

IMPACT OF THE HYDRIC REPOSITION IN SOIL ON THE AGRICULTURE IN SEMI ARID REGION

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Abstract

Scientists around the world have shown impacts of the climate change in agriculture. The study of impacts climate in agriculture is very important for different areas, human, economic, hydrology, social, environment, etc. The aim this study is to analyze the spatial-temporal variation of agriculture due hydric reposition on semiarid region of Brazil. In this study we used Landsat image for estimate NDVI – Normalized Difference Vegetation Index and method of Thornthwaite and Matter for estimate water balance. The results of this study show that knowing the amount of water that is stored in the soil during rainy season is very important to specify the conditions of the agriculture in this year. Finally, it is possible to predict the conditions of the agriculture using climatic water balance and vegetation indices obtained satellite images of the rainy season.

Keywords: NDVI, Water balance, agriculture, correlation.

Introduction

Different studies in world have shown impacts of the climate change in agriculture, (Res et al., 1998, Rosegrant et al., 2008, Soelma et al., n.d., Szwed et al., 2010, Galvínio et al., 2011a, Freire, J. L. M.; Lima, J. R. A.; Cavalcanti, 2011, J Ferrez et al., 2011, Silva et al., 2013 and Teixeira et al., 2009). For example, the agriculture in the United States produces approximately \$300 billion a year in commodities with livestock accounting for roughly half the value. Production of these commodities is vulnerable to climate change through the direct (i.e., abiotic) effects of changing climate conditions on crop and livestock development and yield (e.g., changes in temperature or precipitation), as well as through the indirect (i.e., biotic) effects arising from changes in the severity of pest pressures,

availability of pollination services, and performance of other ecosystem services that affect agricultural productivity. Thus, U.S. agriculture exists as a complex web of interactions between agricultural productivity, ecosystem services, and climate change (USDA, 1935).

Yet, second USDA, increases in temperature coupled with more variable precipitation will reduce productivity of crops, and these effects will outweigh the benefits of increasing carbon dioxide. Effects will vary among annual and perennial crops, and regions of the United States; however, all production systems will be affected to some degree by climate change. In others country this situation is not different, for example, Brazil.

Global agriculture will be under significant pressure to meet the demands of rising populations using finite, often degraded, soil and water resources that are predicted to be further stressed by the impact of climate change (Rosegrant et al., 2008).

Climate is the primary determinant of agricultural productivity. Given the fundamental role of agriculture in human welfare, concern has been expressed by federal agencies and others regarding the potential effects of climate change on agricultural productivity. Interest in this issue has motivated a substantial body of research on climate change and agriculture over the past decade (Adamas et al., 1998, Medeiros, Raimundo; Francisco, Paulo.; Bandeira, 2012) (Gusmão et al., 2012)(Grilo and Petreire, n.d.)(Giongo et al., 2011)(Fernando et al., 2010)(Silva et al., 2013).

Climate change is expected to influence crop and livestock production, hydrologic balances, input supplies and other components of agricultural systems. However, the nature of these biophysical effects and the human responses to them are complex and uncertain (Adamas et al., 1998).

The water balance now includes more frequent and intense droughts and floods in many agricultural regions. These events can damage and at times even destroy crops. Over the next 30-50 years, average temperatures will likely increase by at least 1.0 °C. Anticipated regionally-dependent changes include increase number of heat waves and warm nights, a decreasing number of frost days, and a longer growing season in temperate zones.

There are several methods in the literature to assess the water balance and vegetation cover. The method of Thornthwaite and Matter is simple and has shown satisfactory results for the study of water balance on a local scale and with reasonable temporal variation. To study the variation of vegetation the remote sensing has emerged as a great alternative that allows a better assessment of the environmental characteristics, as well as assist in the study of soil cover and its variation over time. According to Morais et al. (2011) several indexes were created, among which is the NDVI (Normalized Difference Vegetation Index). The NDVI is used to differentiate the levels of vegetation growth and its calculation is done using the bands of red and infrared range of the electromagnetic spectrum. It is known that the amount of water that is stored in the soil during

the rainy season is of great importance for the maintenance in agriculture.

The union of traditional water balance, such as method of Thornthwaite and Matter and remote sensing can help in the understanding and impact of extreme, droughts and peak rainfall events.

Much has been discussed about global climate change, greenhouse gases, global warming, and its possible effects in Brazilian agriculture. A recent study coordinated by Pinto & Assad (2008), indicates that the increase in temperature can cause, in general, a decrease in regions with lower climate risk for the grain cultivation and significant economic losses (Galvêncio et al., 2011b).

Remote sensing data is widely used for canopy monitoring in different vegetation types. Though it is possible to analyze biochemical characterization of plants in different wavelengths of the electromagnetic spectrum, apparently few is known about spectral traits and chlorophyll content into leaves in tropical plants. It can be also used to modeling and to simulate biological and physical processes (Galvêncio and Pimentel, 2012). The products obtained through remote sensing are widely used for the management and natural resource management (Mayla et al. 2012).

Given the above, the study's main objective is to analyze the spatial-temporal variation of agriculture due hydric reposition on semiarid region of Brazil.

Materials and methods

Characterization and localization of the area

The municipalities of this study are located in Mesoregion the San Francisco River Pernambucano and Microregion Itaparica. It's distant about 430km from the capital. Borders on the cities of Serra Talhada, Betania, Custodia, Tacaratu, Inajá, Petrolândia, Rodelas (BA), Ibimirim, Carnaubeira da Penha and Itacuruba (Figure 1). It lies between 08°36'02" south latitude and 38°34'05" west longitude according to the Geographic Coordinate System. According to the Koppen Climate Classification, the climate of the city's BSh (semi-arid tropical with summer rains), with the highest concentration of rainfall between the months of January to April, with average rainfall of less than 800mm. Forest has a semi-arid climate with hot oscillation of monthly average temperature in the years studied between 19 and 30.05 degrees Celsius. According to map Exploration Soil EMBRAPA, the municipality soils predominant types of Bruno No Calcic (NC) and Planosols. Vegetation is typical of Caatinga,

considered hiperxerófila with stretches of deciduous forest.

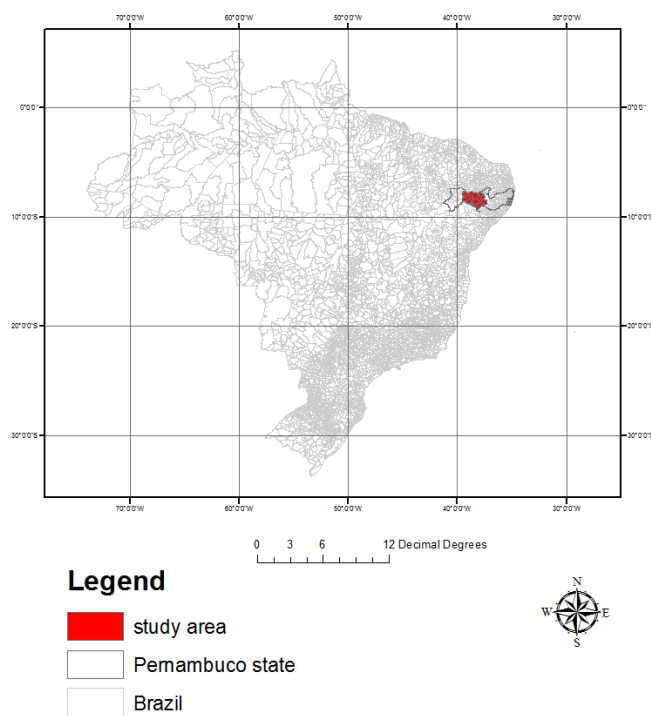


Figure 1: Spatial located of the municipality this study, in Pernambuco state, Brazil.

