RBSO Revista Brasileira de Saúde Ocupacional
ISSN: 2317-6369 (online)

Essay
Dossier Sustainable Development and Work

# Climate change and its implications for the health of workers, agricultural production, and the environment

## *Mudanças climáticas e suas implicações para a saúde de trabalhadores e trabalhadoras, produção agrícola e ambiente*

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**Hot to Cite (Vancouver):**
Moreira MFR, Meirelles LC, Coradim CM, Portella S, Oliveira SS. Climate change and its implications for the health of workers, agricultural production, and the environment. Rev Bras Saude Ocup [Internet]. 2025;50:eddsst5. Available from: https://doi.org/10.1590/2317-6369/13024en2025v50eddsst5

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## Abstract

**Objective:** This essay aimed to contribute to reflections on climate change (CC) and its implications for the health of workers (WH), agricultural production, and the environment in Brazil. **Methods:** The work presents aspects of the production process in conventional agriculture and its relationship with increasing temperatures on the planet, as well as addressing sustainability as a strategy capable of reducing greenhouse gas emissions, with the possibility of maintaining economic and environmental gains for this production model. **Results:** Furthermore, it highlights the potential dangers of CC for WH and the environment, even in conventional production models or family and subsistence agriculture, in which the latter has been more vulnerable, mainly due to the reduced capacity to respond to extreme events. It also highlights the importance of adopting prevention and damage reduction measures as mitigation and adaptation practices for CC. **Conclusion:** It concludes that to combat CC and reduce impacts on WH and the environment, a new development model with sustainable production and consumption based on experiences of popular surveillance in territorial-based health and agroecology will be necessary.

**Keywords:** Climate Change; Agriculture; Occupational Health; Greenhouse Gases; Sustainable Agriculture.

## Resumo

**Objetivo:** Refletir sobre as mudanças climáticas (MC) e suas implicações para a saúde de trabalhadores e trabalhadoras (STT), produção agrícola e ambiente no Brasil. **Métodos:** O ensaio foi baseado nos aspectos do processo de produção na agricultura convencional e sua relação com o aumento das temperaturas no planeta. **Resultados:** A agricultura sustentável foi abordada como uma estratégia capaz de reduzir as emissões de gases de efeito estufa, com possibilidade de manutenção de ganhos econômicos e ambientais. Destacam-se os potenciais perigos das MC para a STT e meio ambiente, tanto no modelo de produção convencional como na agricultura familiar e de subsistência, em que esta última tem sido mais vulnerável, principalmente em razão da capacidade reduzida de resposta aos eventos extremos. Ressalta a importância da adoção de medidas de prevenção e redução de danos como a prática de mitigação e adaptação às MC. **Conclusão:** Para o enfrentamento da MC e a redução dos impactos à STT e meio ambiente, será necessário um novo modelo de desenvolvimento com produção e consumo sustentável baseado em experiências de vigilância popular em saúde de base territorial e na agroecologia.

**Palavras-chave:** Mudança Climática; Agricultura; Saúde do Trabalhador; Gases de Efeito Estufa; Agricultura Sustentável.

## Introduction

Since the industrial revolution, the effects of human activities have contributed significantly to damage to health and the environment, alongside social progress. However, it was only when the economy and quality of life were threatened by successive extreme events that countries turned their attention to understanding the imbalances that were progressively occurring with nature. Although climate variability, with cycles of warming and cooling, and greenhouse gases (GHG) emission have always been part of the planet's different geological periods, industrial activities have accelerated the concentration of GHG. Therefore, the environmental imbalances that have occurred over the last 200 years are undeniably the result of human activity[1].

Climate change alters the lives of entire populations and impacts biodiversity. Its consequences range from global warming and localized heat waves to a gradual increase in ocean temperatures, intensification of droughts and floods, mass extinction of animal species and displacement of people due to environmental causes, among other events[2,3]. The United Nations (UN) has defined the Conference of the Parties (COP) to the UN Framework Convention on Climate Change as the common international body for tackling the problem.

The COP's main objective is to conduct negotiations and promote action at a global level to reduce the rise in the planet's temperature. In March 2024, the World Meteorological Organization (WMO) released its annual report, The State of the Global Climate 2023, indicating that 2023 was the hottest year in the last 174 years, with a global surface temperature of 1.4°C above pre-industrial levels, and the year 2024 confirmed this same trend. The WMO estimates that this acceleration in the planet's temperature has already made the proposals set out in the Paris COP Agreement, which aimed to curb global warming by 1.5°C by 2100[4,5], unachievable.

