HUMAN GEOGRAPHIES – *Journal of Studies and Research in Human Geography*
(2010) **4.2**, 99-107

www.humangeographies.org.ro

HUMAN GEOGRAPHIES
Journal of Studies and Research in Human Geography

SOCIAL AND ECONOMIC IMPACTS OF CLIMATIC WATER BALANCE IN FOUR MICROREGIONS OF THE WESTERN PARANA STATE BRAZIL

Claudia Moreira Garcia[a]*

[a] *Federal University of the Paraná - Curitiba – Paraná, Brazil*

Abstract: This article aims to look in a certain degree of depth at a possible relationship established between climatic aspects such as the phenomena of El Niño and La Niña, water retention at soil level and the influence on economic life of four most agricultural cities in western Paraná State/Brazil The depth of the study is given by statistical data and specific statistics performed on it. Methodology includes techniques such as specific spreadsheet development, statistical tests to confirm the results. Once the tests have confirmed the climatic characteristics, statistical tests have also been performed on the data concerning El Niño and La Niña phenomena in order to have their degree of impact on the studied cities, confirmed. The foreseen and expected results were with respect to the relationship established at the level of water excess in the ground in the periods of El Niño and water scarcity in the ground in the woolen periods of La Niña, and its impact on the economic life of the whole region.

Key words: El Niño, La Niña, Water excess, Water scarcity, Agricultural economy, Parana State.

Introduction

The State of Paraná has always been considered one of Brazil's agricultural barns. There has always been in the past, problems with cyclical climatic variation, such as big frost of the seventies, but from the eighties a new element is added to the research climate in southern Brazil, El Niño or ENSO - Southern Oscillation which is more generally a phenomenon of the atmosphere-ocean interaction, associated with changes in normal patterns of sea surface temperature (SST) and the trade winds in the Equatorial Pacific, between Peru and the Pacific Coast west near Australia (Oliveira, 2001).

These changes are represented by increased precipitation and consequently changing the water balance, which means that farmers have to adapt to these changes.

According to Costa (1995), the water balance of soil water or simply water balance will relate the physical and hydraulic properties of soil components with input and output of water the same is a practical method to quantify and study the water factor. Reichard (1987) distinguishes two basic types:

a. Water Balance Real - which shows the water situation for crops through the accounts of all additions and withdrawals of water that actually occur in a given area.

b. Climatic Water Balance - will get through a series of meteorological data obtained own stations in a given period and place (daily, monthly, yearly or for certain periods). From these data it has been estimated to occur in that particular area regarding the water situation, characterizing this place in terms of hydrology.

Climatic water balance proposed by Thornthwaite (1948), subsequently modified by Mather (1955), known today as the Thornthwaite Water Balance & Mather (1955) is one of several ways to monitor the change in water storage in soil. Become one of the most practical and most used for this type of work (Costa, 1995).

*Corresponding author:
Email: claudia_moreiragarcia@yahoo.com.br

For Pereira et al (1997), the water balance is an accounting system for monitoring soil water and by applying the principle of conservation of mass to volume of water in soil vegetated. They are also though the climatic water balance, described by Thornthwaite & Mather (1955) is one of several ways to monitor the water storage in soil.

This study is based on the survey of the average historical weather data from 1988 to 1998 in four regions of the State of Paraná, namely: Palmas, Guarapuava, Cascavel and Pato Branco. Besides the aspects related to water balance, we investigated the influence of El Niño and La Niña, climate and rainfall in the behavior of regions through statistical analysis based on ANOVA and Duncan's test.

Study area

The State of Paraná is located in the south of Brazil, characterized by having most of its area dedicated to agricultural practices (Figure 1). It is a state small compared to others; it has about 200.000 square kilometers, roughly corresponding to 2.34% of Brazil which has about 8.511.965 km ². Compared to other states of Brazil Paraná occupies the 5th place in extent. Geological evolution composed mainly of igneous and metamorphic rocks that make up the bedrock of the South American plate, where after different periods have been covered by volcanic and sedimentary rocks.

Figure 1. Location of the State of Paraná

From the geomorphologic point of view the state of Parana was classified into units based on the structure and forms.

These units are classified as: Orogenic Belt of the Atlantic, and its maximum representation to the track owned by the Coast Range, which separates the coastal plain of the First Paranaense Plateau. Within this unit are the structural units sculptural called Serra do Mar and First Paranaense Plateau (also known as the Curitiba plateau), the second unit is the Paraná Sedimentary Basin, an extensive area covering several states of Brazil showing the bedrock of the period Precambrian, being composed of crystalline rocks that were covered by marine and continental sediments of the Upper Silurian to the Cretaceous.

