022).

Brazil has investigated food insecurity through national surveys. The last edition of the POF conducted by IBGE included **EBIA** (Brazilian Food Insecurity Scale). In 2017-2018, POF estimated a total of 68.9 million permanent private households in Brazil. Among these, 63.3% were in a situation of food security (**FS**) while 36.7% of the remaining private households had some degree of food insecurity **(FI**). In this period, the proportion of households in mild FI was 24.0%, with 8.1% of private households in moderate FI and 4.6% in severe FI. Considering the level of severe FI as the most severe form of low household access to food, it is possible to affirm, based on the results of POF 2017-2018, that about 3.1 million households underwent quantitative food deprivation, which reached not only adult members of the family but also their children and adolescents (IBGE, 2020a). There was, therefore, a rupture in feeding patterns in these households and hunger was present among them at least at some moments in the three-month reference period. This research carried out in a period prior to the pandemic, already showed the country back to the map of hunger.

To analyze food consumption, the foods mentioned in the individual consumption module were grouped into 20 groups. It was established that meat consumption is lower by individuals classified with severe IA. This identified difference was also observed in the consumption of cereals and fruits, that is, lower consumption of these food groups. Regarding the consumption of legumes, a higher consumption was identified by individuals with severe AI compared to those with food safety. For legumes and vegetables, although slightly higher consumption was observed in individuals with food insecurity, it is noteworthy that consumption is low in both groups, around 10 to 12 grams and 18 and 22 grams (respectively, food insecurity and food safety). Also, for roots/tubers, snacks (pizza/savory/sandwiches) were observed higher consumption in the group with food insecurity.

Final considerations

Brazilian dietary patterns have been modified and moved away from its traditional culture. There has been an increase in the consumption of ultra-processed foods, while foods known to be connected to good health are scarcely consumed by most of the population. Considering the fundamental role of nutrition for health, and the need to ensure the human right to adequate food and the guarantee of food and nutrition safety with healthy and sustainable diets, it is essential that efforts be directed toward the implementation, continuity or improvement of public policies aimed at a fair and sustainable food system and support food justice.

- In addition to a high percentage of the population being in situations of food insecurity, Brazilians have different dietary patterns according to income class.
- In general, there is low consumption of fruits, vegetables and legumes and low adherence to a healthy and sustainable food standard.
- Efforts need to be directed toward the implementation, continuity, or improvement of public policies aimed at a fair and sustainable food system and support food justice.

... "dietary patterns that promote all dimensions of the health and well-being of individuals; have low pressure and environmental impact; they are affordable, cheap, safe and equitable; and they are culturally acceptable"

Chapter 17

Connecting education and food amid the COVID-19 crisis

Claudia Costin

I write this article based on a reflection resulting from an individual mentoring experience provided to dozens of state and municipal education secretaries during the multifaceted crisis generated by COVID-19. In fact, it was a simultaneously sanitary, economic, and educational crisis, amid an almost absolute absence of federal response to the challenges that were lived in each state and municipality. To better share my personal learning that occurred in this period, I chose to write it with the configuration of more than one testimony of what was lived and not of an academic text. So, I deleted footnotes or bibliographical references and tried to clearly point out what I could perceive, experience, or design.

The COVID-19 crisis revealed some important facets of Brazilian education that were less visible to an important part of the population, among them **the profound educational inequalities that exist** (which are not restricted to differences between students from public and private schools) which eventually deepened further with the pandemic, given the differences in **access to connectivity, equipment and books or the presence of adults who could support the learning at home of children and young people**. But if there is something that has become even clearer with the social isolation resulting from COVID-19, it is that with hunger, **it is very difficult to learn**.

It was a time when the economic slowdown removed income from families and brought serious food insecurity to children and young people, in a country that had just left the hunger map. What happened, however, and that perhaps has not been so evident to those who do not closely monitor education: The prolonged closure of schools has deactivated one of the best food security mechanisms created in the period of president Getúlio Vargas and progressively improved **school meals**. **About 35.3 million students make a free meal every day at school**. With schools closed, families had to provide additional food for them for almost two whole years. Some educational networks started sending boxes with groceries to the students' residences, but there were few who did so and food insecurity remained.

The reduction of transfers of resources from the federal government to school meals, in the resumption of classes after the most critical moment of the pandemic, made it difficult to quickly resolve the problem. It was only in 2023, after the beginning of the new federal administration, that the problem was equated, with an increase in the funds passed on to the states and municipalities for school feeding. Interestingly, some countries

were more aware of the risk and kept school canteens open even before vaccination, especially for the most vulnerable. We didn't do it in Brazil, which was really sad!