According to the latest measurements, the warming trend of the planet, especially the oceans, is set to continue at an accelerated pace, indicating the seriousness of what we are experiencing and the future difficulties we will have to face. Average global warming above 1.5 °C has already been reached by 2023, jeopardizing not only climate models, which have proved to be too conservative, but also aggravating the extreme events that have been occurring on a global scale. In the cases of Brazil, Morocco, and Spain, the current examples of the floods in Rio Grande Sul, the Sahara Desert, and Valencia are emblematic[6-8]. In an article for the *Jornal da Unicamp*, researcher Luiz Marques explains that this is the reason why Gavin Schmidt (Nasa) has taken up the hypothesis that the climate system may already have entered "uncharted territory"[9].

This impact is also crucial in the world of work because, according to data from the International Labor Organization (ILO), more than two billion people are exposed to excessive heat at some point during their working day. Of these, 22.9 million occupational injuries are attributable to this type of exposure. It is estimated that more than 70% of the world's workers will have their health seriously affected by climate change[10].

In this context, the conventional model of agricultural production stands out. As well as contributing significantly to the increase in GHG, it also makes this activity one of the most vulnerable to climate change, as it is naturally subject to weather conditions, is dependent on natural resources and painful human labor with high exposure to high temperatures. This compromises the workers' health (WH), food and nutritional security (FNS), the preservation of biodiversity, and the survival of island nations and coastal cities, among other things[11].

Climate variations increase plant stress, alter soil and water microbiology, and make it impossible to continue producing certain crops and species in certain biomes and territories, directly impacting agricultural productivity and, consequently, generating global food supply crises. FNS is compromised by variations in the scale of production and relocation of the world's main agricultural production chains[12]. Climate change (CC) has a harmful effect on FNS, which, combined with poverty, social inequalities, and the exploitation of agricultural workers, has devastating consequences, contributing to an increase in work-related illnesses, as well as a reduction in the supply of and access to food[13].

Although knowledge and some progresses have been made on the various possibilities for agricultural production, they are still not enough to meet the global demand for sustainable food. Environmentally and socially sustainable

production systems require investment in agricultural production and research. Advances in this field depend on the conscious use of soil (less degradation) and water (reduced demand and contamination), the reduction of GHG, the recovery of degraded land, green methodologies for soil protection and plant diversity, the use of inputs to control pests and diseases and natural and selective fertilizers, as well as plant breeding to guarantee the use of nutrients by plants[14].

With the increased frequency and intensity of extreme events, family farming is the most vulnerable, due to the low level of financial resources available, reduced access to production and protection technologies, and the need to maintain subsistence agricultural production[11].

Against this backdrop, the aim of this essay was to contribute to reflections on CC and their implications for WH, agricultural production, and the environment in Brazil.

## Agriculture and sustainability

Dominant agricultural production in Brazil is based on monocultures, large estates, intense mechanization, and agrochemicals (pesticides and fertilizers). It has undergone few changes in recent decades, especially regarding production practices to reduce the impacts of this production model, which causes significant environmental damage, such as deforestation, water exhaustion, contamination by pesticides and fertilizers, soil degradation and contamination, silting up of watercourses, destruction and reduction of biodiversity, among other impacts[15].

According to data from the 4th Report of the Intergovernmental Panel on Climate Change (IPCC), a recent survey carried out in Brazil estimated that there would be losses in agricultural area, a reduction in exports, a shrinkage in gross domestic product (GDP), a reduction in the income of the poorest families, and an increase in socio-environmental vulnerability in certain territories, due to an agricultural model that generates climate change and the potential transformations already underway in Brazilian agricultural activities caused by these climate changes. Some scenarios, including pessimistic ones, point to a reduction in arable land and a decrease in soybean production and exports, especially in the Central-West. In addition, the study points to the growing vulnerability of farming in the Northeast, given the lower level of capitalization of these families and their greater tendency to suffer prolonged droughts[16].

As for the impact on the main commodities, it is estimated that the decrease in annual soybean production could reach 28.70%, while its exports could shrink by up to 51.19%. Thus, it is assumed that, with the reduction in arable land in the Central-West, there will be a tendency to replace annual crops, especially soybeans, with sugar cane and rice plantations (Paraná), forestry and pasture (Central-West)[16]. Thus, based on this study, it can be inferred that areas that are highly dependent on a production model based on intensive soybean monoculture, whose local economy is based on this commodity, and in areas that have historically been more vulnerable due to socio-economic aspects, are the most likely to experience the greatest impacts of climate change on their activities.

