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The Agricultural Crisis And Climate Change In Brazil

Iran Carlos Lovis Trentin
Phd In Agroecology
State University Of Rio Grande Do Sul (UERGS)

Summary
The central purpose of this article is to understand and discuss the situation caused by the constant droughts that have plagued the agricultural economy of several regions in Rio Grande do Sul in recent decades, especially with the adoption of degrading and polluting production models since the 1970s. It also discusses some information about the natural phenomena that intensify the constant droughts, as well as human involvement in worsening the droughts. To this end, we conducted extensive bibliographic research and interviews with researchers in the field. From this, it was identified that agroecology as a sustainable agriculture model is an alternative to replace the dependent and degrading model of ecosystems in the production of food for the gaúchos and for export. Furthermore, with this sustainable production model in agroecosystems, it is possible to guarantee environmental, economic and social improvements for farming families in all agricultural regions, in addition to mitigating the constant droughts and dry spells that have become frequent in recent decades, causing very large economic and environmental losses for all production in Rio Grande do Sul.
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I. Introduction

In recent years, the issue of significant changes in the climate has gained prominence worldwide. Researchers from various countries have been at odds, with some presenting a conformist view that the changes are natural, while others counter, with very strong arguments, that climate change is caused by the uncontrolled actions of man and capital on nature. In recent decades, many reports and reports from international agencies have presented these two views and gained followers according to their interests.

But we are all certain of one thing: the climate is changing and this is causing significant changes to the environment, especially in a country like Brazil, which has continental dimensions and several biomes that have been established for millions of years. The biodiversity of each biome is altered for every tenth of a second of the temperature that changes for a long time, either upwards or downwards. And many species may even disappear or be transformed, losing characteristics that are specific to their species. (Trentin, 2019).

In addition, other issues deserve to be discussed and analyzed, such as: the fires that increase every year in the Center-West and the Amazon region, the increase in temperatures in the semi-arid region of the Northeast, the advance of the sea on the Brazilian coast due to its increase, more frequent extreme rain and temperature events in the country's large cities and in mountainous regions with high population density, as well as a higher incidence of transmission of infectious diseases, all of which are caused mainly by the current increase in greenhouse gas levels.

The agricultural model developed in Brazil from 1970 onwards, known as the "green revolution", based on the intensive use of synthetic inputs, petroleum derivatives and machinery, guaranteed an increase in productivity per area but also caused dependence, degradation, contamination and pollution of the environment. (Trentin, 2015)

Many of these factors are listed by several researchers as promoting the increase in annual temperature and causing constant climate changes across the globe. Understanding these climate changes and observing their possible relationships with the constant droughts and dry spells in southern Brazil is the objective of this work. As well as listing sustainable agriculture models capable of mitigating or alleviating these harmful effects of climate change.

In developing this work, we sought to identify works, articles and publications that discussed this topic and could contribute to identifying the relationship between the agricultural model, climate change, droughts and sustainable production alternatives in order to contribute scientifically to this problem. In addition, several interviews were conducted with researchers from different areas, farmers and technicians in order to better understand this topic and identify possible alternatives to mitigate climate change.

II. Climate Change

Thus, the UN defines in Art. 1 of the Convention on Climate Change, 1992, as: "climate change means a change in the climate attributed directly or indirectly by human activity that alters the composition of the global atmosphere and that is added to the natural variability of the climate observed during comparable periods of time."

Climate change is mainly caused by human activity, through the intensive use of fossil fuels (coal, oil, gas, etc.) and through deforestation and loss of forests in the most diverse biomes around the globe. (Altieri and Nicholls, 2013).

The same authors also corroborate that global warming has intense environmental impacts such as the melting of glaciers and polar seas, as well as on agroecosystems and their biological processes, such as the flowering and germination periods of plants, for example. The international press also reports every day on some climate changes in some part of the globe, such as "Alps lose 10% of their ice in one year" (MMA, 2010).

Major climate changes have been observed on all continents over the last century. Temperatures in traditionally cold regions are rising faster than the global average. For example, "in 2003 alone, 10% of the glaciers in the Alps melted," according to a report published in November 2005 by the European Union's Environmental Agency (European Union Environmental Agency, 2005 in MMA, 2010).