Are your unit's morphosculptural the Second and Third Paranaense Plateau, known as Planalto Ponta Grossa and Guarapuava respectively. The third unit is called the Cenozoic sedimentary basins and tectonic depressions are subdivided into smaller unit's morphosculptural: the coastal plain, the alluvial plains associated with major rivers of the state and sedimentary basin of Curitiba

The municipalities studied in this research belong to the mesoregions Southwestern (Pato Branco), center-south (Guarapuava and Palmas), west (Rattlesnake) of Paraná. All municipalities belong to the 3rd Paranaense Plateau, known as Plateau Guarapuava (Figure 2).

The city of Pato Branco presents peculiar characteristics. It is considered a city of recent development presenting as agriculture and economic profile today, a

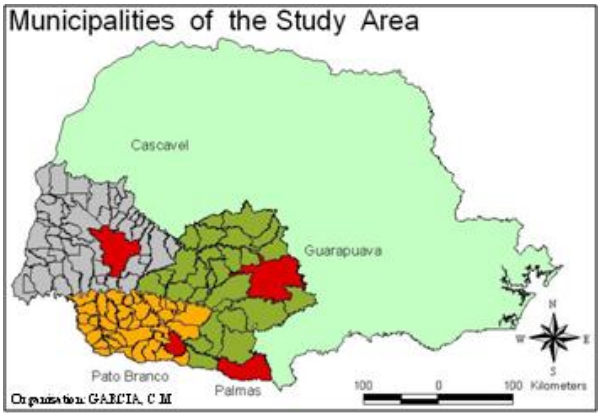

Figure 2. Study area

small technology center industry, mainly in software development. Family farms and small owners is the focus on the development of productive activities.

Already Guarapuava, considered a regional center in Parana, presents a historical evolution in economic and agricultural state. Extraction of timber from the beginning of the twentieth century, the capitalist agriculture of the century, this town shows up with a peripheral economy, since it is dependent on other more developed economic centers. Despite that agriculture is still one of the region's economic engines. Rattlesnake is one of the most important regional centers of the State of Paraná, economic activity was the exploitation of mate tea and timber in the twentieth century. Today, the exhausted timber resources, has in agriculture and agribusiness starting point for economic development.

The city of Palmas is part of the rancher called economy, economic activity beyond agriculture and horticulture stand out within the economic aspects. Although not a regional economic center, is one of more of the municipalities develop economically.

The four cities studied has the economic leverage, agricultural production, either through small agrcultores or atarvés agribusiness. Municipalities are of great influence at the regional level, depending on where a larger metropolis, such as the capital Curitiba.

Characterization of the studied municipalities

Some characteristics of these municipalities have small variations, especially with regard to climate.

a. Guarapuava: the Guarapuava located in Southern classified as central-southern state of Parana. It is located at 25º21 'south latitude and 51º.30' west longitude with maximum altitude of 1.058m. According to Maack (2002), is seated in the third or the Parana Plateau Plateau Guarapuava. Its population is characteristically urban, despite their economic activities mainly focused on agriculture. Maack (2002), from the standpoint of vegetation, Guarapuava characterized by a landscape of grassland, woods and riparian vegetation associated with Araucaria. Today, much of this vegetation has been replaced by areas of agricultural production. Also according to Maack (2002), from the standpoint of vegetation, Guarapuava characterized by a landscape of grassland, woods and riparian vegetation associated with Araucaria. Today, much of this vegetation has been replaced by areas of agricultural production.

Regarding climate, characterized by presenting Köppen, characteristics of temperate (Cfb), with average temperatures in the coldest month below 18º C (mesothermal), with cool summers and temperature in the warmest month, down 22º.C without a dry season. In the region we found a variation in precipitation around 1500 to 1800 mm per year.