Agribusiness accounts for 23% of the country's GDP and therefore has a lot of political power, capable of changing laws, regulations, and standards with the aim of weakening environmental protection and its institutions, as well as labor rights and the social protection network for workers, delaying, for example, the measures needed to implement the agreements related to the CC and the reduction of GHG[17,18].

On the other hand, in recent years we have seen a doubling of the area under cultivation, which has allowed production per area to increase in tons per hectare. As a result, cereal production has intensified dramatically. However, with the introduction of genetically modified crops and the consequent increase in the use of pesticides, monocultures of soy, corn, and sugar cane have expanded, especially in the Central-West and North regions, with soybean production increasing by 100% in five decades[12].

Most of the soy that stays in Brazil goes to feed pigs, poultry, and dairy cattle, which, by the way, is produced by family farmers in the South and Southeast. The soybean for export mainly supplies pig production in China.

As a result, meat production has increased dramatically, since 80% of the soy produced is destined for animal feed, which explains why a third of the world's deforestation is taking place in Brazil, due to the expansion of plantations and pasture facilities. In the same period, cattle slaughter increased by 82%[12].

The sectors that emitted the most GHG in Brazil were land use change (46%), agriculture (27%), energy (18%), industrial processes (5%), and waste (4%), although a large part of emissions in other countries are from burning fossil fuels (energy). Brazil's emissions have been growing since 2011, despite the country's commitment to reducing its GHG emissions. In ten years, the volume of gases emitted by the energy sector has doubled due to the burning of fossil fuels to generate energy by thermoelectric plants. However, deforestation and burning, due to agricultural expansion in the Amazon, are the main culprits for a large part of Brazil's emissions. Of these, most of the total emissions from farming come from cattle[2].

As a result of the commitments made at the 2009 Climate Conference to implement Low Carbon Agriculture (LCA), more significant, albeit timid, progress towards incorporating sustainable practices has been made in the production of commodities and conventional foods, given the potential of this economic activity to contribute to environmental sustainability[19].

With a view to reducing the impacts of CC on the environment, the country has invested in lower impact technology, fertilization and agro-energy from biomass, integration between agriculture, livestock, and forestry, recovery of degraded areas, optimization of water resources and no-till farming, among others. This set of actions aims to invert current carbon-generating agricultural activity into environmental services that reduce GHG and contaminants, maintain and recover biodiversity and restore watersheds[20].

Even with these advances, infrastructure, research, and economic viability need to be prioritized, since the proposal to make the current model of agriculture more sustainable still lacks a basic consensus on its meaning from a social, economic and ecological point of view. Currently, conventional agriculture establishes production and consumption patterns within a certain socially established development model, based on that practiced since the post-war era[19].

Brazilian family farming is made up of a diversity of social subjects who, culturally and historically, live from diversified agricultural and non-agricultural activities in the countryside[21]. They express relations of subalternity and resistance, both familial and collective, against the domination of hegemonic food systems[22]. In this model of agriculture, it is the nuclear family that manages its production unit.

Data from the 2017 Agricultural Census showed that family farming accounted for around 77% of rural establishments, corresponding to an area of 23% of these establishments, with approximately 3.9 million agricultural production units. These farms were responsible for 23% of the gross value of agricultural production in the country and constituted the social base that maintained Brazil's domestic food production market, producing around 70% of the main food groups consumed by Brazilians (rice, beans, corn, cassava, milk, beef, pork and poultry, fruit, vegetables, and legumes). These production units employed 10.1 million people in these activities, 46.6% in the Northeast, 16.5% in the Southeast, 16% in the South, 15.4% in the North, and 5.5% in the Central-West[23] regions. Given their socio-historical condition, Brazilian family farmers experience structural precariousness, with few rights won through countless social mobilizations since the 1990s[24].

Farming, the main activity of these families, has as its biggest challenge sustainable production in areas that often have limited rainfall, such as the semi-arid region, combined with animal husbandry, plant production, and extractivism[25]. Agroecology therefore appears to these farmers as an alternative for a more dignified existence in the face of such circumstances.

