

REVIEW

Water Crisis in Parana: Causes and Consequences

Crislaine Trevisan da Rocha Ribeiro Ferrari^{1*}, Altevir Signor¹

¹Universidade Estadual do Oeste do Parana-UNIOESTE, Brazil

*Corresponding author: Crislaine T.R.R. Ferrari: crislaineribeiroferrari@gmail.com



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Abstract:

The water crisis that Paraná is going through is unprecedented in the last 90 years. The measures that must be adopted by Companhia de Saneamento do Paraná (SANEPAR), must not only be emergency and immediate, it must be intuitive and implemented with a view to the long term. Therefore, the objective of this work is to present and list the losses caused by the water crisis, mainly in the State of Paraná, which worsened from 2019 and lasted until mid-2021. The El Niño and La Niña phenomena have relevant role in the anomalies of the temporal distribution of rainfall, causing, respectively, an increase or decrease in precipitation in periods of marked variation in the average temperature of the Pacific Ocean. The scarcity of rain corroborates several sectors of society. According to the Departamento de Economia Rural (DERAL), the computed losses for soybeans represent more than R\$ 23 billion, for corn it represents a total of R\$ 2.2 billion and for beans, the losses exceed R\$ 395 million. This entire amount will no longer circulate in Paraná's economy, affecting practically all segments. The measures that must be adopted by SANEPAR, together with public policies, must not only be emergency and immediate, it must be planned and implemented with a view to the long term.

Keywords: water crisis, El Niño, La Niña

Introduction

Increased consumption, inappropriate use of the resource, decrease in rainfall and poor use of the soil close to springs. All these points are directly linked to the lack of water in the different regions of Brazil and, depending on the situation, can lead to more serious problems, such as water crises, for example.

The State of Paraná is suffering from the drought of recent months. The lack of rain not only causes problems in the water supply for the population, but also affects agriculture, fish farming and livestock, in addition to water transport. In the West, Center, South, Center-South, Metropolitan Region and Coast regions – the occurrence is extreme drought, the greatest in 50 years (PARANÁ, 2021).

The long period of drought has caused several problems, mainly in terms of water supply for homes, industries and commerce in general. However, this factor is not restricted to the water distribution, corroborating with the implementation of rotation and “empty faucet” schedules.

The water crisis that Paraná is experiencing is unprecedented in the last 90 years. Low rainfall in recent months has affected the population as a whole.

The most affected sector is the water supply network, which has sought alternatives to meet demand, such as the use of artesian wells, but the most used strategy is rationing the supply to the population.

The electricity and logistics sectors were also affected by the low flow of rivers and lakes. An example is the value of the electricity tariff, which increasingly, with changes in the colors of the collection flags due to the increasing use of energy obtained by thermoelectric plants, production in hydroelectric plants is not managing to meet the demand for the product. And as for logistics, there is the use of more expensive modes for the transport of inputs, commodities and products, since the Paraná River Basin 3, as well as the Itaipu lake, are used for transport in the waterway modal, in which it is the modal that has the best cost-benefit ratio among the others. Strategies were also adopted so that Argentina and Paraguay could dispose of the 2020 harvest, Itaipu Binational Plant decided to open the floodgates so that the flow of the Paraná River would increase and the grains could be disposed through the modal.

However, also with great importance, food production, agriculture and livestock stand out. These activities require regular rainfall to have high productivity associated with products quality. Nevertheless, farmers who have access to financial resources, opted for investments to maintain their production, the impacts caused by the lack of rain can be minimized, but this is not a reality for everyone, especially when farmers are classified as small family farmers.

Water crises are characterized as cyclical due to the seasons and periods of rain, a problem that can be mitigated with planning and investment. According to the president of CREA-PR, Civil Engineer Ricardo Rocha, he argues that a major public policy by the Paraná Government in the management of hydrographic basins and aquifers would be fundamental to mitigate the problem, highlighting the importance of promoting the use of this resource by the large consumers, such as hydroelectric plants, agricultural irrigation, domestic supply and industries (REVISTA CREA-PR, S/D).