The link between education and food, however, is not limited to the supply of school meals, so important, especially now that many public networks have started to offer full-time high school in many of the schools. **It includes learning the elements necessary for a healthy diet**. Given the lack of information on food in some families, the fact that the National Common Curriculum Base and the subnational curriculum references **include health, self-care, and nutrition** in elementary and high school makes a lot of sense, and not only for vulnerable families. Bad habits in daily eating affect different social classes and learning in school can have an effect not only on the student but, from it, on future generations. In addition, **educating for health** helps in learning other contents, since sickle cell anemia, among other morbidities, brings serious damage to the cognitive process. But interventions in this sense, when done in early childhood, educating parents and guardians of the child and providing in kindergartens and preschools food suitable for the age group, under the supervision of prepared nutritionists, have a greater impact, given that brain development happens with greater speed at this stage. It also makes sense to avoid entry into daycare before six months, to ensure exclusive breastfeeding and the formation of affective bonds until this age. More solid educational systems in the world propose that the institutionalization of young children does not occur before the age of two for similar reasons. After all, breastfeeding being no longer exclusive, it is recommended, however, to be complementary until this age. To this end, it occurs in many more advanced countries in their demographic transition, the approval of a longer maternity leave. Right here in Brazil, the municipality of Boa Vista, considered a reference in early childhood, accepts the children only after they complete their second birthday in daycare, with priority for the most vulnerable and reinforces the programs linked to support babies and small children with home visits of community health agents and social workers. After all, the daycare effect is more important from the age of two. The same occurs in Salvador and some other cities in Brazil.

But food challenges become even greater in adolescence. It is important, in this sense, that, from the final years of elementary school, the contents related to **Health, Food, and Self-Care, in the classes of Sciences or Biology**, be reinforced. It is also good to involve young people in activities aimed at student agency or protagonism, in the dissemination of good eating habits among their families and, in particular, their younger siblings.

It is necessary to educate for a healthy diet. Photo: Carrão-Panizzi, Mercedes Concórdia. Embrapa Trigo. Source: Embrapa Archives.

I do not believe that schools alone can solve the food problems of children and young people. It is, however, one of the most important elements in an ecosystem that helps promote the healthy development of students and, through them, that of future generations. For this, **good intersectoral public policies are necessary, not only in relation to the provision of income and the teaching and earning process itself.**

The law of 2009 (11.947/09) helps promote more adequate food and supports small farmers in the community when determining that **at least 30% of the resources received from the federal government for school meals are used by states and municipalities in the purchase of food from family agriculture**. It was not easy, initially, for many municipalities, to implement the law. But the advances made with it are undeniable. The law also reinforces the importance of relying on nutritionists in the manufacture of menus that guarantee healthy food, but unfortunately, often, given some logistical problems, the constant lack of water or gas for cooking makes them limited, in emergencies, to sweet juices and cookies

Another common problem is the existence of canteens that sell food, even in public schools, bringing, in addition to the feeling of exclusion on the part of those who cannot buy any desired foods, an offer of unhealthy products. In this sense, it is worth avoiding the existence of these spaces or, if necessary, being more selective in relation to the foods offered there, always in dialogue with the students and their families.

In the two whole school years of total or partial closure – in a system of student rotation – of school buildings, one issue always turned to mind: the idea **that education does not mean the mere transmission of content to be assimilated by the students, but the integral development of the students**. To imagine that what happened was limited to the immense learning losses is not to understand that **schools fulfill a much broader social function, that of educating the whole child** . **This includes socialization, in other words, learning to live peacefully, and health and nutrition for a healthy development of body and spirit**. It also involves **the possibility for students to feel builders of their futures** – that of each one of them and of the planet. Without this, there is no possibility of relying on a more harmonious and just society.

In addition to the profound educational inequalities revealed by COVID-19, there was a strong impact on food security for children and young people because about 35.3 million students depend on school meals on a daily basis due to their families´ limited income. But the link between education and food is not restricted to income; it is necessary to educate for health, with learning about health, self-care, and nutrition, toward the construction of a new generation.

... good intersectoral public policies are necessary, not only in relation to the provision of income and the teaching and earning process itself.