Its geological origin dates back to the Mesozoic Era, Jurassic and Cretaceous, with the formation of Group Sao Bento, more specifically in the Botucatu Formation (aeolian sandstones) and Serra Geral (acidic and basic igneous). Its soil and throughout the third plateau, developed from magmatic rocks is very fertile and is characterized by soil type cambiss and latossolos

Its main products are corn agrosilvopastoris (normal crop), soybeans (normal harvest) and dry potato (plain), these productions represent 8.95% of economic activities in the region

b. Cascavel - Belonging to the middle region of the West of Paraná, located at 24º.53 'south latitude and 53º33' west longitude. Displays maximum altitude of 660 m. From the climatic point of view this region and is classified as subtropical (cfa), with an average temperature of the coldest month below 18º.C (mesothermal), the average temperature in the warmest month above 22º C, with hot summers, infrequent frosts and trend of concentration of rainfall during the summer months, but with no definite dry season. Its rainfall varies between 1.800 and 1.900 mm annual average.

Originally, this area was composed of grasslands; areas of Araucaria Forest and Vegetation of Lowland, with the introduction

of an extremely active agriculture, there were only small pockets of primary forests of hardwoods and hardwoods with Araucaria Forests. Geologically this region finds, as well as Guarapuava and much of the western state, a region of the Mesozoic era, Jurassic and Cretaceous, forming St. Benedict, with a predominance of basalt lava rocks and sandstones. Because this training will meet the type soil and latosol neossolos. Among the main products is soybean (normal harvest) and poultry. Agricultural activities account for 5.95% of economic activities in the region.

c. Pato Branco - from the middle part of the Southwest Parana. It is located 26º.07' South latitude and 52º41' longitude west, with maximum elevation of 700m. Has the same climatic characteristic of the cities above. Its average annual precipitation is around 1.900 mm. Your vegetative original framework was composed of Secondary Forests (Zone Araucaria) and Araucaria forests in itself. Today it has completely devastated with small areas of hardwood forest with Araucaria. The geology of the area has to be composed of regions in the same manner described above, differs in some aspects related to soil type. In this area we Oxisols, Inceptisols and Neossolos.

d. Palmas - Belonging to the middle region of south-central Paraná, is located on 26º 29' South latitude and 51º 59 'west longitude, with a maximum altitude of around 1.100 climate is subtropical (Cfb) exhibiting the same characteristics described earlier about this kind of weather. Its average annual rainfall is around 1.500 to 1.900 mm, is considered one of the coldest regions of the state.

His original vegetation was composed of Araucaria forest, lowlands and secondary forests (Araucaria zone). Geological features in the same type as described above, your soil is almost entirely composed of Inceptisols, Oxisols and neossolos. From the standpoint agroecology region and characterized by pasture and forage, and apple wood logs. Farming has to correspond to 25.19% of economic activities in the region.

Research methods

To develop this research used three different methods for assessing the climatic water balance and verify the influence of El Niño and La Niña on the municipalities presented, they are:

Method Thortonwait and Mather, 1955

The climatic water balance was performed following the method of Thornthwaite and Mather (1955), this method takes into account the analysis of weather data and will lead to estimates of evapotranspiration, water surplus, water deficit. The calculations were performed using the computer program Normal water balance, using an Excel spreadsheet prepared by Rolim and Sentelhas (1999).

To perform these calculations were needed for the monthly mean air temperature, average monthly rainfall, coordinates Geographical, altitude and CAD (Available Water Capacity), this sets the maximum water storage in the soil, which was adopted in all counties the reference value of 100 mm.

The data used for this research were provided by IAPAR - Institute Agronomy of Paraná (Londrina section) and contains elements of latitude, longitude, altitude and monthly summaries and annual temperature and precipitation of the localities under study: Palmas (weather station - Cod. 02,651,043), Cascavel (weather station - Cod. 02,453,023) Guarapuava (weather station - Cod. 02,551,010) and Pato Branco (weather station cod. 0265235) for a period 10 years (1988-1998).

Analysis of Variance

An analysis of variance that allows various groups to be compared at once, using continuous variables. The test is parametric (the variable of interest should have a normal distribution) and the groups must be independent. After the calculation of water balance has become only the data in the years of occurrence of El Niño and La Niña and from these data is effected analysis of variance by region specific and general.

The procedure of analysis of variance, is to do a randomized block design, connecting the values of "excess" of each region in the period of 10 years in the period of performance of El Niño (1991-92-93-94 - 95-97 and 98) and La Niña (1988-89 - 95 and 96), proceeding in this way the statistical analysis where there was interference or not the phenomena in the counties surveyed.

Duncan Test

To confirm the findings in the analysis of variance used the Duncan test. It is a multiple comparison test, which calculates a set of comparators. Allowing them to be compared all the means of treatment no matter their number, ensuring a level of significance.