Data acquisition and processing of images

We used satellite images from orbit and point 216/66, passing on 15 October 1996, 24 October 2005 and 06 October 2010 Thematic Mapper™ satellite Landsat5 acquired free through the catalog pictures INPE (National Institute for Space Research). The images were chosen to contain little or no cloud. We also used data provided by the Zoneamento Agroecológico de Pernambuco (ZAPE), and rainfall data obtained on the website of APAC (Pernambucana Agency for Water and Climate) regarding data collection station CHESF (São Francisco Hydroelectric Company) and data temperature obtained in the portal Lab Inc. (agro-meteorological monitoring system), all for the years of images.

By obtaining data on precipitation and temperature was conducted a climatic water balance proposed by (Thornthwaite, 1948), considering the available water capacity in the soil (CAD) 100mm.

We used the software ERDAS Imagine 9.3 for the stacking of spectral bands, radiometric calibration, the

reflectance and NDVI and ArcGis 9.3 for the division of classes and final assembly of the maps. The software's are licensed by the Laboratory of Remote Sensing and GIS, Department of Geographical Sciences UFPE. The processes are described below. Radiometric Calibration - The radiometric calibration or radiance is, according to (Jensen et al., 2009) as the most accurate radiometric remote sensing, and is the radiant intensity per unit area projected source in a specific direction. It can also be considered as the value of the solar energy reflected from each image pixel. It is calculated by the following formula:

$$L_{\lambda i} = a_i + \frac{b_i - a_i}{255} ND$$

Where a and b are the minimum and maximum spectral radiance, ND is the intensity of pixel (0 to 255) ei corresponds bands (1 to 7) Landsat 5.

Reflectance of each band is defined as the ratio of the solar radiation reflected by the surface and the flow of incident solar radiation (Allen and Trezza, 2002). The reflectance is calculated by the following equation:

$$\rho_{\lambda_i} = \frac{\pi \cdot L_{\lambda_i}}{K_{\lambda_i} \cdot \cos Z \cdot d_i^2}$$

Where L_{λ_i} is the spectral radiance of each band, K_{λ_i} is the spectral solar irradiance at the top of the atmosphere band, Z is the solar zenith angle and d_i the square of the ratio between the average Earth-Sun distance and the distance Earth-Sun on any given day of the year.

NDVI (Normalized Difference Vegetation Index) is a widely used vegetation index in remote sensing, through it we can evaluate the changes that occur in coverage vegetal. Jansen (2009) say that, is important because it allows your application to observe the seasonal and inter-annual variations of vegetation, contributing to its monitoring. The NDVI may be obtained from the following formula.

$$NDVI = \frac{\rho_{iv} - \rho_v}{\rho_{iv} + \rho_v}$$

Where, ρ_{iv} is reflectance near infrared (band 4) and ρ_v is the reflectance in the red (band 3).

In this study was adopted that in rainfed agriculture area have NDVI between 0.1 and 0.4. The depend of the rainfall in wet period.

Statistical analysis

This study was used descriptive statistics, correlation and regression analysis, cluster analysis and test statistical hypotheses for analyses of the variability climate, similarities or dissimilarities between the variables this study, relation between variables and analysis of difference be attributed to chance of the variables.

Results and discussion Floresta municipality

Figure 2 shows the spatial and temporal variability of NDVI in municipality of Floresta, Pernambuco. Note that in October 1996, in general, NDVI values were 0.20 to 0.40. The rainfed agriculture area is similar of the natural vegetation. In October 2005, the NDVI values were between 0.20 and 0.60. In this year is possible distinguish rainfed agriculture area of natural vegetation. The rainfed agriculture area is between 0.20 and 0.4 index. In October 2010, the NDVI was generally 0.10 to 0.20. In this year the rainfed agriculture area is similar soil exposed. The precipitations 1996, 2005 and 2010 are shown in Table 2. Note that the year 1996 had the lowest amount of annual rainfall and the year 2010 the majority. The higher rainfall in 2010 no increased the vegetation cover in the dry period of the study area, Figure 2C.

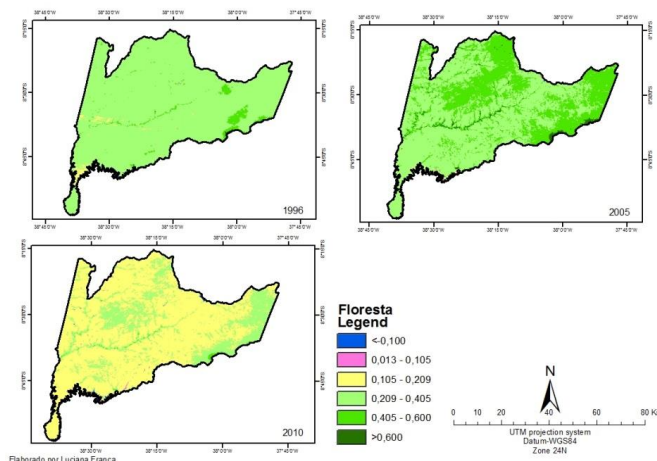


Figure 2: NDVI October 1996, 2005, 2010 for the city of Floresta- PE.

Table 1: Mean values of monthly rainfall for the city of Floresta-PE.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sec	Oct	Nov	Dec	Total
1996	0	32	113	159	10	10	2	6	2	3	188	0	527
2005	53	23	112	37	135	36	2	4	2	0	6	127	749
2010	74	90	48	211	33	20	24	4	13	68	0	188	780

Figure 3, 4 and 5 have the water balance of the years 1996, 2005 and 2010. Note that the year 1996 had the highest reposition hydric even with the occurrence of lower precipitation, Table 1. This result is due to the occurrence of lower temperatures in 1996 and therefore lower potential evapotranspiration. When comparing 2005 with 2010 notes that the greater vegetation cover in 2005 is due to lower evapotranspiration in 2005 and increased reposition hydric, Figures 4 and 5. Note that the amount of annual rainfall is greater in 2010 than in 2005. Even with higher precipitation replacement soil water presents less in 2010. Note that fluid replacement in the soil is of great importance for the maintenance of the vegetation and rainfed agriculture. It is known that the amount of water that will be stored in the soil depends on several factors including the amount, duration and intensity of precipitation than the amount which is evapotranspirated which depends on temperature variation.