This increase in temperatures and climate change can increase, in addition to water shortages, the incidence of serious diseases and epidemics, especially tropical diseases such as malaria, dengue fever and dysentery. And poorer regions are more susceptible to these problems, either due to worsening health conditions or droughts that affect food production for community food security.

As a large contingent of families living in poverty are in rural areas, especially in Africa, Asia and Latin America, they are more affected by rising temperatures and climate imbalances, as their crops and animals that are used for food suffer more and the supply of local food decreases every year.

All these climate changes have a much more catastrophic impact on the poorest rural populations, since they live in the most remote regions, with rugged terrain, and with fewer housing resources and food security and sovereignty. Poverty levels in rural areas are increasing worldwide, and these farmers suffer from the catastrophic effects of the climate, even without having participated in this change. In many cases, changes or aggressions to the environment that were carried out on another continent by conventional farmers, highly dependent on chemical inputs, pesticides, and oil, and/or by heavy industries, first affect the most vulnerable populations, who are thousands of kilometers away from the sources of catastrophes. (Trentin, 2021)

In Brazil, studies published by the Intergovernmental Panel on Climate Change (IPCC, 2001) concluded that "the average temperature of the atmosphere has increased by 0.6ºC + 0.2ºC during the 20th century". Reports from the IPCC and several other universities have shown "that between 1900 and 2100 the global temperature could rise by between 1.4 and 5.8ºC". If this occurs, serious environmental problems will be observed every year in every corner of the planet.

In this sense, we need to understand why the climate has been changing so much in recent years. Studies carried out by the Brazilian Ministry of the Environment state that the climate varies naturally depending on the time and place, but that in the last two centuries, due to the intensive burning of fossil fuels, these climate changes have become more visible and are causing catastrophes in several regions of the planet.

According to Nobre et al, (2012, p. 8) "in the last 400 thousand years, four distinct cycles have occurred. These cycles are glacial and interglacial. At the interglacial peak, in which we find ourselves, the temperature is about 5°C to 6°C higher than at the peak of the last glacial period, approximately 20 thousand years ago". 120 thousand years ago, we had the last interglacial period and the temperature was slightly above the current temperature and these slight alternations are natural in time and space.

Nobre et al, (2012, p. 8) also states that, for example, "during the last glaciation, 20,000 years ago, as mentioned above, the surface of the planet was 5°C to 6°C colder". And during this period, the Earth took 10,000 years to warm up and now it has increased a lot in a short time. But now, in the last two decades, it has been warming almost 0.2°C per decade, which is a speed 50 times faster than the natural glacial-interglacial cycle. So, some different things are happening. If all this were natural, it would have to be easily explained, because there is no scientific justification that this high rate of warming is merely natural.

Studies carried out by researchers from all over the world in recent decades state that due to disorderly global warming, ocean levels have already risen by 20 cm, and that snow cover on the Earth's ice caps has been decreasing every year.

According to the IPCC (2007 in Nobre 2012, p. 11), it is essential to note that the ocean is warming. If "the planet is warmer, we have to imagine that the Earth System – atmosphere-continental surface – cryosphere-ocean – is in a higher energy state, that is, it has more energy. And this energy is going to the ocean. Eighty percent of this increase in energy – due to the fact that the average temperature of the planet is 0.8°C warmer – goes to the ocean". Graphs and tables from ocean temperature monitoring centers show this warming across the globe.

As Altieri and Nicholls (2013) have already stated, temperatures are rising because we have more harmful gases in the atmosphere. And there is no doubt that these gases are increasing. Just look at our dominant production systems, whether agricultural or industrial, which are based on the combustion process - when we burn coal, oil, natural gas, forests, etc., we generate carbon dioxide. This increase in CO2, which is increasing in the atmosphere every day, causes the temperature on the surface to rise.

Even though some researchers and transnational companies try to disguise the idea that global warming is caused by the addition of CO2 to the atmosphere through inorganic processes, such as volcanoes, fissures, etc., studies conducted worldwide contradict this position. And there is a consensus among researchers committed to the well-being of the world's population that some things must be done to reduce these growing carbon dioxide emissions.