## Agroecology as an alternative

Agroecology is understood as an ecological practice of cultivating soils, plants, and animals, culturally situated as a science of life production, which seeks to develop technologies and techniques for the sustainable and ecological management of agroecosystems and as a social movement, which organizes and mobilizes for socio-

environmental justice and broader social transformations of societies[26]. Since the 1970s, family farmers in Brazil have been developing experiences. It started in the south of the country, with more specific and localized experiments promoted by non-governmental organizations[27]. Since the 2000s, there has been an expansion of these experiences across the various Brazilian biomes, with special emphasis on those originating from productive backyards, managed by rural women in the semi-arid region. This expansion is the result of public policies aimed at family farming and agroecological production, together with the participation of partner institutions, especially universities and research centers[28]. Agroecological practice, based on a particular type of relationship with nature, in which a more ecological rationality is prioritized, ends up affecting the entire life of these communities, generating a new way of life. As expressed in the entry on agroecology[29]:

> Agroecological social practice is expressed at the same time as a practical-material act and as ideation and reflection, in a dialectical relationship of action-thought-action, praxis, conscious action on nature that also transforms the subject itself. Farmer production is at the same time a unit of production and reproduction of life, production, and consumption; therefore, agroecological production is not isolated from the other spheres of life (p. 64).

Since then, agroecology has undergone a process of public institutionalization, which began with Law No. 10.831/2003 and then became a public policy through Decree No·7.794 of 2012, which instituted the National Policy for Agroecology and Organic Production[30]. It is the search for health, better conditions for access to markets, the generation of decent work and income in the countryside, the promotion of the population's FNS, plus socio-ecological transformation with social justice, which substantially animate these experiences and broaden their scope[31,32].

Agroecology is a better option for WH than conventional agricultural practice. This conventional model of industrial food production is based on excessive workloads, insufficient or precarious nutrition, and expels, expropriates, contaminates, and kills workers[33]. On the other hand, agroecology uses combined social and ecological approaches, which incorporate science, traditional agricultural practices, inclusion, diversity, integrality, social justice, solidarity, resilience, providing renewable, healthy, equitable, plural and sustainable food systems based on healthy living[34], together with the ancestral legacy of native peoples and the economic, political, and cultural diversity of today's farmers[35]. Agroecology doesn't use pesticides and fertilizers, it is community teamwork, it uses mutual aid networks, it minimizes the need for external energy sources, and, above all, it works with natural processes, avoiding mechanical and chemical means, fossil fuels, and the intensive use of inputs. However, despite being hard work, community organization makes the workload more reasonable, contributing to less exposure of workers to extremes of weather. As agroecology does not apply fertilizers and pesticides or use mechanical and chemical means, as well as fossil fuels, it results in less damage to WH and the environment[36].

In 2017, the UN Human Rights Council recommended that member countries end the use of pesticides in food production, given the illnesses and contamination caused to workers and the population in general by these toxins. It has also strengthened numerous initiatives and actions to develop and disseminate agroecology to mitigate or solve health and environmental problems, through the Food and Agriculture Organization (FAO) of the United Nations[37].

In a study conducted in Tanzania on agroecological intervention related to nutrition, with minimal input, the food security of children and families improved, there were advances in sustainable agricultural practices and in indicators of empowerment, as well as women's well-being. Therefore, this research shows important evidence of the impacts on nutrition and well-being generated by agroecology[38].

A study carried out in Ecuador explored farmers' agroecological practices in relation to three main areas: consumption of their own produce, income, and women's empowerment. The results showed that agroecological practice increases agricultural diversity and develops social and human capital to improve nutrition. Thus, the study revealed the potential of agroecology to disseminate nutrition-promoting practices through farmers' networks[39].

## Consequences of climate change and human activities for the health of workers and the environment

The environmental imbalances caused by CC have a negative impact on biodiversity, driving many species to extinction and aggravating health problems, including emerging diseases. Associated with human activities, such as intensive farming, agricultural use of complex biomes, deforestation of native forests to establish pastures, among others, CC promotes the imbalance of ecosystems, disturbs the structure of microorganisms, waters and soils, and alters the balance between parasites, vectors, reservoirs, and hosts[40].

Cancer, respiratory, cardiovascular, and renal diseases, as well as mental health disorders are some of the various WH conditions associated with CC, according to current ILO data[7].

Rural WH can be affected by continuous exposure to heat, ultraviolet radiation, disease-transmitting vectors, pesticides, and fertilizers, which increase the existing dangers in working conditions and processes, such as inadequate personal protective equipment, poor or non-existent facilities for personal hygiene, product storage, and application equipment. In addition, they are exposed to excessive workload and repetitive physical effort, including during the hottest hours[41-43].