Geographer Pedro Augusto Breda Fontão, associate professor at the Department of Geography of the Earth Sciences Sector (CT/DGEOG) at the Universidade Federal do Paraná (UFPR), also comments on the importance of risk management, which according to him “As it is a phenomenon that usually takes decades to repeat itself, the planning ends up not being ideal and, when done, it is punctual, affecting the most vulnerable population with agricultural losses, lack of water, problems in the generation of electric energy, increase costs/inflation, between others”. He also points out that in 2021 the water crisis coincided with the Covid-19 pandemic, when hygiene was fundamental to controlling the disease, a factor that caused an increase in consumption, mainly domestic (REVISTA CREA-PR, S/D).

Another factor that corroborates the water crisis is the deforestation of forests. Greenpeace cites that in the last 40 years, the Amazon has lost 19% of its forest. The impacts are felt far beyond forest's borders and are closely linked to the water crisis in the rest of the country. They emphasize that "The Amazon alone transpires, daily, 20 billion tons of water vapor into the atmosphere – a volume greater than the flow of the Amazon River. All this moisture forms "flying rivers" that are carried by the wind to other regions of the country, irrigating crops and filling water reservoirs. By deforesting the Amazon, we interfere in an extremely negative way with the water cycle". In 2012, Greenpeace created a bill calling for Zero Deforestation. As it is a popular initiative, the document needs to reach 1.43 million signatures to be delivered and discussed by the National Congress (CONEXÃO VERDE GREENPEACE, S/D).

Thus, it is up to everyone, the community, public authorities and companies, to seek solutions and rationalize the use of water resources and raise environmental awareness regarding deforestation, in addition to creating and following public policies to preserve and ensure that water availability is not increasingly more scarce. The objective of this work is to present the problem caused by the water crisis, especially at the State of Paraná, in which it has worsened since 2019.

Theoretical reference

Water crisis in Parana

The State of Paraná is going through a severe drought; the rainfall indices of the last two years are below the historical annual averages until then.

In data released by the Paraná News Agency (PARANÁ, 2020), the drought in the West, Center, South, Center-South, Metropolitan Region, Curitiba and Coast - the occurrence is of extreme drought, the biggest in 50 years. The month of June 2020 was the driest month in practically all of Paraná, it rained from 80% to 100% less than expected for the period, and in none of the stations of the Sistema de Tecnologia e Monitoramento Ambiental do Paraná (SIMEPAR) the accumulated value exceeded 60.2 millimeters last month. The lowest rate was recorded at the Maringá station, which reached just 8.6 millimeters.

The same Agency also announced that the Instituto de Água e Terra (IAT) published an ordinance that suspended for 30 days the practice of controlled burning in the cultivation of sugarcane, the most common activity in the Northern region of the State.

Another factor that may be a consequence of the lack of rain is that the water bodies with the reduction in flow have an increase in dissolved and particulate organic matter, increasing its degree of pollution, thus reducing the availability of oxygen causing the death of fish.

Through Resolution nº 77/2021, the Agência Nacional de Águas (ANA) (BRASIL, 2021), highlights that the National Meteorology System has already found that, since October 2019, the volume of rainfall in Paraná is deficient. Consequently, the current levels of the reservoirs are below the marks registered in similar periods of previous years.

"The scenario observed in the Hydrographic Region of Paraná is one of relevant water scarcity compared to previous periods and the unfavorable situation forecast for the coming months represents

impacts on water uses, especially for non-consumptive uses [in which there is water consumption] leisure and tourism, navigation and hydroelectric generation” (BRASIL, 2021).

The rainfall values for the last months of 2021 are well below expectations, to exemplify this situation we have the data for the month of April, in which of the 13 municipalities analyzed by SIMEPAR, only in Guaratuba the rain was higher than average. In total, the precipitation in 13 different points of the State was 369 millimeters (mm), or 25.7% of the historical average, estimated at 1,434.1 mm accumulated for these same areas. Londrina was the city with the least amount of rain in the month of May among the locations surveyed. Just 0.6 mm, compared to an expectation of 85.1 mm. Pato Branco (3 mm), Maringá (3.4 mm), Cascavel (3.8 mm), Guarapuava (4.8 mm), Umuarama (4.8 mm) and Campo Mourão (7.6 mm) appear in the sequence, all with the worst April in history. Ponta Grossa (9.6 mm), Cambará (10.8 mm) and Paranavaí (17.6 mm) also had rainfall well below average. Foz do Iguaçu registered 41.3% of the expected volume (147.1). Curitiba had a rainfall of 8.8 mm, about 10% of the expected for the period (81.6 mm) (PARANÁ, 2021).