During ECO-92 or Rio-92 (1992), the final report promised to reduce CO2 emissions. It is now 2013 and emissions have only increased in all regions of the world. According to Nobre et al, 2012, "CO2 emissions from fossil fuels have increased by 43% in the last 18 years." The 15th Conference of the Parties (COP15) of the United Nations Framework Convention on Climate Change, held in Copenhagen in 2009, stated in its final document "that all efforts should be made to prevent temperatures from rising by more than 2°C." We know that almost no country in the world is fulfilling this fact.

Constant Droughts in Southern Brazil

In recent years, we have observed constant droughts in the southern region of Brazil, which have now come to be called droughts. Of the last 10 years, 7 have been droughts in the summer, river levels have never been so low and water shortages are constant in many southern regions. (Trentin, 2023)

All of these changes are supported by some researchers who claim that this has always existed, and who want at all costs to justify the catastrophe as something cyclical. Climate change in southern Brazil, especially droughts, is routinely reported by elderly farmers. Droughts have always existed, but what we can see is that in the last 50 years they have become more intense and summer temperatures have risen.

This seems to coincide with the beginning of the modernization of agriculture via the "green revolution" with its various harmful effects on the environment, especially the deforestation of several forest areas in southern Brazil.

As we know, no researcher who defends the conventional and predatory model of the environment talks about the negative impacts of deforestation in any Brazilian biome or in other regions of the planet. And it is known that this deforestation can compromise the climate of both the Amazon region and other regions that benefit from the humid masses formed in this forest.

In recent years, observations of the country's climate over longer time scales have revealed profound changes. This serves as a basis for analyzing the climate of the future, thus attempting to separate the normal variations observed from the variability forced by human action that induces climate changes.

El Niño and La Niña.

In recent years, these two Spanish words have become part of everyday life in Rio Grande do Sul. It is common to hear people talking about El Niño and La Niña on radio stations in the countryside, in the waiting lines at agricultural cooperatives, and also in the chimarrão gatherings between family farmers in all municipalities.

Researchers from different international research institutes have found that these phenomena considerably affect rainfall behavior in all Brazilian biomes. InIn the North and Northeast regions, droughts occur during El Niño, and in the South of Brazil, droughts occur during La Niña and excessive rainfall, including floods during El Niño. Thus, if El Niño increases in frequency or intensity in the future, Brazil will be exposed to more frequent droughts or floods and heat waves. And according to Altieri and Nicholls (2013 in Trentin, 2015. p. 10), "why would it increase? Because the forms of agricultural and industrial production use a lot of fossil fuels and destroy the environment".

We want to delve deeper into these more frequent heat waves to try to understand what happened this summer of 2014 in southern Brazil and which, according to our research, caused substantial losses in agricultural production in Rio Grande do Sul.

Several Brazilian researchers have observed that the El Niño and La Niña phenomena over the Equatorial Pacific region, which alter the SST (Sea Surface Temperature) over the Tropical Atlantic, are associated with other phenomena, which contribute to a large part of the variability in the different annual seasons of the climate in South America. This is significantly reflected in the cereal-producing areas of the Southern Cone, for example.

El Niño and La Niña are characterized by the cooling or warming of surface waters in the Pacific Ocean, especially near the equator. And the combination of different atmospheric circulations, caused by the warming or cooling of the ocean surface, affect the latitudinal positioning of the Intertropical Convergence Zone (ITCZ) in the Atlantic, interfering with rainfall indices in the Atlantic and Amazon biomes.

Several authors who analyzed the behavior of ocean temperatures state that interannual variability of SSTs and winds over the Tropical Atlantic exert a profound influence on climate variability over South America at a global level, among them (Ropelewski and Halpert 1987, 1989 and Aceituno 1988), with studies on the Northeast region of Brazil (Hastenrath, 1984; Nobre and Shukla, 1996; Alves et al. 1997; Rao et al., 1993; Uvo et al., 1998; Xavier, 2001). Regarding the Amazon biome, we can mention, among others (Marengo, 1993; Marengo and Hastenrath 1993; Marengo et al., 1998, 2006; Ronchail et al. 2002; Botta et al. 2003; Sousa and Ambrizzi 2006), and about the South and Southeast of Brazil (Kiladis and Diaz, 1989; Diaz and Studzinsky, 1994; Grimm, 1997a and b;MMA, 2010).

In the Amazon region, for example, El Niño impacts are frequent in the north and center of the region, such as the droughts of 1925-26 (Williams et al 2005), 1982-83 and more recently in 1997-98. (Marengo et al. 2006,in MMA, 2010).