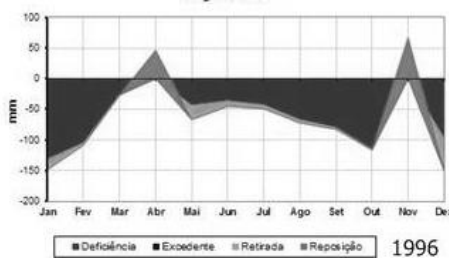


Figure 3: Water balance for 1996.

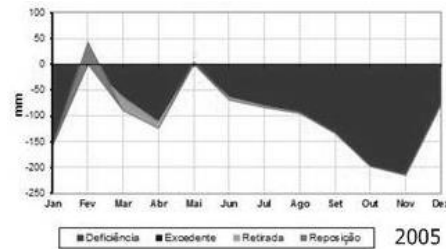


Figure 4: Water balance for 2005.

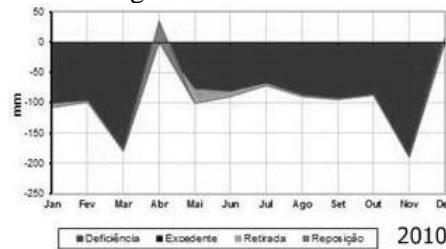


Figure 5: Water balance for 2010.

Belem do Sao Francisco municipality

Figure 6 shows the spatial and temporal variability of vegetation cover in municipality of Belem do Sao Francisco, Pernambuco, using NDVI. Note that in October 1996, in general, NDVI values were 0.20 to 0.40. The rainfed agriculture area is similar of the natural vegetation. In October 2005, the NDVI values were between 0.10 and 0.20 (stress hydric). In this year the rainfed agriculture area is similar soil exposed. In October 2010 is similar 2005, in this year the rainfed agriculture area is similar soil exposed. The precipitations 1996, 2005 and 2010 are shown in Table 2. Note that the year 2005 had the lowest amount of annual rainfall and the year 2010 the majority. The higher rainfall in 2010 no increased the vegetable cover in the dry period of the study area, Figure 6C. The rainfall in 2010 occurred after image in study.

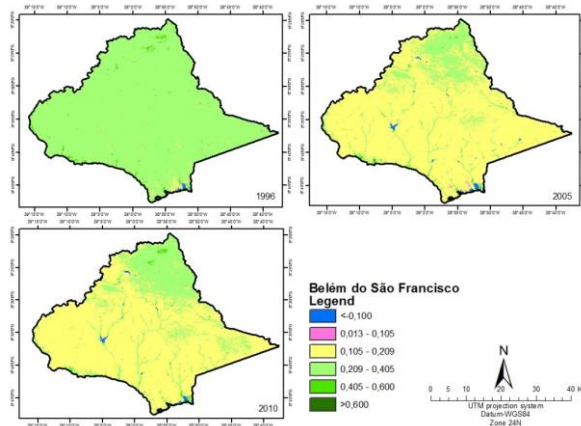


Figure 6 - NDVI October 1996 (A), 2005 (B), 2010 (C) for the city of Belem do Sao Francisco- PE.

Table 2: Mean values of monthly rainfall for the city of Belem do Sao Francisco-PE.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	8	26	42	123	60	25	5	8	0	0	107	34	438
2005	35	129	68	37	22	38	14	0	3	0	3	68	422
2010	80	85	59	36	57	9	23	2	4	23	0	170	552

Figure 7 show the water balance for 1996, Figure 8 for 2005 and Figure 9 for 2010. Note that the year 1996 had reposition hydric in April. In 2005 no

had reposition hydric and in 2010 had hydric reposition in December. Note that the hydric reposition is very important for variable vegetable cover inter-year.

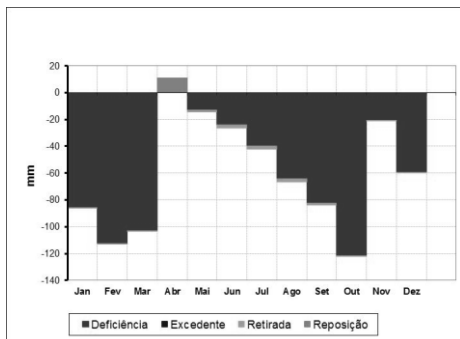


Figure 7 – Water balance for 1996.

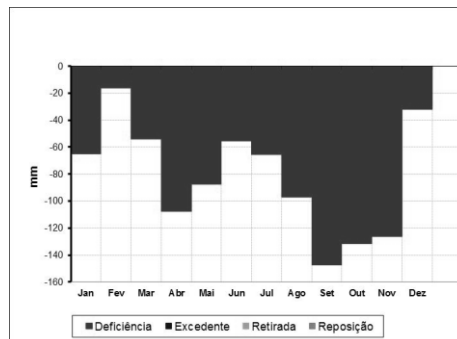


Figure 8 – Water balance for 2005.

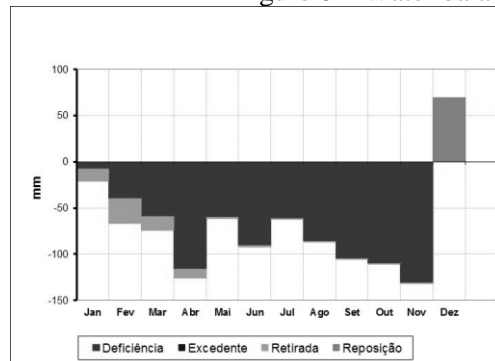


Figure 9 – Water balance for 2010.

Calumbi municipality

Figure 10 shows the spatial and temporal variability of NDVI in municipality of Calumbi, Pernambuco. Note that in October 1996, in general, NDVI values were 0.20 to 0.40. The rainfed agriculture area is similar of the natural vegetation. In October 2005, the NDVI values were between 0.10 and 0.40. In this year is possible distinguish rainfed

agriculture area of natural vegetation. In October 2010, the NDVI was generally 0.10 to 0.20. In this year the rainfed agriculture area is similar soil exposed

The precipitations 1996, 2005 and 2010 are shown in Table 3. Note that the year 2005 had the lowest amount of annual rainfall and the year 1996 the majority. When compared 2005 with 2010 note that the higher rainfall in 2010 no increased the vegetation cover in the dry period of the study area, Figure 10C.