But there are indications that the drought is a reflection of an El Niño. However, this phenomenon causes an increase in the temperature of the Pacific Ocean surface, in the equatorial region, causes more rains and that La Niña is what causes drought, as explained by researcher Alice Marlene Grimm, professor at the UFPR and PhD in Meteorology from the Universidade de São Paulo (USP) (GAZETA DO POVO, 2022).

According to Marcuzzo and Romero (2013) concluded that the El Niño and La Niña phenomena play a relevant role in the anomalies of the temporal distribution of rainfall, causing, respectively, an increase or decrease in precipitation in periods of marked variation in the average temperature of the Pacific Ocean.

El Niño

El Niño, a natural phenomenon classified as a “climate anomaly”, is repeated at irregular intervals, which usually vary between two and seven years. This climatic event occurs due to the abnormal heating of the waters of the Pacific Ocean, more precisely in areas close to the west coast of Peru and neighboring countries (MUNDO EDUCAÇÃO, N/D).

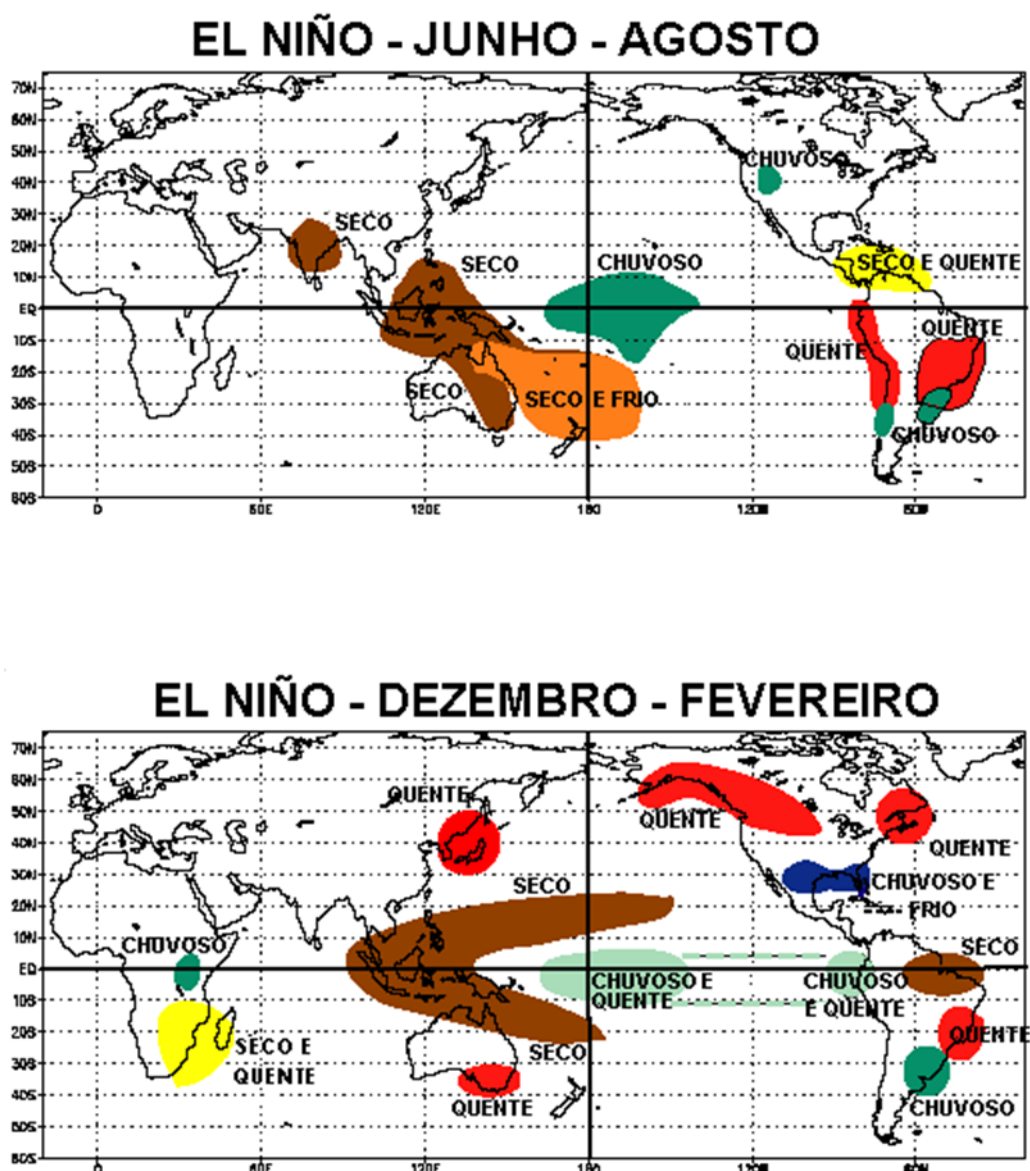
In Peru, the documentary archives of the first settlers confirm that its impacts (floods, disturbance of marine life, etc.) were known by the time the first conqueror, Pizarro, set foot there in 1525. According to paleoclimatic indicators such as geological evidence and tree growth rings, this event has been going on for thousands of years and probably as long as the 20th century (ENFIELD & ENFIELD, 2002).