The influence of El Niño and La Niña in South America, considering the history of these events over the last 50 years, is clear. It is also likely that during some El Niño or La Niña events, the significant impacts will not occur in some regions, since, as highlighted, they are associated with other geographic behaviors around the globe. When El Niño is active in Brazil, droughts predominate in the Northeast and Amazon and more rain in the South. And throughout the Southern Cone, higher atmospheric temperatures are observed, both in summer and even in winter.

The South region experiences the impacts of El Niño from winter and spring onwards, with this phenomenon reaching its greatest expression in summer. The opposite is observed when there is a tendency towards droughts or less rainfall during La Niña, in winter and spring.

The effects of rising ocean water temperatures in the Pacific affect wind systems throughout the equatorial region. Thus, these heavy clouds that produce heavy rainfall near Indonesia are moved eastwards by sea currents to the Central Pacific and then to the west coast of South America, favoring precipitation in the Peruvian desert, for example. (Trentin, 2021)

Changes in the position of rainfall in the Pacific cause changes in the climate conditions in various regions of the globe. Examples include the severe and constant droughts in India, Northeastern Brazil, Australia, Indonesia and much of Africa, which may be the result of the association of this phenomenon with other variations, as well as occasional floods in Southern and Southeastern Brazil, Ecuador, Peru and the Midwestern United States at certain times of the year.

And also, in some areas, according to Silva Dias and Marengo, (2002 and 2006,in MMA, 2010) observed higher temperatures in the central and southeastern regions of Brazil during the winter season, while in other regions there is excessive cold and snow. This summer in southern Brazil was extremely hot. Intense heat waves lasted for up to 10 days without interruption. And it is known that these climate anomalies associated with the El Niño phenomenon can cause serious environmental and socioeconomic damage, especially in agricultural areas in impoverished regions.

Family farmers, including the poorest, are more vulnerable to climate change, as a reduction of a few kilos in annual production could compromise the food security of these families during a longer period of drought, for example.

And since everything in nature is cyclical, the opposite phenomenon to El Niño also occurs, namely La Niña, which is the warming of the waters of the Western Pacific and cooling of the surface waters in the central part of the Pacific. This phenomenon generally occurs less frequently than El Niño. These climate variations associated with the La Niña phenomenon are the opposite of those observed in El Niño, but the phenomenon is not constant, that is, variations always occur during the year. El Niño can be characterized as cyclical, not regular, reappearing on average every two to seven years. (MMA, 2010).

The effects of these phenomena are observed every year in Rio Grande do Sul. Among them, we can mention that river flows in southern Brazil show low values during La Niña years, while during El Niño there is more water available and the flows are higher, for example. And since the flow of rivers is mostly fed by rainfall, this means that droughts in Rio Grande do Sul, a state with high agricultural production of commodities for export, cause great losses, thus generating significant losses for the state, farmers and especially the poorest regions dependent on agriculture.

The impacts of El Niño in the South region have been identified in studies by Grimm et al. (1997a,b and 2000) and Berlato and Fontana (2003), among others in MMA, (2010. The greatest impacts are felt in agricultural production, especially in commodities for export that depend on rainfall cycles mainly in the southern summer.

These authors identified that the average yields of soybeans and corn in Rio Grande do Sul during the influence of El Niño in 1995/96, 1997/98 and La Niña in 1998/99 and 1999/2000 were modest in La Niña years, and reiterate that the gains in average yield of the main commodities in the State were greater in El Niño years.

Other researchers claim that El Niño and La Niña are natural phenomena that occur from time to time and that we cannot interfere with. These natural phenomena and variations in the planet's climate system have existed for thousands of years and will continue to exist, hopefully for many more thousands of years.

In recent decades, in the southern region of Brazil, the systematic increase in rainfall in some years and droughts in others have been observed in rainfall records, carried out by agricultural cooperatives and climate research centers.

As already mentioned, in addition to the natural phenomena of El Niño and La Niña, environmental changes caused by human intervention increase the frequency and intensity of these phenomena. Constant deforestation and changes in land use with the use of heavy machinery and synthetic inputs for cereal production, for example, in the most important basin of Mercosur, the Río de la Plata, have increased rapidly in recent decades and it is clear that these actions modify the thermodynamic characteristics of the lower atmosphere.