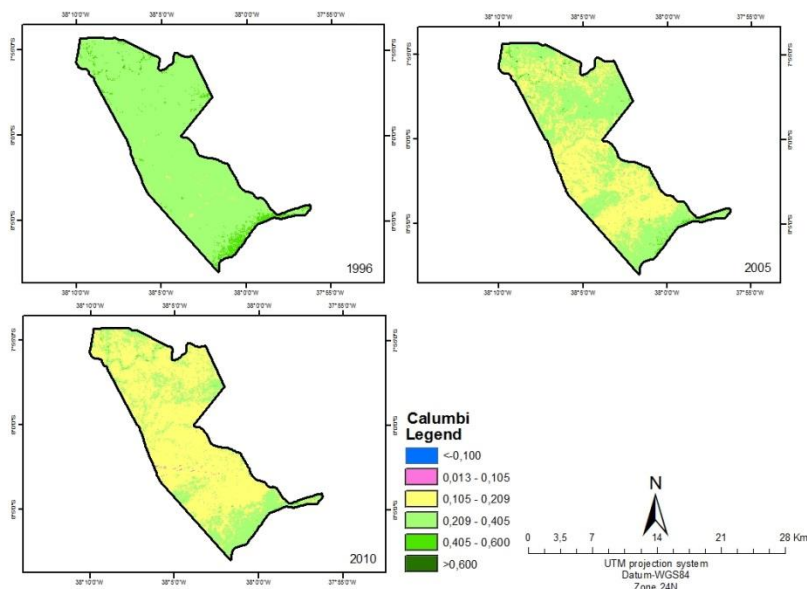


Figure 10 - NDVI October 1996 (A), 2005 (B), 2010 (C) for the city of Calumbi - PE.

Table 3: Mean values of monthly rainfall for the city of Calumbi-PE.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	20	5	153	134	131	97	8	7	74	50	63	5	747
2005	0	75	243	23	23	9	25	0	0	0	0	72	472
2010	49	79	26	177	21	71	24	0	0	84	0	38	572

Figure 11 show the water balance for 1996, Figure 12 for 2005 and Figure 13 for 2010. Note that the year 1996 had reposition hydric in March, April and May,

i.e. three months. In 2005 had high hydric reposition in March and in 2010 had low hydric reposition in March. Note that the hydric reposition is very important for variable rainfed agriculture inter-year.

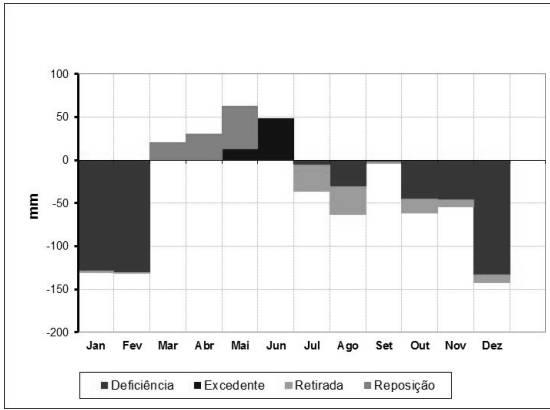


Figure 11- Water balance for 1996.

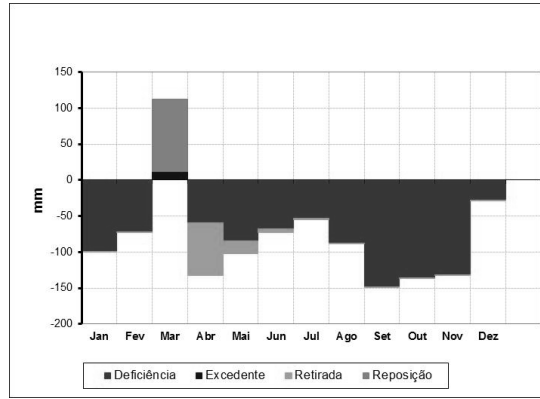


Figure 12- Water balance for 2005.

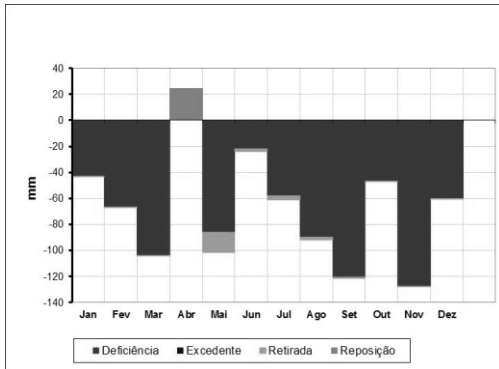


Figure 13 – Water balance for 2010.

Carnaubeira da Penha municipality

Figure 14 shows the spatial and temporal variability of vegetation cover in municipality of Carnaubeira da Penha, Pernambuco, using NDVI. Note that in October 1996, in general, NDVI values were 0.20 to 0.60. In this year is possible distinguish rainfed agriculture area of

natural vegetation. In October 2005, increase the area of the NDVI with values between 0.10 and 0.20. In October 2010, increase area the value of NDVI of 0.10 to 0.20. The precipitations 2005 and 2010 are shown in Table 4. Note that the year 2010 had the lowest amount of annual rainfall and the year 2005 the majority.

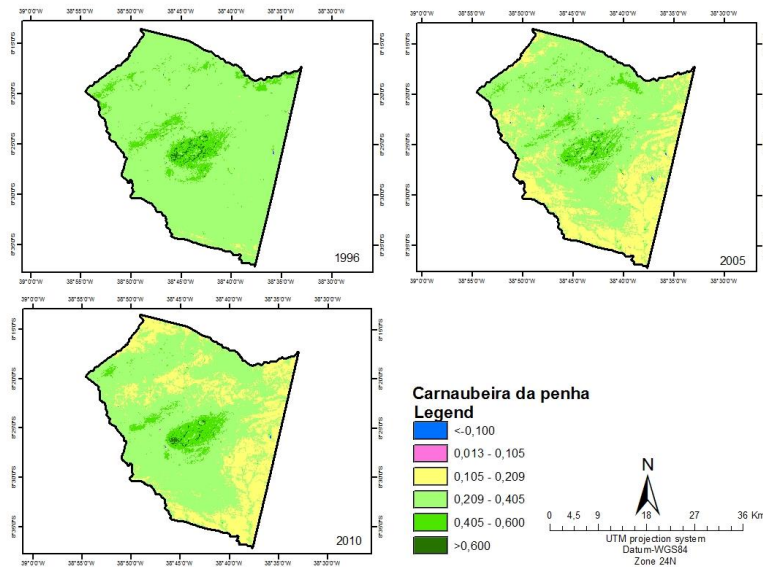


Figure 14 - NDVI October 1996, 2005, 2010 for the city of Carnaubeira da Penha- PE.

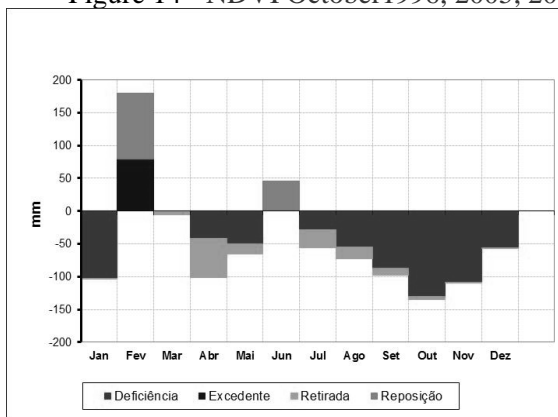


Figure 16 – Water balance 2005

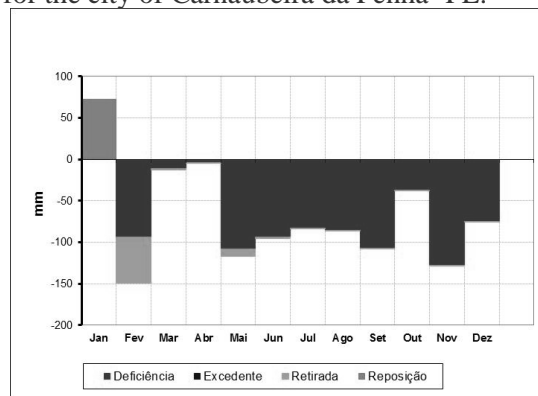


Figure 17 – Water balance for 2010.