Results

Water Balance

Were made spreadsheets and graphs corresponding to the four cities studied, where it was observed that all regions had a water surplus during the historical period studied. These results provide the characteristic regions of temperate climate (subtropical), which does not present a definite dry season. As for the aspects of precipitation, the period studied showed peaks of rainfall that exceeded the historical average. When evaluating each individual council took up the following result:

Guarapuava - shows a water surplus throughout the year, showing a decrease in rainfall in August, however the months of September and October a high rate, to drop again in November. Has a high rainfall in the years 1996-97-98, in comparison with other years, according to a characterization of the area will change rainfall in the region around 1500 to 1800 mm per year, but in the annual summaries can verify it does not happen (Figure 3).

Cascavel – shows a water surplus throughout the year, with a higher peak in October. Checking - if the annual summaries, it appears that in recent years in the period we will have a higher incidence of rainfall, as in

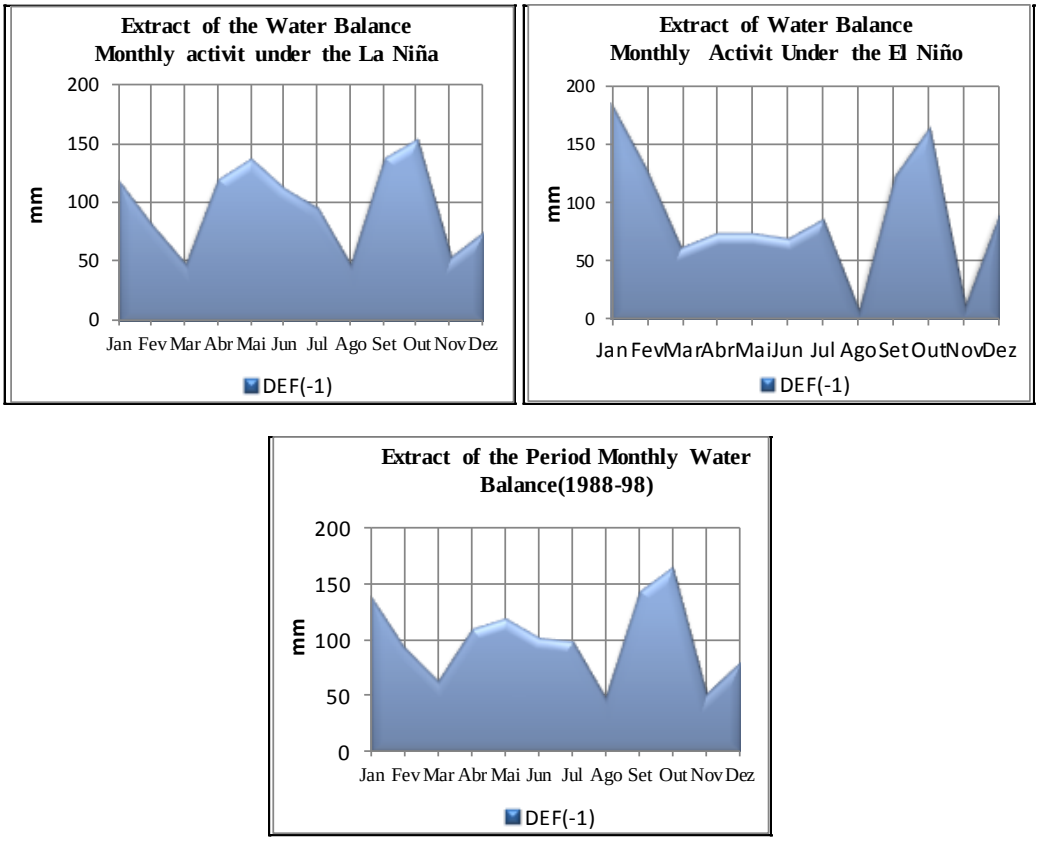

Figure 3. Results of Guarapuava

all other regions and may also be explained by the performance of seasonal weather phenomena (Figure 4).

Pato Branco - shows a water surplus, almost the entire year, a decrease occurring in the month of March, but it does not get less than its capacity. We will have in October a high concentration of rainfall, corresponding to spring season not to feature such as the rainy season is summer. Looking at the rainfall data for the years 1996, 97, 98 will see if we compare to other years, there are very different values (Figure 5).

Palmas – as in other regions will have a significant water surplus and, presenting also the month of October a peak in rainfall, indicating that some phenomenon interfered in this period causing this increase (Figure 6).