In nature, the system is complex and these changes are affected by the complex interactions between climate, hydrology, vegetation and human management of water and land resources, in other words, the predatory exploitation of agroecosystems. In the available literature, we find evidence that changes caused by the green revolution in land use in the basins of the Alto Paraná, Paraguay and Uruguay rivers have generally contributed more than 28% to the average flow of the Paraná River since 1970. (MMA, 2010).

Tucci and Clarke (1998, in MMA, 2010. p. 10) noted that "this increase in river flow occurred after large areas had experienced deforestation or changes in land use". The intensive use of agricultural and industrial activities in the region led to a transition from coffee to soybean and sugarcane, and to cattle raising in the upper Paraná basin. This has increased significantly in recent years, mainly due to the high prices of commodities for export. And some summer crops, such as soybean, require intensive land preparation, which is done with the use of machinery and the addition of inputs from petroleum. (Altieri and Nicholls, 2013).

Another study in the State of Paraná revealed that the Iguaçu River basin has also shown constant increases in flow since 1970, even though there have been few changes in land use and deforestation in this basin in recent decades (García and Vargas, 1998, in MMA, 2010).

A recent analysis of global flow trends is presented by Milly et al. (2005). In their analysis of variations during the 20th century in South America, they reveal that "the most important factor is the increase in flows of around 20-40% in the Plata basin, consistent with the positive rainfall trends in this basin" and in observation posts on the Paraná River (MMA, 2010).

In the summer of 2004-2005 in southern Brazil, the total annual rainfall exceeded the average in the state of Santa Catarina, but in the east and northwest of Rio Grande do Sul and on the coast and south of Paraná, significant drops in rainfall were observed. Thus, the entire region had a rainfall deficit during the months of December 2004 to March 2005. During this period, the total accumulated rainfall was between 100 mm and 500 mm, well below historical averages. (MMA, 2010).

When droughts occur in Rio Grande do Sul, they not only cause major losses to agricultural and livestock production, but also create water supply problems for the population of many municipalities. And family farmers who produce the vast majority of food are the most affected by droughts. In addition to losing their production destined for sale, such as soybeans, corn, vegetables or milk, for example, they also lose production for family self-consumption. Droughts therefore cause two immediate losses for family farmers: in addition to losing the income from the sale of products, they need to make another amount of money available to purchase food, which they were also unable to harvest this year.

Thus, indebted family farmers in Rio Grande do Sul become poorer during periods of drought. Droughts cause crop failures, especially in recent years, when the agricultural commodity production market has been booming. The product most affected so far is soybeans, the star of Brazil's trade balance. (Trentin, 2021)

The National Supply Company (Conab) estimated that production in the 2004/2005 harvest would be 53.119 million tons, 8.281 million tons below the December forecast, which indicated a harvest of 61.4 million tons. In the 2003/04 harvest, farmers managed to harvest more than 49.770 million tons of soybeans, our main agricultural export product.

And even with all this production, which means a lot to Brazil's trade balance, governments, in most cases, are inattentive to the situation of family farmers and adopt only palliative support measures. Negotiations of agricultural debts in years of drought are dramatic and slow, and farmers, for example, have to beg for assistance at most bank branches. Despite so many examples and scientific reports already published, governments continue to fail to treat climate change issues with the respect they deserve.

Due to the area planted in RS, corn is generally the second crop most affected by droughts, after soybeans. For example, the cereal harvest totaled 39.03 million tons in the 2004/05 harvest, compared to 42.191 million tons in 2003/04. The national loss in this harvest compared to the estimate in December was 10% or 3.16 million tons. (CONAB, 2006)

Recent research on maximum and minimum temperatures in southern Brazil during the period 1960-2002 (Marengo and Camargo, 2010) indicated a systematic warming of the southern region. In the summer of 2013/14, the southern region of Brazil experienced very high temperatures. Heat waves reached levels never before recorded and lasted for several uninterrupted days. Data from our field research revealed that even with