According to the Institute of Agricultural Economics of the Secretary of Agriculture and Supply of the State of São Paulo, geological evidence of occurrences in Peruvian coastal communities dating back at least 13,000 years was found. The Incas, who knew about El Niño, built their cities on the top of hills and the population kept food stocks in the mountains; if it was built in the coastal region, it was not near rivers. But only about 25 years ago did the rest of the world begin to pay attention to this phenomenon, after the devastation caused in 1982-83, intensifying efforts to understand how the process occurs globally (SÃO PAULO, 2002).

Experts point out that in El Niño years, rainfall becomes more intense especially during the winter and cold waves are generally less frequent.

The 1997-98 El Niño marked, for the first time in human history, the occurrence in which climate scientists were able to predict in advance times of abnormal floods and months of drought, allowing threatened populations to prepare for time (SUPLEE, 2002).

As can be observed in the Figure 1 (from June to August and from December to February), during the winter and summer of the Southern Hemisphere, rainy in Southern Brazil and warmer in the Southeast to Northeast region; from December to February, rainy in the South, hot in the Southeast and dry in the Northeast.



Source: CPTEP, 2001a.

Under normal conditions, the trade winds blow west across the Equatorial Pacific. These winds accumulate warm surface water in the Western Pacific, so the sea surface is approximately half a meter higher in Indonesia than in Ecuador. During the occurrence of El Niño, the winds relax in the Center and Western

Pacific and the sea surface temperature is approximately 8 °C higher in the Western region (SÃO PAULO, 2002).

Thus, when an El Niño phenomenon occurs, the evaporation of sea water from the Pacific increases, causing movements that transport moisture to the upper levels of the atmosphere, forming clouds and causing above-normal precipitation over the Pacific.

Also, according to meteorologist Luiz Renato Lazinski, El Niño is characterized by warming, while La Niña is the cooling of the temperature in the equatorial portion of the Pacific Ocean, which due to the size of this ocean, being the largest and covering almost half of the globe, with changes in temperature, evaporation increases or decreases, generating more or less energy in the atmosphere. This energy modifies the intensity and direction of winds across the globe, altering rainfall patterns (O PRESENTE, 2021).

La Niña

According to Naime (2011), the La Niña phenomenon corresponds to the anomalous cooling of the sea surface, in the equatorial region of the Center and Eastern Pacific Ocean. This increases the pressure in the region, with the generation of more intense trade winds. The duration of the phenomenon is also 12-18 months. However, the Centro de Previsão de Estudos Climáticos (CPTEC, s/d(b)) mentions that the episodes may also present frequencies from 2 to 7 years, but with lower occurrence and periods approximately 9 to 12 months and only a few episodes persist for more than 2 years.

However, this meteorological phenomenon produces less damage than El Niño. As a consequence of La Niña, the cold fronts that reach the South of Brazil, have its passage accelerated and become more intense. When this occurs, the interior and coast of Bahia and Alagoas are affected by increased rainfall, which also occurs in the North and East of the Amazon region. In the Center-south region, droughts can occur with the fall of rainfall between September and February, with a more intense arrival of polar air masses, generating anticipation of the winter periods and large drops in temperature already in the autumn (CPTEC, s/d(b)). These conditions have been observed in recent years, mainly in the State of Paraná.