Statistical analysis

The process of statistical analysis of interference or not the climate phenomena known as El Niño and La Niña, in the periods of his performance in the areas of study, begins with the breakup of the worksheet for calculating the water balance, to act on specific phenomena and one containing the data over the worksheet general, El Niño and La Niña, in all regions studied, moving then to the ANOVA and Duncan's test. The following are the calculations and graphs for statistics.

After the calculations is followed by the comparison of differences between means, two by two, with the value of its comparator (D), we shall, if there is a difference between the two averages less than or equal to the value calculated the averages are considered statistically equal. When observed the difference between two means greater than the value calculated averages are considered statistically different. This demonstration is extensive and we chose to present only the result, which is confirmation of the results found by analysis of variance.

Aspects observed in the results start to have a meaning from the moment that the regions are analyzed separately, and then regionally putting together the four regions for analysis, as it found that:

a. Guarapuava - this region was observed that in respect of excess water during periods of operation of the El Niño and La Niña and General (blocks) there was no real differences between the blocks of the f required 5% and 10%, and there is therefore, differences, and it was then a true null hypothesis. Observing the data of the months (treatment), there was a significant difference for them, since they have a value greater than the observed f applied to 5% . It then rejects the null hypothesis. This will indicate that the differences did not occur by chance, but were influenced by phenomena studied.

Observing the data of the months (treatment), there was a significant difference for them, since they have a value greater than the observed f applied to 5%. It then rejects the null hypothesis. This will indicate that the differences did not occur by chance, but were influenced by phenomena studied.

b. Cascavel – this region will have the same characteristics found in Guarapuava, ie the observed value of f less than f required, both for 5% to 10% as showing that the null hypothesis is valid for blocks (periods of activity of the phenomena), thus having no statistically significant differences.

In relation to treatment (months) we observe that there is a statistically significant, thus rejecting the hypothesis of nullity. We then demonstrated that interference occurs at the level of phenomena (El Niño and La Niña).

c. *Pato Branco* – this region appears different from the previous two by the fact that significant differences in both blocks and treatments, showing that the area had influences of El Niño and La Niña, in the past decade significantly. The null hypothesis is rejected and it appears that the differences were not by chance, they suffered external influences.

d. *Palmas* - this region appears different from the previous two by the fact that significant differences in both blocks and treatments, showing that the area had influences of El Niño and La Niña, in the past decade significantly. The null hypothesis is rejected and it appears that the differences were not by chance, they suffered external influences.