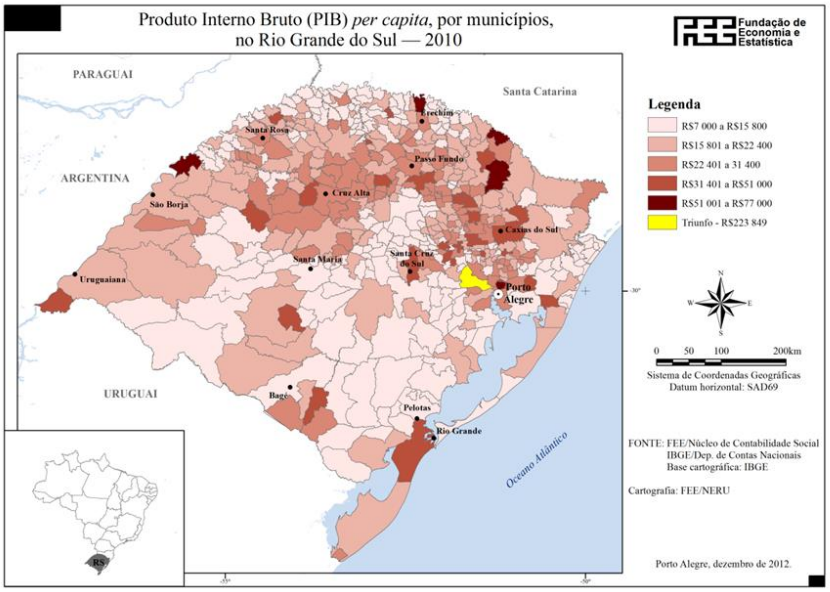
historical average rainfall during this period, these heat waves affected agricultural productivity in the state, especially in regions with a predominance of poor family farmers and steeper soils. Figure I.

The map shows us two significant regions with the presence of poorer family farmers and soils less suitable for the development of activities known as agribusiness, based on the intensive use of modern machinery, industrial equipment, inputs from petroleum and pesticides, which are the municipalities located in the great Uruguay River Valley and in the region known as central-serra-sul, from the vicinity of Santa Cruz do Sul to Pelotas.

In addition to the productivity of agriculture and livestock, these climate fluctuations cause other problems for the society of Rio Grande do Sul. As we have already mentioned, there are difficulties in supplying water in several regions and, in particular, the low tax revenue generated by the production chain in years of drought, which further limits the state's ability to implement public policies to mitigate these effects.

Thus, in regions where GDP per capita is lower, drought makes the economic situation worse. And poor farmers tend to become poorer or indebted during these periods of frequent droughts. This situation affects the entire society and the local-regional economy. (Trentin, 2023)

Figure I: Distribution of GDP per capita by municipality in RS in 2009.



Source: Author, 2020.

These constant economic losses in the economy of these communities further aggravate the regional imbalance in Rio Grande do Sul, which even in the 21st century has still not managed to resolve structural problems in many regions.

And every day it becomes more necessary to adopt more sustainable agricultural techniques so that the droughts that have become part of daily life in Rio Grande do Sul do not cause even more impoverishment in regions with agricultural production.

III. Agroecology As An Alternative For Development.

In the late 1970s and early 1980s, some researchers, including GLIESSMAN, ALTIERI, ERIC GIMÉNEZ, NICHOLLS, ZEVILLA GUZMAN, among others, began to shape what we now know as agroecology, a science that we also call a model of sustainable agricultural production. At that time, several studies pointed out several negative changes, caused by the green revolution, in the different ecosystems of both rich and developing countries. This led them to begin searching for new models of agricultural production that were more sustainable in time and space.

Thus, a reference publication emerged during this period, that of researcher Stephen R. Gliessman, from the University of California-USA, who wrote in 1996, El Concepto de Agroecosistemas, where he developed a series of concepts seeking to understand and interpret agroecosystems in a systemic way.

GLIESSMAN, 1996, states that “agroecosystems are production units”, such as properties, farms, estates, plots of land, and smallholdings, where farmers interact with each other and with the surrounding nature, i.e., they form an agroecosystem. He also states that “to understand the concept of agroecosystems in a food production system, we need to know the energy input and output flows and their interrelationships”. He goes on

to say that "the ecosystem is a system of complementary relationships between living organisms in a given environment and at a given time, where it remains in dynamic equilibrium, always considering its structure and functions".