Chapter 18

Communication science-society and its relationship with hunger, food insecurity, and misinformation

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Communication in the context of the digital age society

The transition from the 20th century to the 21st century was marked by intense and rapid social, cultural, political, and economic changes. The dilution of borders, made possible by new communication and information technologies, has dramatically intensified the interaction between the various social players that make up the public of interest of public institutions and organizations, forcing them to rethink their institutional positions and the paradigms of management and relationships. These are, daily, provoked to act under the new dictates of the demands of the digitalized society and the circulation of information on social networks. It is an indisputable reality the power that communication, for its most varied aspects and typologies, as well as by traditional mass media and by the social media of the digital age, has in society.

Manuel Castells questions "why, how, and who builds and exercises power relations through the management of communication processes and how social actors who seek social transformation can modify these relationships by influencing the collective mind" (Castells, 2009). Communication, therefore, exerts power in the processes and in the exercise of interactions and negotiations by the actors involved in the most diverse applications in the context of public and private spheres. In this sense, it is reiterated that communication should be considered as a basic social process and as a phenomenon, seeing the power that it and the media exert in contemporary society and, consequently, in the context of public institutions and organizations.

The challenges of the digital age and disinformation

In the digital age, citizens are bombarded by an excess of unreliable information through free and real-time access to the Internet and any electronic device. This contaminates the formation of a public opinion based on true bases. The great challenge for the players involved, especially in the communication sciences, is to defend freedom of expression and, at the same time, to create possible mechanisms for citizens to establish the differences between a reliable source of information and an unreliable source.

Citizenship is bombarded by the excess of unreliable information that contaminates the formation of a public opinion based on real bases.

In the specific case of health, we have found harmful circulations against vaccines worldwide and, particularly, in Brazil, where they have had serious consequences on a population that already had a culture of ingrained vaccination. Such a situation triggered new attitudes in a part of the population, which eventually stopped taking children to health posts to vaccinate. Another case was the disclosure of chloroquine as a cure for COVID-19 without scientific proof in the middle of the pandemic, thus opposing the benefits and effectiveness of the vaccine resulting from numerous scientific ventures moved by researchers in laboratories of universities and research centers.

Science and scientists have a mission to accomplish to deconstruct information of this nature that damages people and society as a whole. In relation to food and hunger, there is also erroneous information that seeks to misrepresent objective data of national and international organizations with wide legitimacy. Provoking obscurity in the minds and perceptions of people about true facts is a common practice of ideological and political groups that seek to make their interests and their pretensions prevail to manipulate public opinion.

In relation to food and hunger there are also erroneous information that seeks to misrepresent objective data from international national organizations with broad legitimacy.

Assigning *fake news* a widespread burden to all false narratives circulating on the internet is a reductionist way to face the problem. In fact, they are matters manufactured with intentionalities and without social responsibility, whose contents are, in fact, an influencing and manipulative power of purposeful "misinformation", with enormous commercial and ideological interests behind the scenes that need to be unveiled by public authorities and society. It is an industry that produces harmful content in relation to gender differences, ethnic groups, threats of violence in schools, etc, which mainly affect children, adolescents, and citizens less aware and inattentive.

One of the biggest challenges in an information-dominated society, especially by the power of platforms of the giant big five ecosystems, Amazon, Apple, Meta (Facebook,

Instagram, WhatsApp, Google), and Microsoft, which dominate the technology and information sector, is the fighting misinformation, fake news, the advancement of Artificial Intelligence, such as ChatGPT and Vhatbot, and their risks to humanity.

There is an urgent need for regulation on the part of the countries to hold technology big five and communication platforms accountable, such as Alphabet, Meta, TikTok/ByteDance, Twitter, Telegram, and Brasil Paralelo, among others that hold the power of information; the funders; and the producers of false disinformation content that so badly harm society, especially the most vulnerable social segments. In the case of Brazil, the Bill of Law (PL) 2630/2020, which has been in progress in the National Congress since 2020 and today is in full discussion in the Federal Chamber and in various social, political, and economic segments, aims to institute the Brazilian Law of Freedom, responsibility and transparency on the Internet.

Public communication as a strategic factor in the dissemination of science to combat food insecurity and hunger

The field of communication has much to contribute to issues related to food in its most diverse aspects. It is a complex thematic scope that involves a set of social, cultural, political, and economic factors, as well as the human right to adequate food for the entire population of any country or nation. The focus here, with emphasis on public communication, will be restricted to the problematic situation of food insecurity and hunger experienced in Brazil, both in the past and in the present, which requires an integrated action with the other areas of knowledge in an interdisciplinary perspective.