In the study by the authors Grimm et al (2020) concluded that the 2020 drought in the Southern region of the country caused by low levels of precipitation and this behavior is due to the combination of opposite phases of two interdecade climatic oscillations in sea surface temperature, and this oscillation is directly related to the El Niño and La Niña effects. This combination produces variation in the basic state of the atmosphere that favors drought in Southern Brazil and the more frequent occurrence of droughts. For an extreme event to occur, it is usually necessary that, in addition to interdecade oscillations, an interannual oscillation event that also favors drought, such as the Central El Niño events in 2020 and La Niña in 2009 and 2012, years of droughts in Southern Brazil during the same phase combination of the two interdecadal oscillations.

Meteorologist Luiz Renato Lazinski comments that in the South region, in La Niña years, the chance of droughts increases. In addition, he emphasizes that winters are usually colder (O PRESENTE, 2021).

The National Institute of Meteorology, linked to the Ministério da Agricultura, Pecuária e Abastecimento ((MAPA) 2022), the probable performance of La Niña until the beginning of summer (December) may impact the final stages of winter and second crops, in addition to the beginning of the summer crop in Brazil. As

the climate models indicate, the persistence of the phenomenon, even if of low intensity, makes the climate forecasts in the producing regions to be evaluated with more attention. Often, La Niña causes a reduction in rainfall in the Southern region of the country and an increase in the Northern and Northeastern regions. The climate in Brazil, however, is not influenced only by the phenomenon, considering that there are other factors to be considered and that interfere with meteorological and climatic conditions.

Methodology

This work is characterized by bibliographical and documentary research and data collection, thus obtaining extensive knowledge and information about the subject.

Bibliographical research is of paramount importance for obtaining knowledge and bringing the author closer to the subject, in which it is applied by searching books, articles, theses, among other ways through a theoretical framework. This research, also known as secondary research, refers to references already published in the form of scientific articles, whether printed or virtual, books, doctoral theses or master's dissertations (MARCONI; LAKATOS, 2019).

The bibliographical research will use data published in public documents on government websites, as well as works that have already addressed information on rainfall indices, with average annual rainfall, as well as the use of documents made available by meteorological systems.

Results and discussions

Drought effects in Parana

Water supply

The effects of the long period of below-average rainfall are causing water supply problems across the State. The Companhia de Saneamento do Paraná (SANEPAR), informs on its homepage the critical situation in all regions of the State.

Bellow are some publications that the company linked in the year of 2021 and also in early 2022.

- a) “Sanepar alerts the population of Ubiratã, in the Northwest of the State, to the rational use of water due to the drought that reduced the flow of the Água Grande River, the city’s water source by 50% [...]
- b) Sanepar alerts the population of Umuarama to save water. The Company increased water production in the city by 15% in December, compared to previous months, but the increase in consumption due to high temperatures and dry weather raises the alarm. The water production and distribution units are operating at the limit of its capacity and the Piava River had a 45% drop in flow due to the drought [...].

- c) Sanepar had to adopt the rotation system so that all properties in the city of Palotina, in the West of the State, would receive equally treated water [...].
- d) The prolonged drought, with rainfall around 50% below the average, reduced the flow of the seven wells and mines that supply the system. The springs lost more than 15% of its flows, compromising the system that supplies more than 30,000 residents of the city. On the other hand, drought and high temperatures have increased consumption by 20% [...].
- e) The lack of rain, the increase in temperatures and the increase in water consumption put Sanepar in a state of alert in the Northwest region of the State. With the reduced flow rates in the springs and the drop in the levels of the reservoirs that supply the residents, there is the possibility of a temporary lack of water or low pressure in the water distribution networks. The most affected cities are Goioerê, Iretama, Paranaíba, Porto Rico, in addition to the districts of Águas de Jurema, in Iretama, and Bredápolis, in Janiópolis [...].
- f) Laranjeiras do Sul, Dois Vizinhos and part of Colombo, in the metropolitan region of Curitiba, have implemented a rotation system. The cities of Nova Esperança do Sudoeste, Capanema, Planalto, Salto do Lontra, Matelândia, Nova Laranjeiras and Palmital are in a state of alert, with water sources at minimum levels and very high consumption due to the heat wave, causing a deficit in production in relation to the demand from the population [...].
- g) The three wells that supply the city of Céu Azul lost about 50% of the volume of water available for collection and treatment. In addition, higher temperatures and the consequent increase in water consumption are directly interfering with the city's water supply system. The weekend was critical and the system had low pressure in the networks and even a lack of water at certain times. With no forecast of regular rains, it is possible that in the next days it will be necessary to implement a rotation in the supply [...].
- h) The cities of Nova Prata do Iguaçu, Salto do Lontra, Salgado Filho, Capanema and Planalto are in a state of alert. The prolonged drought drastically affected the flow of springs in some cities in the Southwest of the State and the high temperatures caused an increase in water consumption. In the Siemens, Tamanduá, Santa Cruz, Salto do Lontra and Cotegipe rivers, which supply these cities, the reduction in flow reaches, on average, 60%, putting the water supply to the population at risk. The cities of Santo Antônio do Sudoeste, Pranchita, supplied by a well, and Dois Vizinhos, supplied by the Girau Alto River and by a well, are already running on water supply [...]" (SANEPAR, s/d).