According to GLIESSMAN, (1996) "ecosystems are formed in a hierarchical way, by individuals with specific characteristics that provide them with a series of components making them "fit" to live in a certain time and space"; and also, "by populations that are groups of individuals of the same species, where one must understand the factors that correspond to the size and growth of this population in order to understand the capacity of the environment to support this population over a period of time". Agroecologists differ from conventional agronomists "who are concerned with determining the optimal quantity and distribution of a single population in an environment to ensure greater productivity". (Gliessman et al, 1996 in Trentin, 2021 p 234).

In natural ecosystems, populations of different species are in constant interaction both in space and time in order to organize a community, or a set of individuals that interact with each other. Thus, "the level of interrelationships affects the distribution and abundance of species in the community". (Altieri and Nicholls, 2010).

In this sense, the same author states that "the agroecosystem is the result of the adaptation and interrelationships of the species populations that compose it". And so, "we have to consider the diversity of species, that is: the number of species present in a community that can be many or few"; as well as "the dominance and relative abundance, where the species that has the greatest impact on the biotic and abiotic components are the dominant ones; the structure of the vegetation with its different extracts and associations; the trophic structure, where each species has its nutritional needs and the way in which this develops determines the structure of the interrelationships, energy capture, biomass transformation and use by another species, for example"; also, "the stability where if no interference occurs they remain in relative harmony"; and, "the functioning of the ecosystems that refers to the dynamic process that occurs within them, with an emphasis on efficiency, productivity and development, which makes it very important in an agroecosystem". Thus, the author reiterates that "the two most fundamental processes in an ecosystem are the flow of energy between parts and the nutrient cycle". (Gliessman et al, 2010 in Trentin, 2021. p 245).

And in the search for a sustainable production model based on the concept of interactions within the agroecosystem, agroecology is undoubtedly the science that can offer responses to the recovery of impoverished agricultural areas with respect for the environment and human health and guarantee food security for the planet.

In recent years, in studies and in some Brazilian public policies, references to the term Agroecology as a model of sustainable agricultural production have increased. Agroecology "is yet another socio-political expression of the greening process experienced in recent decades. This has initially been positive, as it reminds us of styles of agriculture that are less harmful to the environment, that promote social inclusion and provide better economic conditions for family farmers. Even though there is still much theoretical confusion in understanding what agroecology really is" (Nicholls, 2013 in Trentin, 2019. p. 35).

Likewise, the same author states that "even with the growing use of the term and the generation of new research on this topic, there is still a profound confusion in the use of the term Agroecology, generating conceptual interpretations that, in many cases, harm its understanding". And they also "make it difficult to treat Agroecology as the science that establishes the bases for the construction of sustainable agricultural styles and sustainable rural development strategies". (Nicholls, 2013).

This work understands "agroecology as a scientific approach aimed at supporting the transition from current models of conventional rural development and agriculture to sustainable rural development and agricultural styles" (Caporal and Costabeber, 2000a; 2000b; 2001; 2002). These statements are based on the writings of Miguel Altieri and Clara Nicholls, who state that "agroecology is a theoretical and methodological approach that, using various scientific disciplines, aims to study agricultural activity from an ecological perspective". Thus, "like agroecology, it uses a systemic approach, adopting the agroecosystem as a unit of analysis, with the ultimate purpose of providing the scientific bases (principles, concepts and methodologies) to support the process of transition from the current model of conventional agriculture to sustainable agricultural styles".

Thus, it can be stated that "more than a specific discipline, Agroecology constitutes a field of knowledge that brings together several theoretical reflections and scientific advances, originating from different disciplines that have contributed to shaping its current theoretical and methodological corpus" (Guzmán Casado et al., 2000).

According to Gliessman et al. (1990), sustainable agriculture, from an agroecological point of view, "is that which, based on a holistic understanding of agroecosystems", is capable of meeting, in an integrated manner, the following criteria: a) low dependence on commercial inputs; b) use of locally accessible renewable resources; c) use of the beneficial or benign impacts of the local environment; d) acceptance and/or tolerance of local conditions, rather than dependence on intense alteration or attempted control over the environment; e) long-term maintenance of productive capacity; f) preservation of biological and cultural diversity; g) use of the knowledge and culture of the local population; and h) production of goods for domestic consumption and export.

Thus, it is clear that in impoverished rural regions, in every sense, and especially with weak arable soils, agroecology is the science that can promote environmental recovery and generate development.