The science produced in various fields of knowledge dealing with these issues needs to reach the population, with a view to their health and the improvement of their quality of life, and the decision-making bodies of public policies in this direction. The practice of strategic and effective public communication is one viable way.

It is believed that public communication has not been strategically used by the public authorities/governments (federal, state, and municipal), with defined policies and integrated actions planned and effective communication, to raise awareness of society regarding health care, malnutrition, food insecurity and the problem of hunger. It is

verified the existence of sporadic campaigns, punctual actions, news published in the media and media products without consistency and longer-lasting permanence.

Public communication is a complex concept, which allows the extraction of multiple theoretical approaches and reflections on its practice in the different perspectives of the communication field. It implies several aspects and meanings, and one can understand it, basically, according to these conceptions: state communication; communication of organized civil society that acts in the public sphere in defense of the community; institutional/governmental communication of the public agencies, for the promotion of image, services and achievements of the government; political communication, focusing more on political parties and elections; and public communication in the social dimension and in defense of matters of public interest made by organizations (Kunsch, 2011; Kunsch, 2013).

> The science produced in various fields of knowledge, dealing with these issues, needs to reach the population, with a view to their health and the improvement of the quality of life.

The effective practice of communication in the three segments – State, private initiative, and organized civil society – will depend, without exception, on an integrated organizational communication work that is configured in the communicative modalities (administrative, internal, institutional, and market) (Kunsch, 2003), synergistically involving the subareas of communication, such as public relations, journalism, advertising and advertising, multimedia, audiovisual communication, digital communication, among others. If strategically applied, integrated organizational communication can help mitigate the problem of hunger and guide the most needy population, through concrete actions on information regarding the adoption of healthy eating habits, the cultivation of food, and the construction of community gardens, among other measures, as well as raising awareness of access to healthy eating as a human right for all.

It is up to the three branches of the Republic and to specific national and international entities or bodies, related to the issues of agriculture, health, food, food, and nutrition, to develop effective public communication that takes into account the public interest, well-being, and the quality of life of the population. Food companies, as well as agribusiness, also have their share of responsibility to contribute in this direction.

It is not enough to produce alone, it is necessary to have a public commitment to food systems and society.

To enable such initiatives, it is necessary to have specific sectors of communication in organizational structures, counting on specialized professionals. Based on structuring bases, the responsible sector must establish a communication policy and open channels of communication with the public, public opinion, and the various players involved in the society, to organize the sources of information, to "listen" to the population taking into account social demands, to be aware that hunger is a problem for all of us. They are guiding premises for constructive and effective communicative actions.

The problem of food insecurity and hunger in Brazil is part of human, social, political, and economic nature. Because it is an issue that affects the public interest, it is believed that public communication, governed by the force of multiple players, is introduced as a strategic proposal and should be integrated into the debates and central actions of society in the current scenario of the country.

Scientific dissemination as a public commitment

Scientific research and new knowledge generated in universities and specialized research centers related to the issue of food, food insecurity, malnutrition, and fighting hunger, need to be more democratized and contribute to social transformations. Undertaking systematic and permanent scientific dissemination presupposes political decisions and structuring bases, with teams of professionals trained in the dissemination, dissemination, and popularization of science and technology.

The implementation of public policies to combat hunger and food insecurity cannot do without effective scientific communication, which includes dissemination, dissemination and dissemination by public authorities and other sectors involved. As it is already known, scientific dissemination is understood as a broad set of all resources and processes used to convey scientific and technological information, involving dissemination, dissemination. and even scientific journalism itself. The dissemination reaches a more restricted universe or a certain segment of a selected audience that knows the subject. It is the exchange of scientific information between peers/experts. Whereas

the scientific dissemination/popularization of science is the use of resources, techniques, and processes to transmit scientific and technological information in a language accessible to the general public, in different media, such as the large press, social media, and through the production of alternative media such as, among others, booklets, guides, manuals.

The public communication of science in universities and research institutes/centers is a strategic factor for the dissemination of new knowledge generated for social transformations. Two main models are present in this communication: unidirectional and dialogical.

The unidirectional privileges the sources and scientists as the holders of knowledge, not considering the knowledge of other players. It acts in a very linear perspective to inform and disseminate to agents who consider themselves unprepared scientifically and who do not have much to contribute.