Table 4: Mean values of monthly rainfall for the city of Carnaubeira da Penha-PE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	Problem in equipment												
2005	41	307	127	5	15	115	2	4	2	0	22	47	687
2010	168	0	118	151	0	0	0	0	0	91	0	23	554

Salgueiro municipality

Figure 18 shows the spatial and temporal variability of vegetation cover in municipality of Salgueiro, Pernambuco, using NDVI. Note that in October 1996, in general, NDVI values were 0.20 to 0.40. The rainfed agriculture area is similar of the natural vegetation. In October 2005, the NDVI too presents values between 0.10 and

0.40. In this year is possible distinguish rainfed agriculture area of natural vegetation. In October 2010, the NDVI was generally 0.10 to 0.40. In this year is possible distinguish rainfed agriculture area of natural vegetation. The precipitations 1996, 2005 and 2010 are shown in Table 5. Note that the year 2010 had the lowest amount of annual rainfall and the year 1996 the majority.

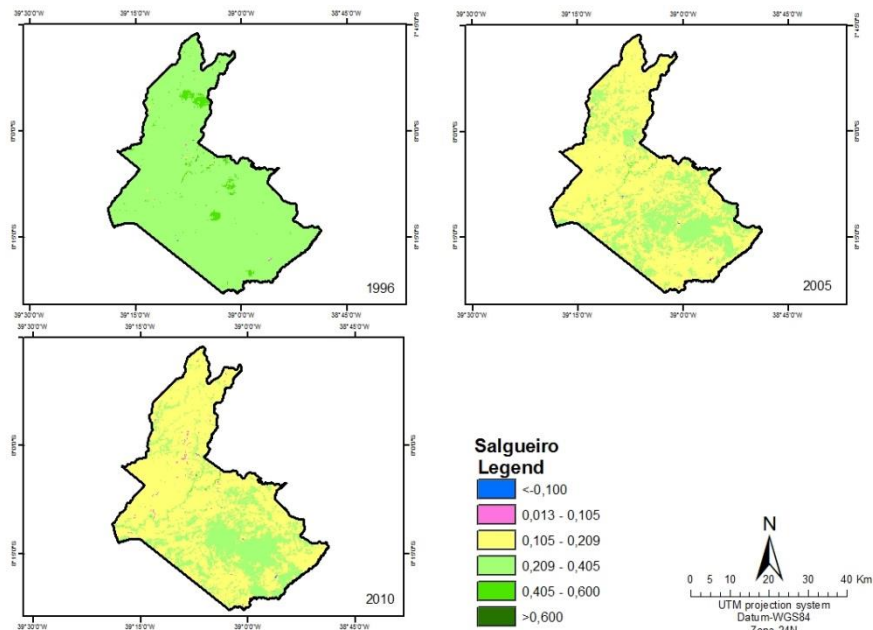


Figure 18 - NDVI October 1996, 2005, 2010 for the city of Salgueiro- PE.

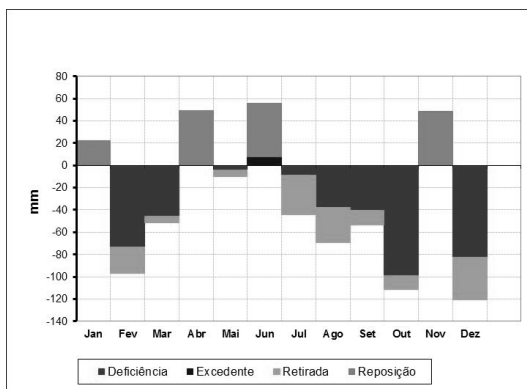


Figure 19 – Water balance for 1996.

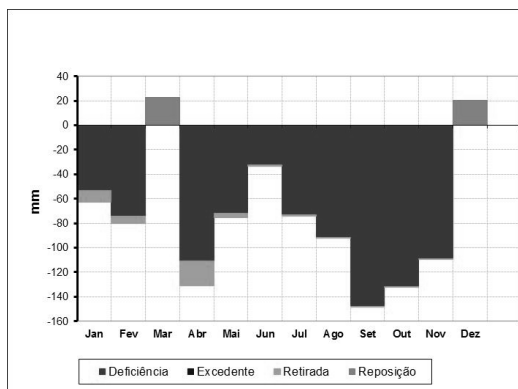


Figure 20 – Water balance for 2005.

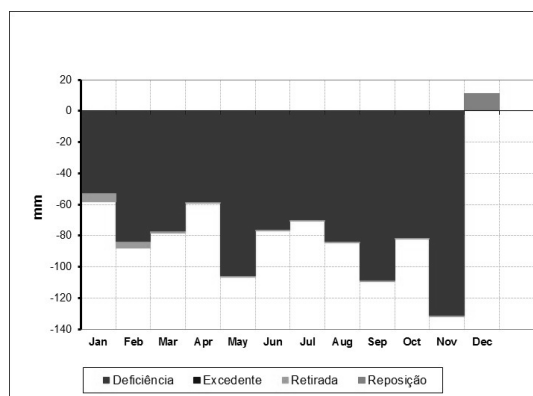


Figure 21 – Water balance for 2010.

Table 5: Mean values of monthly rainfall for the city of Salgueiro-PE

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	173	39	80	152	59	104	0	0	24	0	166	26	823

2005	37	70	150	20	45	56	11	4	0	0	17	114	526
2010	94	60	52	91	12	18	11	1	4	53	0	110	511

Serra Talhada municipality

Figure 22 shows the spatial and temporal variability of vegetation cover in municipality of Serra Talhada, Pernambuco, using NDVI. Note that in October 1996, in general, NDVI values were 0.20 to 0.60. The rainfed agriculture area is similar of the natural vegetation. In October 2005, the

NDVI values were between 0.10 and 0.40. In October 2010, the NDVI was generally 0.10 to 0.20. The precipitations 1996, 2005 and 2010 are shown in Table 6. Note that the year 2005 had the lowest amount of annual rainfall and the year 1996 the majority. When compared 2005 with 2010 the higher rainfall in 2010 no increased the vegetation cover in the dry period of the study area, Figure 6C.