High temperatures cause several adverse reactions to heat in the human body. These include hyperthermia, cardiovascular diseases, fainting, respiratory diseases, and dehydration[3,10]. The damage caused to health by exposure to heat is also intensified by the length of exposure, the type of activity, the clothing worn, and the working environment, which can be indoors or outdoors. Depending on the activity, in the case of a closed environment, there may also be an artificial source of heat, such as a blast furnace[3,43].

Factors such as old age, overweight, skin diseases, dehydration, alcohol, drugs, heavy clothing, pre-existing illnesses, and medication thermally unbalance the worker's body, increasing sensitivity to heat. However, a return to thermal equilibrium depends on the ability of workers and their working environments to adapt to the hot climate. This adaptation will only be possible with the adoption of various measures, such as managing heat stress in the workplace, raising awareness and informing workers and managers about the dangers of extreme heat, access to information about facilities, amenities, and appropriate workplace practices, among others[42].

In general, the increase in productivity of intensive monoculture farming occurs with the use of excessive pesticides and fertilizers, which causes damage to the environment and to the WH. In addition to the damage to health caused by exposure to heat, the use of pesticides at high temperatures increases the risk of poisoning due to intense dermal absorption, causing acute poisoning and damage to the immune, endocrine, and metabolic systems, even in the short term. In the environment, they are important contaminants for water, soil, flora, and fauna. In fact, the exposure of certain bacteria and fungi to certain pesticides increases resistance to antibiotics and antifungals used to treat infections caused by these microorganisms. On the other hand, fertilizers containing nitrogen (N), phosphorus (P), and potassium (K), used to increase productivity, are also harmful to environmental health. Nitrogen fertilizers are the most widely used and the main result of their use is the emission of GHG, especially nitrous oxide ($NO_{2)}$, which is more harmful than carbon dioxide ($CO_2$). N and P from fertilizers in aquatic bodies are responsible, along with other factors, for eutrophication, which is the uncontrolled proliferation of algae and cyanobacteria, for example[40].

In addition to the development of pathogens normally favored by the tropical climate and changes in ecosystems, deforestation and industrial agriculture favor the emergence of new disease-causing agents. Wild animals are hosts to numerous microorganisms and responsible for making animals and humans sick, especially rural workers. Environmental changes are a determining factor in infectious diseases caused by these wild animals, the onset of which is generally facilitated by rising temperatures. Likewise, heat has an impact on the spread of fungi and the proliferation of insects contaminated with pathogens. Thus, the preservation and balance of ecosystems are necessary for the control of zoonoses, as well as vector-borne infections[2].

Recent research has analyzed the health effects originated by the agricultural and livestock model based on land concentration, monocultures, and the intensive use of synthetic fertilizers and pesticides, and has shown

widespread contamination of rural properties, watersheds, territories of indigenous peoples, traditional peoples, and communities, as well as territories earmarked for environmental conservation and agroecological production[44]. The effects of this pesticide contamination are exacerbated by successive deforestation and agribusiness pressure on these territories. As carbon emissions intensify in the environment and reduce the atmosphere's capacity to absorb heat and $CO_2$, environmental contamination and degradation, together with obesity and malnutrition promoted by ultra-processed foods, are leading to a global syndemic process. Syndemic is the synergy between epidemics and refers to adverse health effects, encompassing group diseases, interactions between diseases, and environmental and/or social factors that favor vulnerability or disease action[45].

Faced with this scenario, we agree with Fava and collaborators[46] when they point out the importance of implementing Worker Health Surveillance (Visat) actions directed at this productive sector, with a view to mitigating this negative impact, "offering information that highlights the need for a model of sustainable agriculture that goes beyond the environmental issue and establishes the guarantee of worker health as fundamental" (p. 11-12).

Visat's approach with the experiences of Territorial-Based Popular Health Surveillance also points to appropriate ways by integrating health, work, environment, territory, and community participation. Popular health surveillance actions, in relation to the Unified Health System (SUS), favor the emergence of a care network shaped by the problems defined in the territories, with social participation and monitoring by equally participatory and integrated management and governance mechanisms[47].