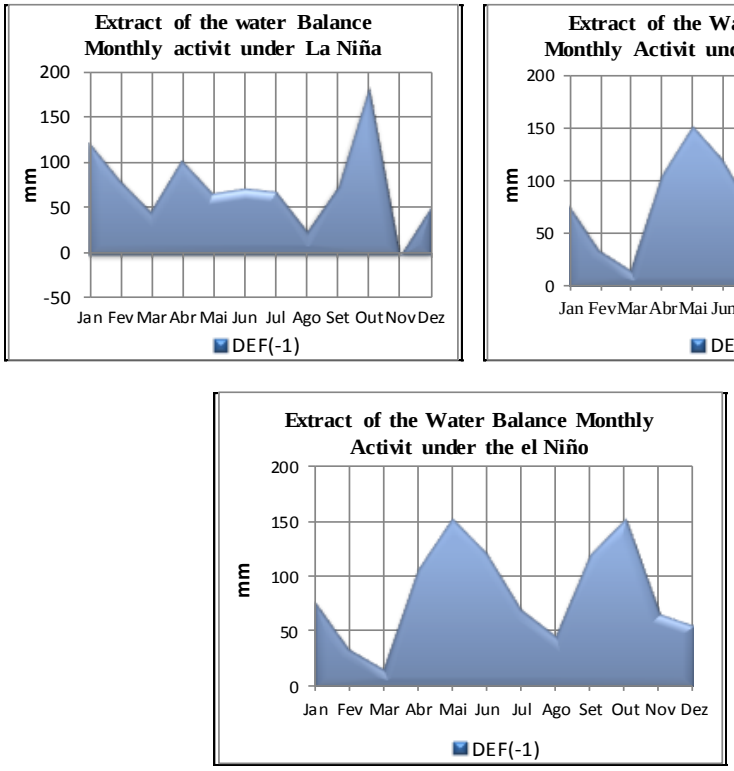

Figure 4. Results of Cascavel

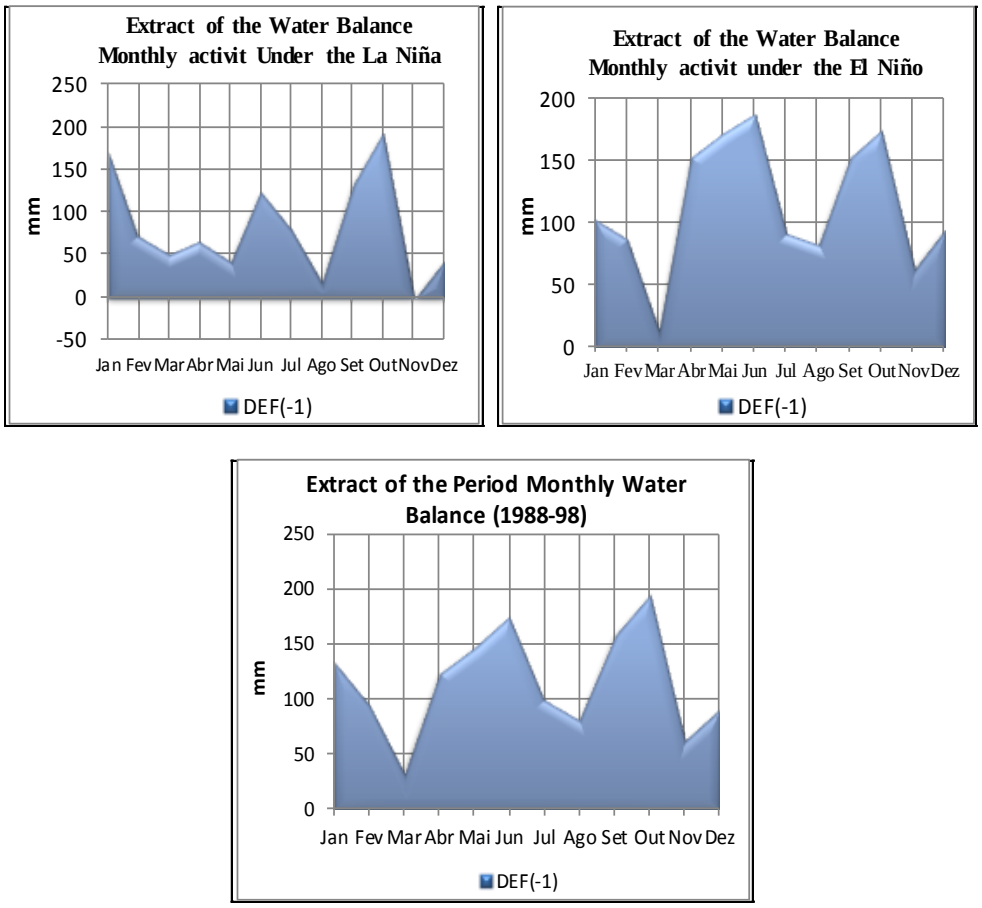

Figure 5. Results of Pato Branco

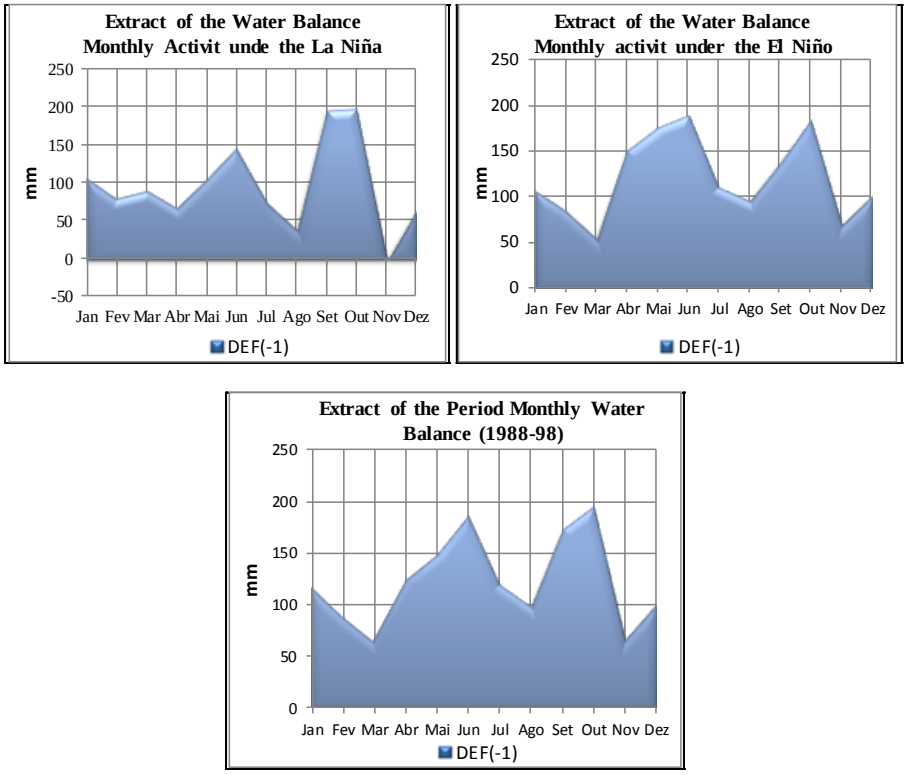

Figure 6. Results of Palmas

Regional analyse - analyzing the four regions together it was found that they were greatly influenced by climatic phenomena such as El Niño and La Niña, and this is well represented in the values found in relation f observed and f required, the first being much higher than the second, taking a margin of interference exceeding 10% s which becomes significant. The same result was found regarding the role of El Niño in the four regions together, and also its influence during the quarter, is what we will not observe the actions of La Niña, which will present a f observed, less than the required f indicating that the true null hypothesis for this phenomenon, that is, its influence is not observed in this period, or if there was a very tenuous, not influencing the climatic region

Conclusions

Studying the climatic water balance for the four regions presented, demonstrated that in the last ten years (1988 -1998), excess water was remarkable in all regions and in periods of scarcity rainfall the soil was already saturated enough, not to do feel the lack of water. It also conformed to the type of climatic region determined by Köppen, ie a region of temperate climate (mesothermal), with abundant rainfall with no dry season and may have an indication of climates Cfb type and Cfa.

Another point addressed in this work was related to the performance of weather phenomena, known El Niño and La Niña. It can be confirmed by the statistical calculations we have performed a level of terference especially in El Niño, which becomes significant when viewed month by month, showing an excess of rainfall, beyond the characteristic of the region. As for La Nina, there was not a strong influence in the regions during the study period. This study demonstrates the need for observations that presented mainly related to weather phenomena, as they might somehow undermine the whole society, both in the agricultural aspect as social and ecological.