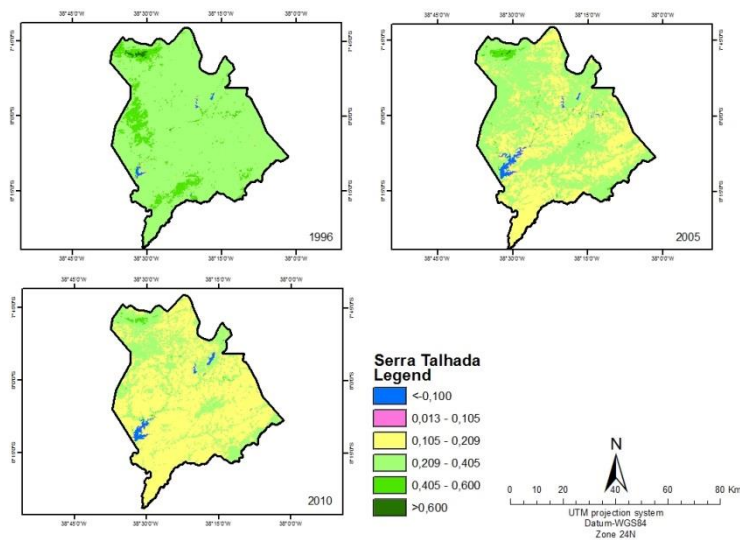


Figure 22 - NDVI October 1996 (A), 2005 (B), 2010 (C) for the city of Serra Talhada- PE.

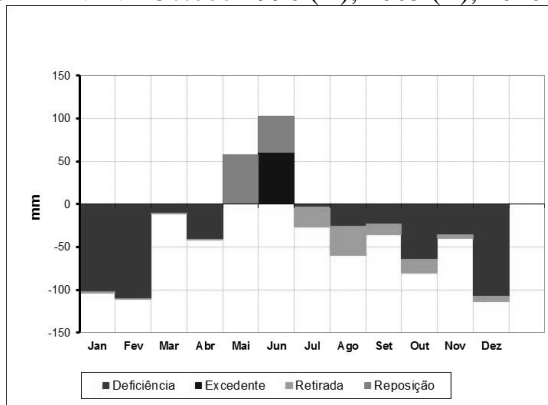


Figure 23 – Water balance for 1996.

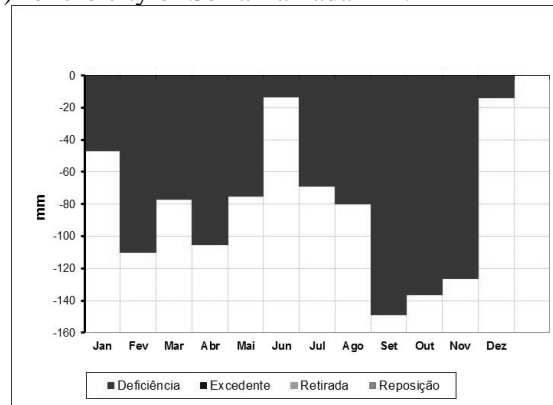


Figure 24 – Water balance for 2005.

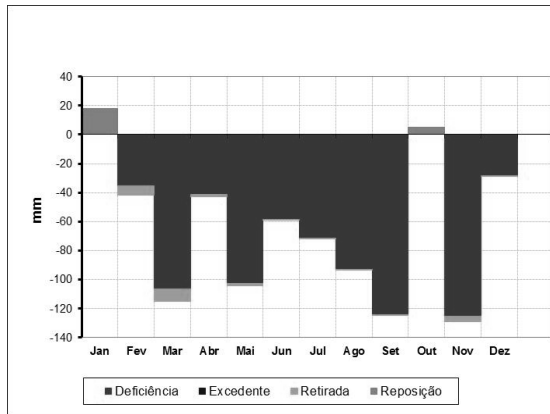


Figure 25 – Water balance for 2010.

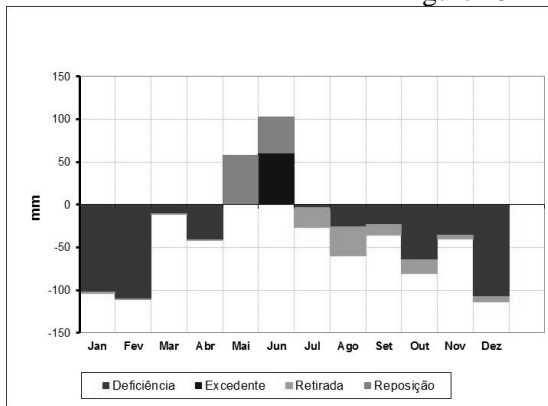


Figure 23 – Water balance for 1996.

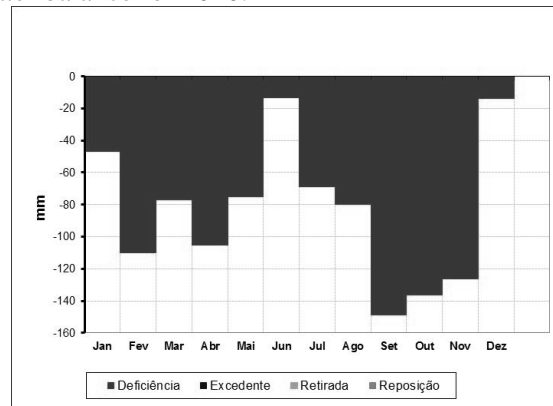


Figure 24 – Water balance for 2005.

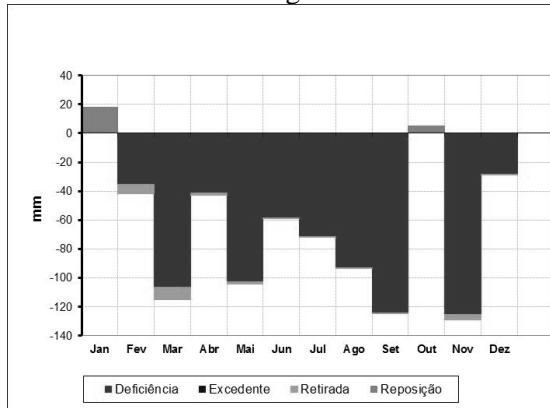


Figure 25 – Water balance for 2010.

Figure 22 - NDVI October 1996 (A), 2005 (B), 2010 (C) for the city of Serra Talhada- PE.

Table 6: Mean values of monthly rainfall for the city of Serra Talhada-PE.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	42	21	117	59	125	150	17	8	40	28	74	29	710
2005	52	37	54	43	24	68	0	7	0	0	5	86	379
2010	111	105	16	112	21	39	16	0	0	138	0	70	631

Tacaratu municipality

Figure 26 shows the spatial and temporal variability of vegetation cover in

municipality of Tacaratu, Pernambuco, using NDVI. Note that in October 1996, in general, NDVI values were 0.20 to 0.60. In October 2005, the NDVI values were between 0.20 and 0.40. In October 2010, the NDVI was generally 0.10 to 0.40. The precipitations 1996, 2005 and 2010 are

shown in Table 7. Note that the year 2005 had the lowest amount of annual rainfall and the year 2010 the majority. The higher rainfall in 2010 no increased the vegetation cover in the dry period of the study area, Figure 26C.