The dialogical model acts in another perspective. It aims to value the local knowledge of communities and interact with the stakeholders, including the marginalized and forgotten ones. It promotes public participation in science and technology affairs and the formation of public policies through forums, debates, conferences and interactive programs. Science is seen as an integral part of society and is encouraged to develop a scientific culture in the various social segments. The dialogical model contributes to social inclusion because there is a permanent concern in the sense of listening to the demands and needs of the population.

The dialogical model of communication contributes to social inclusion because there is a permanent concern for listening to the demands and needs of the population.

Despite the scientific efforts that have been made in the world to reduce social exclusion, this is a crucial problem we face and for which we have to fight, through public communication of science. In May 2014, the 13th International Conference on Public Communication of Science and Technology (PCST, 2014) took place in Salvador (BA), which brought together researchers and professionals from 49 countries, with 507 participants, to discuss exactly social inclusion and political engagement with scientific dissemination.

The communication sector of the university and other scientific centers can contribute to the diffusion of science and technology, valuing and incorporating the true meaning and meaning of public communication of science. To do so, it is necessary to make the communication consultants more strategic, dynamic, and productive; professionalize the sector responsible for the dissemination of science; establish appropriate policies and strategies of communication; provide accountability to society; and contribute to the achievement of research institutions and cultivate the culture and human values of pluralism, universalism, solidarity, ethics, and excellence.

When I conducted my doctoral research in the late 1980s, and in 1992, I published the book University and Communication in Building Society (Kunsch, 1992) argued that the university has in its organizational structure an integrated communication that also includes a Center for Scientific Communication. This center must exist to act in the diffusion, dissemination, and dissemination, as an irradiator pole and capable of developing/executing new projects aimed at expanding the interaction with society through the promotion of greater visibility for the scientific, technological, and cultural production of the university. I would add today that this center is governed by a public communication of science and that it is practiced in a dialogical and inclusive way.

Final considerations

The field of communication sciences is broad and can contribute greatly to mediation between science and society. I emphasized in this article the importance of public communication to be produced by segments of the first, second, and third sectors to mitigate the problem of hunger and food insecurity that plagues the country. It is a joint and partnership work that cannot be done without a strategic communication plan with clear guidelines to implement public policies for changes in social realities affected at local, national, regional, and international levels. The adoption of the advocacy practice, through joint strategic actions to influence decision-makers, may be a promising initiative in the changes of the current *status quo* in Brazil.

It is emphasized that public communication produced by segments of the three sectors of society is important to mitigate the problem of hunger and food insecurity that plagues the country.

The proposition of strategies and actions for public communication presupposes the existence of a global communication policy, the use of research and audits, strategic planning, and, above all, the practice of integrated organizational communication, which effectively and efficiently capitalizes the synergy of the different subareas of the communication sciences.

Hunger and food insecurity affect needy populations around the world, and our initiatives and proposals for solutions must be combined with the United Nations (UN) Agenda 2030 and the Sustainable Development Goals (SDGs), particularly Objective 2: "**Hunger – End hunger, achieve food security, improve nutrition and promote sustainable agriculture." That is what we strongly desire.**