Still according to SANEPAR (s/d), the high temperatures in the first months of 2022 caused consumption to increase significantly, as mentioned above, and the rainfall deficit corroborated the drop in the flows of rivers and wells, being fundamental the adoption of rotational supply in a large part of the State.

The Court of Auditors of Paraná issued an official document on August 16, 2022, requesting that SANEPAR present what measures were adopted to face the water crisis and makes 28 recommendations to the company, among which we can mention (TCEPR, 2022):

- a) Schedule of delayed works and investments.
- b) Consolidate the information resulting from the comparison between production and demand of the various Sanepar supply systems, in order to enable the extraction of reports that allow for the strategic management of these needs.
- c) Integrate information on the availability of groundwater collection into the hydrometeorological information system, so that it can be used in the monitoring of water supply systems, in addition to considering the use of this information as a strategic subsidy in the decision-making process in events of water shortage.
- d) Review the water unavailability indicator so that it is able and sensitive to generate strategic alerts in water scarcity scenarios.
- e) Improve and standardize the technical criteria, indicators and parameters that allow subsidizing the decision to start, remain, end and resume water supply rotations.
- f) Establish an action plan that allows monitoring the implementation of the Water Safety Plans (WSP) in Sanepar's supply systems, containing a schedule of procedures to be performed, as well as the deadline and unit or sector responsible for the execution.
- g) Establish adequate mechanisms for measuring the results of the water rationing plan.
- h) Propose to the regulatory agency a model contract or amendment that establishes responsibilities, conditions and deadlines for the implementation of Programs for the Conservation of Springs, Basin Management or projects and works for the preservation and recovery of strategic water bodies for supply.
- i) Propose to the regulatory agency adaptations in the program-contract model for the provision of public water supply service to Article 10 of Law n° 11.445/2007, for the inclusion of clauses that provide for reducing losses in the distribution of treated water.

SANEPAR has a period of 180 days to make the requested adjustments.

Agricultural production

Agricultural production also suffers from low rainfall, as well as rising soil and air temperatures. According to the current Secretary of Agriculture of Paraná, Norberto Ortigara, cites in Canal Rural Paraná Portal (2022) that the break until January 2022 is 9 million tons of soybeans, corn and beans, with a loss of about R\$ 30 billion, he also estimated soybean losses of 65% in the West and 73% in the Southwest of Paraná, in addition to a loss of 55% of corn in the West and 64% in the Southwest, where the grain cannot be used even for silage.

On the other hand, the OCEPAR System Portal (2022) cites, as an estimate, that soybean, the main crop of this period in the 2021/22 harvest, had a loss percentage of 37%. Initially, a harvest of just over 21 million tons was projected. However, according to the January survey, approximately 7.9 million were not harvested, leaving a production of 13 million tons. In this crop alone, the estimate of monetary loss is R\$ 21.5 billion. Soybeans planted in Paraná, in January 2022,

in the planting and harvesting bulletin, the crop had 13% in vegetative development, 31% in flowering, 49% in fruiting and 7% in maturation. And when comparing the current bulletin with that of December 2021, the percentage of soybean in poor condition increased from 13% to 31%, on average condition it went from 30% to 39%, while good condition it fell from 57% to 30%.

Also according to the same portal, in corn first-crop, the partial forecast was a 34% drop, from 4.2 million tons initially forecast to 2.7 million tons. Producers will no longer receive R\$ 2 billion. Of the sown corn, the bad condition rose from 10% to 25% of the harvest. On average, it is 40%, against 27% in December 2021. While the percentage of good ones dropped from 63% to 35%.