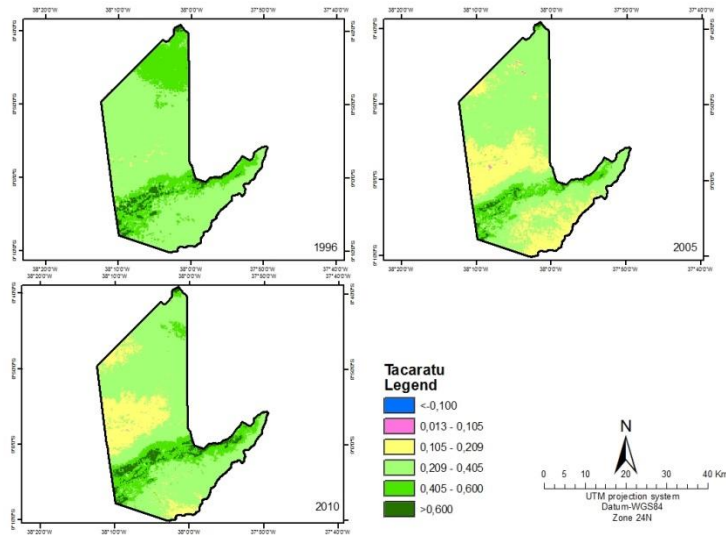


Figure 26 - NDVI October 1996, 2005, 2010 for the city of Tacaratu- PE.

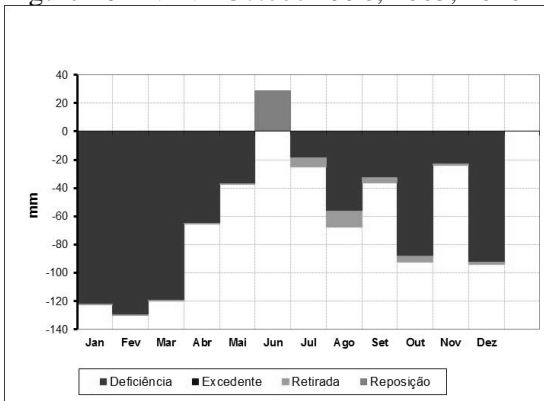


Figure 27 – Water balance for 1996.

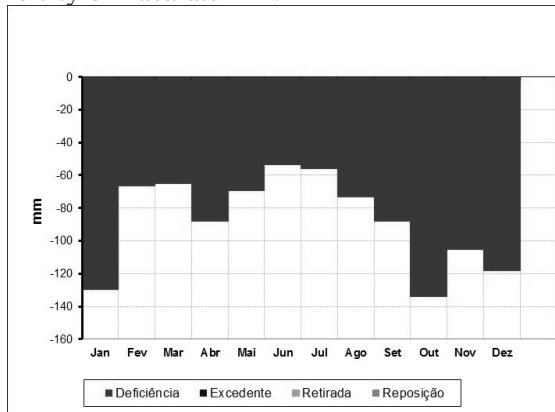


Figure 28 – Water balance for 2005.

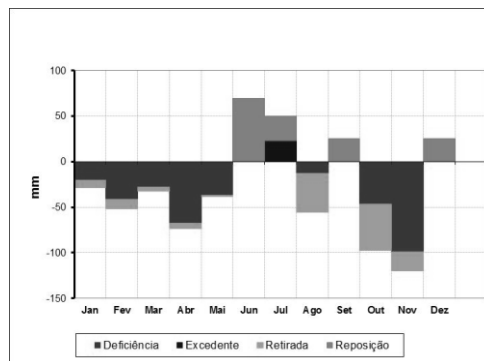


Figure 30 – Water balance for 2010.

Table 7: Mean values of monthly rainfall for the city of Serra Talhada-PE.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1996	22	1	7	34	30	76	18	0	39	15	89	47	378
2005	11	58	64	17	12	16	3	4	2	0	8	31	227
2010	67	95	97	78	70	159	127	24	121	25	4	121	992

Statistics analysis for all municipality

In average the NDVI in October was 0.38. The year rainfall was 556mm, the

hydric reposition was 68mm and this reposition occurs in average 1.6 month, Table 8.

Table 8- Descriptive statistics of NDVI, annual rainfall, hydric reposition and among of the month of the hydric reposition.

	Statistic	Bootstrap ^a				
		Bias	Std. Error	95% Confidence Interval		
				Lower	Upper	
NDVI	Mean	.3825	.0002	.0317	.3200	.4460
	Std. Deviation	.14639	-.00423	.01242	.11297	.16281
	N	20	0	0	20	20
Year rainfall	Mean	556.60	-1.50	49.93	449.06	650.49
	Std. Deviation	223.965	-7.434	40.229	138.973	294.688
	N	20	0	0	20	20
Reposition	Mean	68.440	.200	12.791	44.325	94.142
	Std. Deviation	60.3718	-1.4174	5.1852	48.6903	68.7537
	N	20	0	0	20	20
Month reposition	Mean	1.60	.00	.26	1.10	2.10
	Std. Deviation	1.231	-.037	.176	.826	1.525
	N	20	0	0	20	20

a. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

The correlation between annual rainfalls with hydric reposition was 0.76. The annual rainfall with month of hydric reposition was 0.877 and annual rainfall with NDVI was 0.15, Table 9. The correlation between NDVI with hydric reposition was 0.31. Note that hydric reposition and NDVI present the better correlation. This results confirm that to study the variability of the rainfall (intensity and frequency) is most important than amount annual rainfall.

Trying to show that variations in annual rainfall and soil water reposition not differ statistically among municipalities was accomplished cluster analysis data. The data were grouped into three major groups' homogeneous, Figure 31. Group 1 (Calumbi-1996, Salgueiro 1996

Carnaubeira Penha-1996, Salgueiro 2010, Serra Talhada-2010, Belém do São Francisco-BSF-2010. Group 2 (Tacaratu-2005, BSF-2005, Tacaratu 2010, Serra Talhada 2005 Carnaubeira Penha-2005) and Group 3 (Salgueiro 2005 Tacaratu-1996, Calumbi-2005, Floresta 2010, Serra Talhada 1996, Floresta 2005, Carnaubeira Penha-2010 Calumbi,-2010, Floresta-1996). Note that the clusters do not coincide with the same years among municipalities. Note that, exist influences spatial variations of precipitation in NDVI. This interference of precipitation in vegetation cover differs statistically, Table 10. This suggests that the impacts of climate change will different spatially according spatial and temporal variations climate of the place.

The impact of vegetation cover on temperature extreme values can be expected

to be different from its impact on average values. If we wish to understand the potential impact of climate change on forests, we require more insight into the

specific impact of different vegetation cover types on temperature extremes, (J. Ferrez et al., 2011).

Table 9 – Correlations between annual rainfall, hydric reposition, month of hydric reposition and NDVI.