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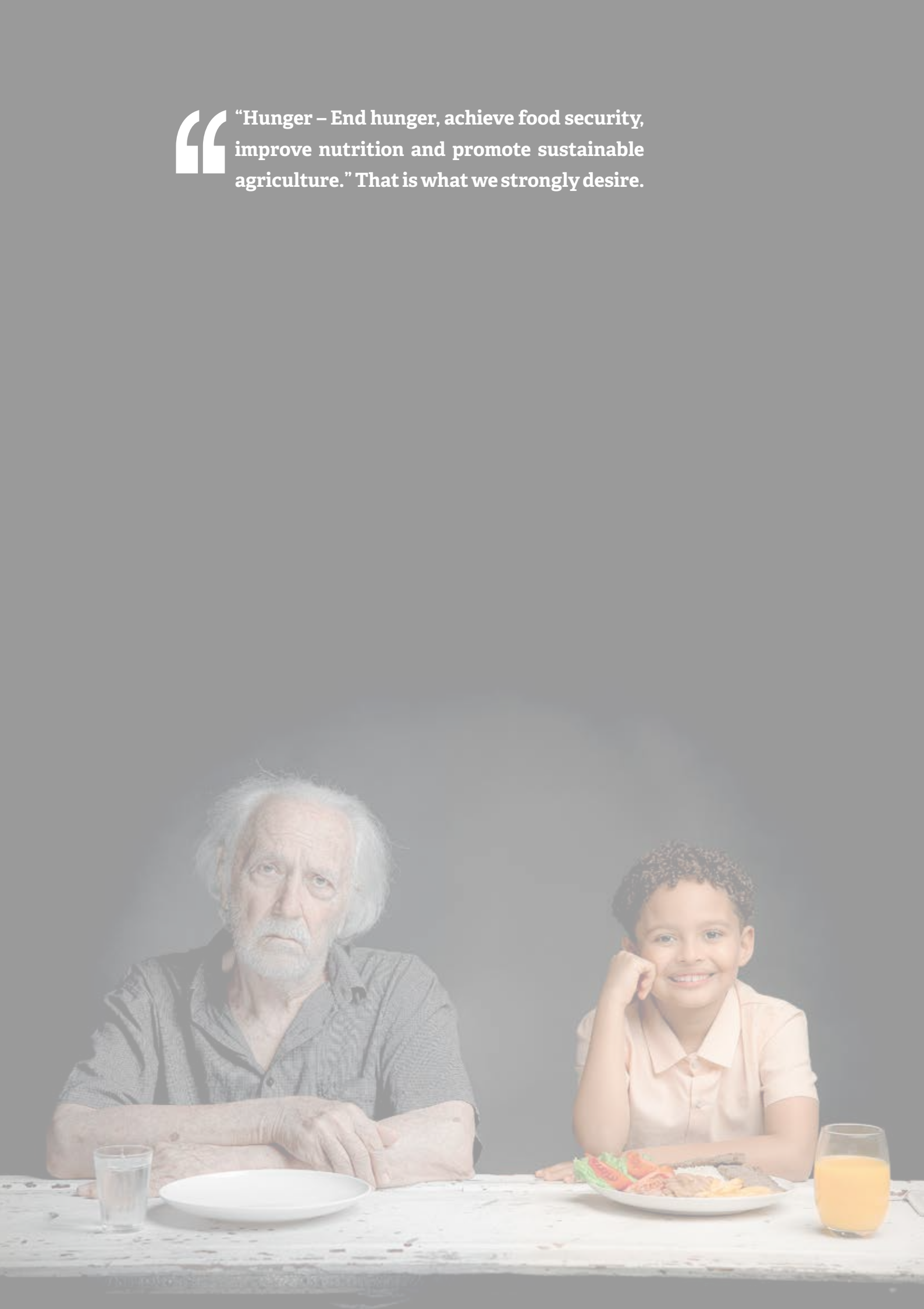

Capítulo

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Final reflections

Each text presented here addressed, in a plural and diverse way, different aspects of science, all fundamental to the fight against hunger in Brazil. There are reports of episodes of success and failure in the past, whose discussion is important, because knowledge is built from carefully analyzed mistakes and achievements errors that must be analyzed in the light of science. A comprehensive current diagnosis of the hunger situation in Brazil is presented, including social, economic, nutritional, health information, current public policies, and the participation of the private and the third sectors.

The texts leave no room for doubt about the impact that science has had on food production, toppling the Malthusian theory, as well as for the progress of society as a whole. But hunger persists and the texts point to the great challenges we face in guaranteeing our national sovereignty in food. Proposals for each branch of science are presented, starting with food production, particularly in the face of climate change and the demands for sustainable production. It is evident that having food on the table is no longer enough, it is necessary to know how to eat. In this way, it is crucial to enable the population to access nutritionally healthy foods and to understand how healthy eating should be. Only through educating new generations in the context of healthy eating we will achieve the desired food and nutrition security.

It is up to science to develop tools and apply them to population, social, and economic diagnostics. These diagnostics should cover all levels of the population, providing increasingly specific and regionalized information down to community levels. This will enable the establishment of appropriate public policies for the nourishment of Brazilians. Our cover reflects the hope of replacing a suffered past with a healthy, abundant, and diverse future in terms of diet.

A new era of science is presenting itself to society, with possibilities unimaginable a few decades ago. However, investments are needed to elevate Brazilian science to the level of the most developed countries, a status that Brazil aspires to and has the potential to achieve. It is necessary to communicate to society the importance of science and to publicize the returns on research investments, fostering the engagement of all. A new participatory society in science will be the solution to problems such as hunger.

The Brazilian Academy of Sciences hopes that the texts presented here can guide investments in science, technology, and innovation, as well as the discussion and formulation of public policies towards national sovereignty in the food and nutrition security of all Brazilians.