As Clara Nicholls (2013) states, "Agroecology provides the scientific and methodological bases for the promotion of sustainable agricultural styles, with one of its central axes being the need to produce food in adequate quantities and of high biological quality for the whole of society." Even though, despite its closer link with technical-agronomic aspects (it has its origins in agriculture, as a productive activity), this science is nourished by several disciplines and advances to broader spheres of analysis, precisely because it has an epistemological basis that recognizes the existence of a structural relationship of interdependence between the social system and the ecological system (the culture of men in co-evolution with the environment)."

In observations carried out in the North of Rio Grande do Sul and in interviews with rural extension technicians from cooperatives and other institutions, it was found that even with regular and relatively well-distributed rainfall, the production of soybeans sown in the first weeks of November 2020 was 25% less than expected.

The information points to the constant heat waves in the region in the months of December and January as being responsible for this drop, which caused damage to plants during vital periods to ensure good productivity.

These heat waves, which lasted for more than 10 days without interruption, stained the landscape, especially in areas with shallower soils and/or rock outcrops. This mosaic of greener plants and wilted or dry plants worsened with each new heat wave. Rains alleviated the situation in areas with deep soils, but were unable to stop the loss in areas with shallow soils.

Excessive heat waves like those seen this summer also cause other situations, such as the proliferation of caterpillars, insects and mosquitoes that no longer have natural enemies to control them, since the production model based on the intensive use of chemicals unbalances natural environments. This proliferation of caterpillars in crops causes farmers to apply more pesticides, which further unbalances the environments and increases production costs.

In addition to the economic and environmental losses, heat waves cause discomfort to people, especially the elderly, who are numerous in these regions of impoverished family farming, as most young people have migrated to other regions and productive sectors.

The outlook for the coming years is not promising in terms of solving these problems. The trend is for the situation of imbalance in these regions with poorer family farmers to worsen. Among these, we can mention, among others: changes in ecosystems with an increase in the incidence of pests; a decrease in surface water in rivers, lakes, dams, etc.; a decrease in groundwater (the water table that supplies the majority of the population with artesian wells); losses of species from the regional biodiversity; invasion of plant species that are more resistant to droughts; a greater proliferation of insects (which need higher temperatures to reproduce); loss of the natural properties of soils; an increase in fires; an increase in air pollution; and the possibility of tropical diseases extending to areas that were previously colder.

These are some considerations about problems that may become worse. Within this, there are several attitudes that must be taken by governments and society to alleviate these and other problems.

Since the globe is an ecosystem, solutions depend on all countries. For example, it is necessary to urgently reduce emissions of gases that are harmful to the atmosphere; reduce and control deforestation; increase tree diversity; increase soil coverage; improve soil structure to facilitate infiltration; use techniques that are less aggressive to soils; implement terraces in steeper areas to retain moisture; use seeds that are well acclimatized to different regions, that is, with greater capacity to resist fluctuations; reduce production costs; and, above all, produce food for the food security of families. (Trentin, 2023)

IV. Conclusions

Natural resources are finite, so it is up to everyone to find solutions to alleviate the adverse situations for economic accumulation that arise in each region.

Given the competitiveness of the agribusiness chain, the state of Rio Grande do Sul has exceptional conditions to meet a large part of the expansion in demand for food and other raw materials, despite the current crisis. However, priority should be given to family farming and, within this, agroecological production.

Therefore, we cannot, to the detriment of increasing income, continue to degrade the environment and generate a very high dependence on external inputs, which channels most of the income generated to other regions. And environmental degradation, diseases caused by the intensive use of pesticides and, above all, a condition of food and nutritional insecurity for the majority of the population remain in the unbalanced regions (Trentin, 2015).

In 2020, marked by the COVID-19 pandemic, where farmers have had to deal with new adaptations and control protocols, water supply levels have dropped significantly. In other years, the water crisis worsened from the beginning of February; this year, rationing began in early November. Summer crops in the center-south of Brazil are behind schedule, and there is a lack of water for supply in almost a hundred municipalities in Rio

Grande do Sul. The negative impacts on the regional economy due to constant droughts will be significant, and public policies for environmental protection and recovery, as well as rational and comprehensive management of water resources in the state of Rio Grande do Sul, are becoming more essential each year.

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