In a report to the website O Presente Rural (2022), the Departamento de Economia Rural (DERAL) of the State Secretary for Agriculture and Supply had an initial forecast for the 2021/22 soybean crop to exceed 21 million tons, but only 12.8 million tons were harvested, down 39%. In beans, this loss was around 31%, and in corn, a central input for the development of animal production chains, the percentage of losses reached 36%. The department concludes that the break at the end of the crop triggers a domino effect that impacts other activities that depend on the primary sector to produce, such as the production of animal protein (poultry, cattle, swine, fish, eggs and milk). Cattle raisers will face shortages and high prices in livestock feed and the agroindustry will have less raw material to process.

Investment analysts analyze the effects of La Niña extended for another year and estimate a global recession priced in agricultural commodities as a consequence of weather conditions. Corn planting was anticipated in Southern Brazil, a factor that will benefit grain exports, since in Argentina, the drought caused a reduction in the planted area, and in the United States, with the beginning of the harvest, the quality of the crop improved if deteriorated and demand from China is growing. In the case of soybeans, the prospects are not good: the drought in Argentina and the slower and lower quality harvest in the USA put pressure on prices in the short term (EXPERT XP, 2022).

Conclusions

The lack of rain corroborates several sectors of society. According to DERAL, the computed losses for soybeans represent more than R\$ 23 billion, for corn it adds up to R\$ 2.2 billion and for beans, the losses exceed R\$ 395 million. This entire amount will no longer circulate in Paraná's economy, affecting practically all segments.

As a result, there is an increase in commodities, due to the economic principle of supply and demand, making products that require these raw materials end up becoming more expensive for consumers in general.

The domestic and industrial use of this resource ends up becoming more expensive in terms of expenses and this leads to the financial unavailability of other items also necessary for daily activities. In addition, there is also the restriction for human and domestic use, which can contribute to public health problems.

The measures that must be adopted by SANEPAR, must not only be emergency and immediate, it must be planned and implemented aiming at the long term, because with the effects of La Niña, El Niño, deforestation, pollution and several others environmental effects and climatic problems, make the lack of rain increasingly recurrent and cyclical. It is also up to public policies to face this issue and seek strategies and solutions.