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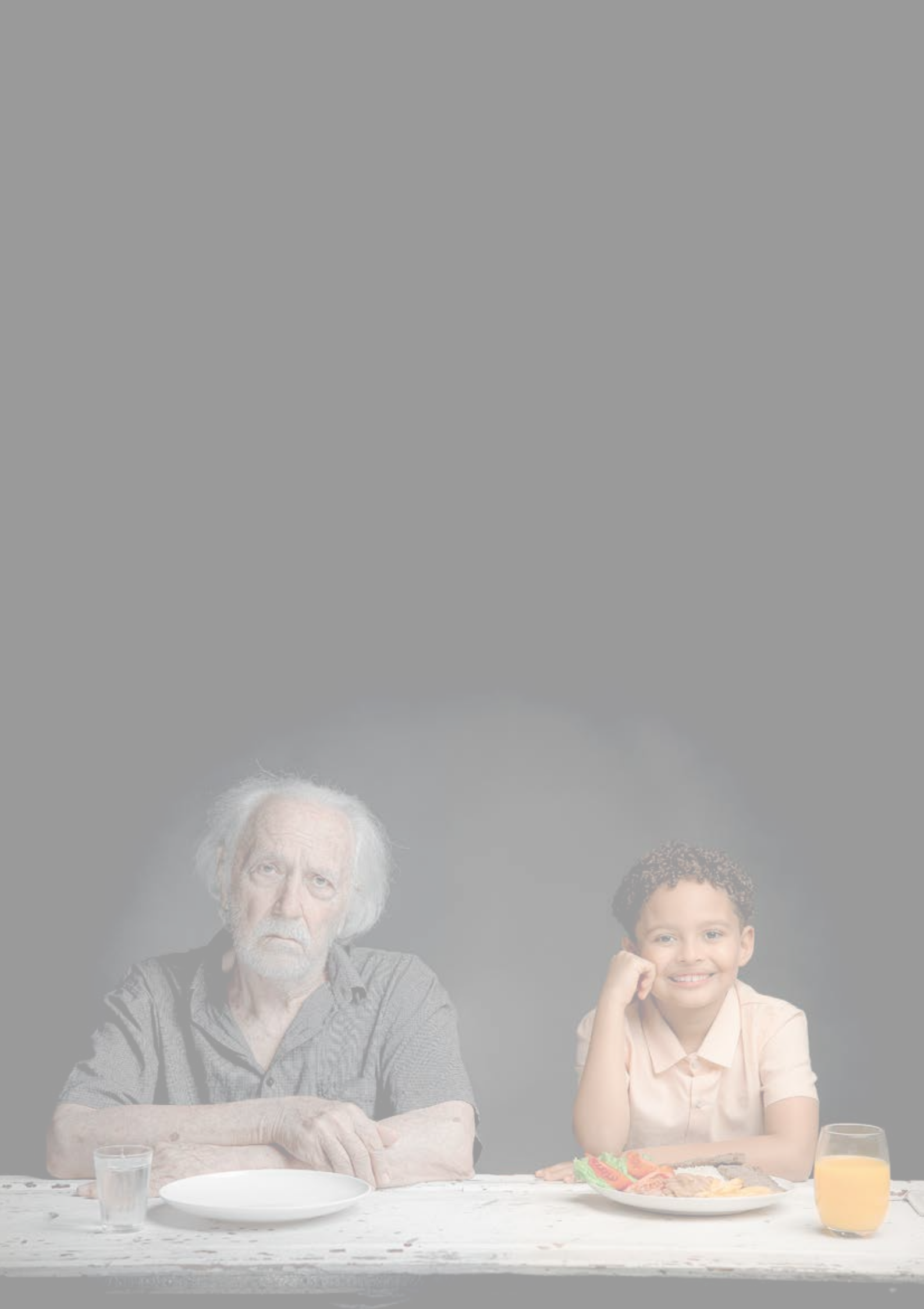