		Annual rainfall	Hydric Reposition	Month reposition	NDVI	
Annual rainfall	Pearson Correlation	1	.763**	.877**	.015	
	Sig. (2-tailed)		.000	.000	.950	
	Sum of Squares and Cross-products	953048.800	196066.520	4592.800	9.260	
	Covariance	50160.463	10319.291	241.726	.487	
	N	20	20	20	20	
		Bias	0	.006	.007	.029
		Std. Error	0	.077	.037	.207
	Bootstrap ^c	95% Confidence Lower	1	.585	.805	-.356
		Interval Upper	1	.895	.945	.465
	Hydric reposition	Pearson Correlation	.763**	1	.809**	.310
Sig. (2-tailed)		.000		.000	.184	
Sum of Squares and Cross-products		196066.520	69250.368	1142.320	51.994	
Covariance		10319.291	3644.756	60.122	2.737	
N		20	20	20	20	
		Bias	.006	0	-.004	.013
		Std. Error	.077	0	.071	.199
Bootstrap ^c		95% Confidence Lower	.585	1	.632	-.078
		Interval Upper	.895	1	.919	.690
Month reposition		Pearson Correlation	.877**	.809**	1	.307
	Sig. (2-tailed)	.000	.000		.189	
	Sum of Squares and Cross-products	4592.800	1142.320	28.800	1.050	
	Covariance	241.726	60.122	1.516	.055	
	N	20	20	20	20	
		Bias	.007	-.004	0	.008
		Std. Error	.037	.071	0	.176
	Bootstrap ^c	95% Confidence Lower	.805	.632	1	-.038
		Interval Upper	.945	.919	1	.624
	NDVI	Pearson Correlation	.015	.310	.307	1
Sig. (2-tailed)		.950	.184	.189		
Sum of Squares and Cross-products		9.260	51.994	1.050	.407	
Covariance		.487	2.737	.055	.021	
N		20	20	20	20	
		Bias	.029	.013	.008	0
		Std. Error	.207	.199	.176	0
Bootstrap ^c		95% Confidence Lower	-.356	-.078	-.038	1
		Interval Upper	.465	.690	.624	1

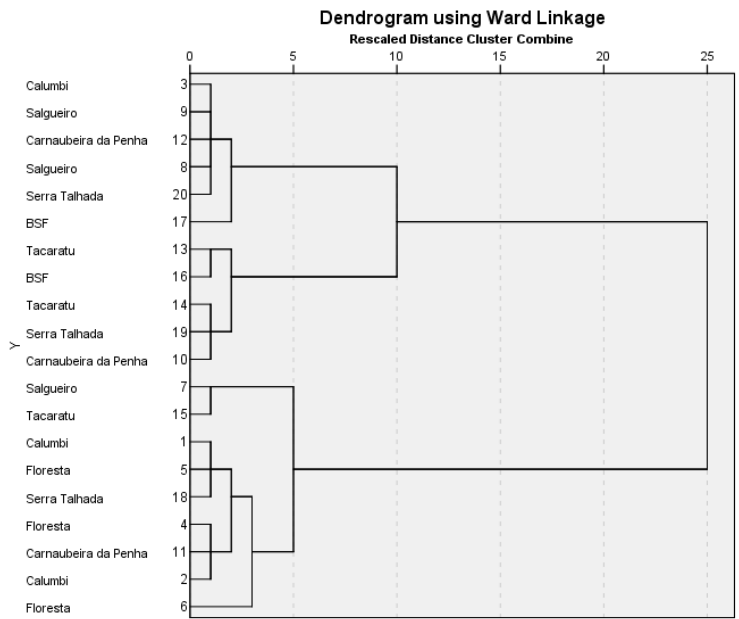
** . Correlation is significant at the 0.01 level (2-tailed).

* . Correlation is significant at the 0.05 level (2-tailed).

c. Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples

Thus, making the water balance and its variables relate to the variation in vegetation cover is of paramount importance for understanding the impacts of climate change on the morphological and

physiological processes of plants, but also in the temporal and spatial variation of vegetation cover. There are several methods in the literature to assess the water balance and vegetation cover.



Legend: 0-1996, 1-2005, 2-2010, 3- 1996, 4-2005, 5-2010, 6- 1996, 7- 2005, 8- 2010, 9-1996, 10-2005, 11-2010, 12-1996, 13-2005, 14-2010, 15-1996, 16-2005, 17-2010, 18- 1996, 19-2005, 20-2010,

Figure 31-Dendrogram of annual rainfall, soil water reposition and NDVI.

Table 10- Regression.

Model Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.950 _a	.903	.670	.08368	.903	3.877	12	5	.072

a. Predictors: (Constant), Média/ Total, Dezembro, Outubro, Fevereiro, Março, Janeiro, Julho, Agosto, Abril, Novembro, Maio, Setembro

b. Dependent Variable: NDVI

Table 11 show correlation between NDVI_{October} with month rainfall. Note that the major positive correlation was $r= 0.512$, September and after $r=0.416$ for May. In January the correlation was $r=-0.358$. In general, note that after April correlation positive with NDVI_{October} and negative before May. This result is very important for decision of the management of the agriculture. But, this results is need repeat because in semiarid climate is very high variability the spatial and temporal climate.

This study show that is very important quantify the hydric reposition of

water in soil in rainy season for predict of the agriculture on semi-arid northeastern Brazil in dry season. The condition of vegetable cover will to depend of the hydric reposition in soil and evapotranspiration (that depend of the temperature). It is noted that the canopy in the study area is more temperature sensitive than the amount of annual precipitated water. Thus, the temperature increase expected by IPCC can cause great impact on agriculture on northeastern Brazil.

There is now a strong consensus that climate change presents a fundamental challenge to the well-being of all countries, with potential of being most harsh on

developing countries. Water scarcity is a well-established context for development in arid and semi-arid countries. For many parts of the arid regions there is an expected precipitation decrease over the next century of 20% or more. The changes in other parts of the world will impact the economy of arid and semi-arid regions too. The overall

water stress will increase. Projected temperature increase will imply higher evaporation and drier conditions. Rain is also expected to reduce in frequency but increase in intensity. All these will result in frequent droughts and floods, (Ott et al., 2004).

Table 11 – Correlation between NDVI_{October} with month rainfall.

	Zero-order
January	-.358
February	-.275
March	.019
April	-.150
May	.416
July	.131
August	.372
September	.512

Conclusions

To analyze the sensitivity of rainfed agriculture as a function of hydric reposition in soil is important, because the water conditions in the rainy season may indicate the production of food, the economic gains and the member's impacts on dry period. It's also important to analyze the magnitude of these impacts. This will depend on the magnitude of hydric reposition in rainy season, which suggests this study. Knowing the amount of water that is stored in the soil during the rainy season is very important to specify the conditions of the agriculture in this year.

Knowing the current conditions of the impacts of extreme events is extremely important. As, to know what are the real impacts of intensification of extreme events, as predicted by the IPCC.

Recommend other studies with similar objectives to this is done in other areas with different climatic conditions and in areas with similar climatic conditions to strengthen the results presented here.

The methods of multiple correlation and grouping of data can be used to identify the relationships and how the strength of these relationships between the variable hydric reposition in the soil (during the

season rainy) and agricultural conditions (dry season).

Finally, it is possible to predict the conditions of the agriculture in the dry season using climatic water balance and vegetation indices obtained satellite images of the rainy season.

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