References

- Brasil. Agência Nacional de Águas – ANA. Resolução ANA nº 77 de 1º de junho de 2021. Disponível em: < <https://agenciabrasil.ebc.com.br/geral/noticia/2021-06/ana-cria-grupo-tecnico-para-monitorar-situacao-na-bacia-do-parana>> Acesso em: junho 2021.
- Canal rural Paraná. No Paraná, estiagem é mais severa em áreas agrícolas do oeste e sudoeste; perdas chegam a 73%. Disponível em: <<https://www.canalrural.com.br/parana/estiagem-e-mais-severa-em-areas-agricolas-do-oeste-e-sudoeste-do-pr-perdas-chegam-a-73/>> Acesso em: setembro 2022.
- Centro de previsão de tempo e estudos climáticos (cptec). instituto nacional de pesquisas espaciais (inpe). Efeitos conhecidos do El Niño. Disponível em: <<http://cptec.inpe.br/products/elinho/efeitos.gif>>. Acesso em: agosto 2022a.
- Centro de previsão de tempo e estudos climáticos (cptec). instituto nacional de pesquisas espaciais (INPE). La Niña. Disponível em: < <http://enos.cptec.inpe.br/lanina/pt>>. Acesso em: agosto 2022b.
- Companhia De Saneamento DO Paraná. Crise Hídrica. Disponível em: <<https://site.sanepar.com.br/noticias/categoria-desta-noticia/crise-hidrica>>. Acesso em: agosto 2022.
- Conexão Verde Greenpeace. Informações sobre a atual crise hídrica no Paraná. Disponível em: <<https://conexaoverde.greenpeace.org.br/system/files/2020-09/Crise%20H%C3%ADrica%20Compilado.pdf>>. Acesso em: outubro 2022.
- Enfield, David B.; Enfield, D. Michael. The 'El Niño' FAQ: Frequently Asked Questions About El Niño-Southern Oscillation (ENSO). Disponível em: http://www.aoml.noaa.gov/general/enso_faq/. Acesso em: agosto 2022.
- Gazeta do povo. O que provocou a falta de chuva no Paraná, deixando torneiras e lavouras secas. Disponível em: <<https://www.gazetadopovo.com.br/parana/crise-hidrica-parana-2020-fenomeno-chuvas/>>. Acesso em: julho 2022.
- Grimm, A. M.; Almeida, A. S.; Beneti, C. A. A.; Leite, E. A. O Efeito Combinado de Oscilações Climáticas na Produção de Extremos: A Seca de 2020 no Sul do Brasil. *Revista Brasileira de Recursos Hídricos*, Porto Alegre, v. 25, e48, 2020.
- Mapa – Ministério da Agricultura, Pecuária e Abastecimento. Instituto Nacional de Meteorologia. Previsão Climática para a safra 2022/2023. Disponível em: < <https://portal.inmet.gov.br/noticias/previs%C3%A3o-clim%C3%A1tica-para-a-safra-2022-2023>> Acesso em: outubro 2022.
- Marconi, Marina de Andrade; LAKATOS, Eva Maria. *Fundamentos de Metodologias Científicas*. 8. ed. São Paulo: Atlas, 2019.
- Marcuzzo, F. F. N.; Romero, V. Influência do El Niño e La Niña na Precipitação Máxima Diária do Estado de Goiás. *Revista Brasileira de Meteorologia*, v.28, n.4, 429 - 440, 2013.
- Mundo educação. Influência do El Niño no Brasil. Disponível em: < <https://mundoeducacao.uol.com.br/geografia/influencia-el-nino-no-brasil.htm>>. Acesso em: agosto 2022.
- Naime, Roberto. Fenômeno La Niña. Disponível em: < <https://www.ecodebate.com.br/2011/03/30/fenomeno-la-nina-artigo-de-roberto-naime/>>. Acesso em: agosto 2022.
- O presente. Retorno da La Niña deve prolongar estiagem no Paraná até abril de 2022. Disponível em: < <https://www.opresente.com.br/parana/retorno-da-la-nina-deve-prolongar-estiagem-no-parana-ate-abril-de-2022/>>. Acesso em: outubro 2022.
- O presente rural. Diagnóstico da seca no Paraná aponta prejuízos bilionários. Disponível em: < <https://opresenterural.com.br/diagnostico-da-seca-no-parana-aponta-prejuizos-bilionarios/>>. Acesso em: setembro 2022.
- Paraná. Agência de Notícias do Paraná. Estiagem no Paraná pode perdurar até fevereiro de 2021. Disponível em: <<http://www.aen.pr.gov.br/modules/noticias/article.php?storyid=108289>>. Acesso em: junho de 2021.
- Paraná. Agência de Notícias do Paraná. Abril mais seco da história volta a agravar a crise hídrica no Paraná. Disponível em: < <https://www.aen.pr.gov.br/modules/noticias/article.php?storyid=112168&tit=Abril-mais-seco-da-historia-volta-a-agravar-a-crise-hidrica-no-Parana> >. Acesso em: junho de 2021.
- Revista crea-pr. a Crise Hídrica no Paraná: Problema Cíclico, Escassez de água pode ser mitigada com planejamento e investimento. Disponível em: <<https://revista.crea-pr.org.br/a-crise-hidrica-no-parana/>>. Acesso em: outubro 2022.
- Sistema ocepar. seca II: Com estiagem, agricultura paranaense estima redução nas safras de soja, milho e feijão. Disponível em: <<https://www.paranacooperativo.coop.br/ppc/index.php/sistema-ocepar/comunicacao/2011-12-07-11-06-29/ultimas-noticias/138686-seca-ii-com-estiagem-agricultura-paranaense-estima-reducao-nas-safras-de-soja-milho-e-feijao>>. Acesso em: setembro 2022.

São paulo. Secretaria de Agricultura e Abastecimento. El Niño 2002-03 E A Anomalia Climática. Disponível em: < <http://www.iea.sp.gov.br/out/LerTexto.php?codTexto=122>>. Acesso em: agosto de 2022.

Suplee, Curt. El Niño/La Niña: Nature's Vicious Cycle. Disponível em: <http://www.nationalgeographic.com/elniño/mainpage2.html>. Acesso em: agosto 2022.

Tribunal de contas do estado do paraná – tcepr. tce-pr indica 28 medidas para auxiliar Sanepar a enfrentar crises hídricas. Disponível em: < <https://www1.tce.pr.gov.br/noticias/tce-pr-indica-28-medidas-para-auxiliar-sanepar-a-enfrentar-criSES-hidricas/9932/N>>. Acesso em: outubro 2022.