## Socio-environmental aspects in the mitigation and adaptation of the impacts of climate change

Assessing a system's vulnerability and its behavior over time makes it possible to understand the real impacts caused by climate change and, consequently, to minimize risks and adapt work processes and conditions to these new circumstances. Predicting these locally caused impacts, experimentation, and crop models, including the advancement of trends in land use changes (fires and deforestation, hydrological balance, droughts, water excesses and desertification, etc.), are some of the methods for mitigating the impacts of CC. In addition, it is also necessary to build adaptation strategies for land use, agriculture, rural development, hydroelectric generation, river transportation, water resources, and wetland ecological systems[48].

Faced with the impacts of CC on agriculture, it is necessary to adopt measures to prevent and reduce damage. Mitigation and adaptation practices, such as low-carbon production processes, plant breeding, and polyculture, are fundamental to ensuring the sustainability of food production and environmental protection[25].

Low-carbon agriculture uses a series of techniques that mitigate GHG emissions and also contribute to the fixation of atmospheric $CO_2$ in vegetation and soil, allowing agriculture to adapt to climate change. Practices such as soil cover, no-till farming, crop rotation, agroforestry systems, silvopasture agroforestry systems, and biological control are the main technical measures that seek to reduce carbon emissions in agriculture and create production systems that are more resistant to climate variations. All these agricultural practices are fundamental in transforming food systems and increasing the ecological resilience of agro-ecosystems, understood as strategies for mitigating and adapting to climate change. However, if dissociated from the socio-economic conditions of rural families, these agricultural practices alone are insufficient to reduce situations of socio-environmental vulnerability resulting from climate change[25].

Family farming in the Brazilian semi-arid region, for example, is fundamentally characterized by diversified subsistence production systems, mostly run by women from their productive backyards. These production systems are highly dependent on rainfall and integrate animal husbandry, plant production, and extractivism. Therefore, agroecology in these environments can be a viable productive, ecological, economic, social, and political alternative to mitigate and reduce the impacts of the CC, insofar as it increases the ecological resilience of local agroecosystems, strengthens the capacity for collective social organization, access to markets, rights, and basic services, promoting better conditions for remaining on the land[25,28].

According to the predictions on CC, it is necessary to develop adaptation strategies to reduce the vulnerabilities of family farming through technologies. The use of new plant varieties that are resistant to high temperatures and low hydration, water, and soil management to improve efficiency, changes to the planting season, growing several species in the same area, promoting genetic diversity, access to technical assistance, and the application of FNS policies are some of the possible techniques to be used for adaptation[25].

## Final considerations

Locally and globally, we are not prepared for the increase in extreme weather events. That's why building a minimally sustainable society requires major efforts in all sectors, with strong collaboration between academic networks, knowledge producers, networks of managers, public policy makers, and community networks. With this in mind, we would like to highlight the importance of strengthening the experiences of territorially based popular health surveillance and agro-ecological movements.

To tackle CC, we need to build a new development path that includes the global economic system, with its unsustainable model, even in the short term. This is a critical situation that calls for urgent prevention and control policies that incorporate the already-known processes of CC and that seek to prepare society as a whole for the "unknown territory" that we may be entering faster than we imagined. At this point, special attention needs to be paid to rural workers, who already live in a situation of vulnerability and will still have their life and work routines greatly altered and, at times, made impossible.

In view of the above, we believe that this scenario calls for urgent prevention and control policies that incorporate the processes already known about CC, and that seek to accelerate known and recommended mitigation and adaptation strategies, without forgetting to give the necessary attention mainly to rural workers

We are therefore committed to a development model based on agroecology, which includes science, human, and environmental health, ecological resilience, social aspects, solidarity economy, culture, and justice. This model needs to incorporate the various forms of organization of rural communities, guaranteeing access to basic services, markets, and citizenship. In this way, we will achieve conditions that preserve the environment and quality of life for Brazil's present and future rural populations.

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**Authors' Contributions:** Moreira M, Meirelles LC, Coradim CM, Portella S, Oliveira SS contributed to the conception of the study; the data collection, analysis, and interpretation; and the drafting and critical review of the manuscript. All authors approved the final version and assume full responsibility for the work done and the content published.

**Data availability:** The entire data set supporting the results of this study has been published in the article itself.

**Funding:** The authors declare that the study was not subsidized.

**Competing interests:** The authors declare that there are no conflicts of interest.

**Presentation at a scientific event:** The authors declare that the study has not been presented at a scientific event.

**Received:** July 22, 2024
**Revised:** November 19, 2024
**Approved:** November 25, 2024

**Editor-in-Chief:**
Leila Posenato Garcia