This study showed that the climatic water balance can show how the El Niño and La Niña act on these four counties, causing farmers to use strategies in the production area to avoid significant losses in agricultural production. These results could be used by

managers as a way to prevent future problems, that is, knowing that these phenomena may influence the agricultural production, they should take precautions to ensure that the economic and social impact is minimized.

Bibliography

Costa, MH 1994, 'Balanço Hídrico segundo Thornthwait & Mather', 1955. *Viçosa. AEGRI MG/UFV*. n. 19, p. 1-16

IAPAR – Instituto Agronômico do Paraná 1999, *Dados climáticos. Seção Londrina.*

Koehler, HS 1994, *Estatística Experimental*. Universidade Federal do Paraná.

Maack, R 1968, *Geografia Física do Estado do Paraná.* 1ª ed. Curitiba: Banco de Desenvolvimento do Paraná.

Monteiro, CAF 1971, *Análise Rítmica em Climatologia. Instituto de Geografia* - USP. São Paulo, n.1, p. 1-21.

Nimer, E 1989, *Climatologia do Brasil*. 2 ed. Rio de Janeiro: IBGE, Departamento de Recursos naturais e Estudos Ambientais..

Oliveira, GS 2001, 'El Niño e Você' *in Fenômeno Climático*. Editora Transtec - São José dos Campos (SP).

Pereira, AR, Villa Nova, NA & Sediyama, GC 1997, 'Evapo(transpi)ração' 2 ed, *Piracicaba*: *FEALQ*, p. 143 -164

Reichardt, K 1990, 'Balanço Hídrico' In: Reichardt, K *A água em Sistemas Agrícolas.* 2 ed. São Paulo: Manole, p. 113-126.

Sentelhas, PC & Rolim, GS 1997, *Balanço Hídrico e Sequencial por Thornthwaite & Matter, 1955.* Departamento de Física e Meteorologia da ESALQ-USP. BHseq.2.0.