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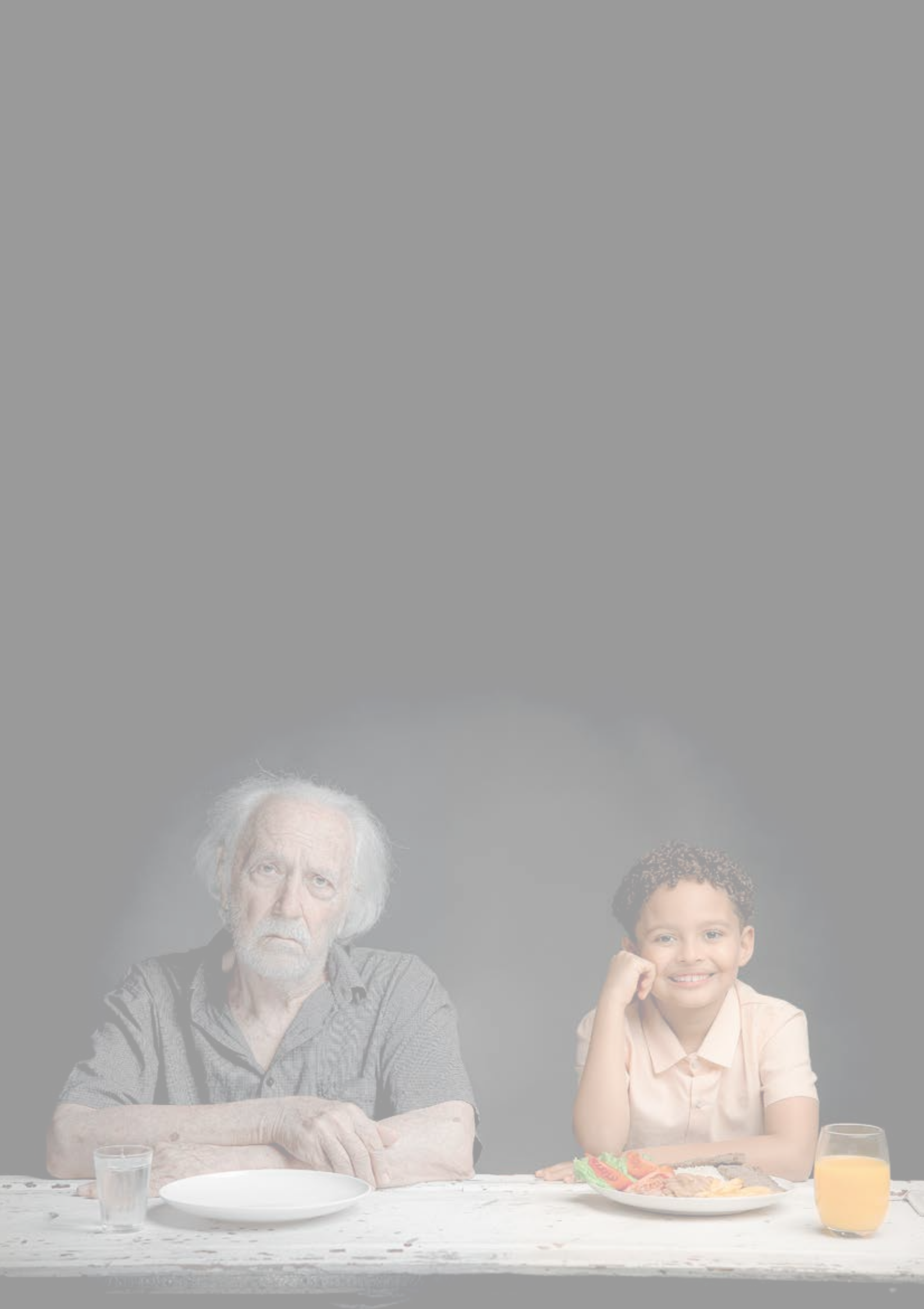

"Investments in research have revolutionized Brazilian agriculture, transforming it from a food importer in the 1960s to a major exporter of grains and meat today. However, we face the paradox of producing enough food to feed nearly a billion people globally while having over 33 million Brazilians in our own backyard suffering from severe food insufficiency. Brazilian science, multidisciplinary and with transversal actions, is crucial in resolving this dilemma. Scientific data is critical for obtaining accurate diagnoses of hunger, which must be communicated in a way that informs and mobilizes society. Agricultural sciences are essential for continuing the trajectory of increasing productivity but within the context of environmental regeneration and combating climate change. Science must aid in seeking innovations for small farmers, finding solutions for the bioeconomy, and valuing the role of women in family and community nutrition. Social, economic, and political sciences must work to define assertive government policies that allow broad access to food for the population. At the foundation of all this is education, ensuring dietary habits that will build a nutritionally healthy new generation. This book addresses the history of sciences in these themes because it is necessary to know the successes and failures of the past to move forward. It discusses the present and shows how Brazilian science can contribute to achieving the desired food and nutritional sovereignty for Brazilians."

Helena Bonciani Nader
Mariangela Hungria

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