OPEN JOURNAL SYSTEMS
ISSN:2237-2202

Available on line at Directory of Open Access Journals

Journal of Hyperspectral Remote Sensing, vol. 04, n.02 (2014) 65-74.

Journal of Hyperspectral Remote Sensing
www.ufpe.br/jhrs

VEGETATION INDEX IN THE SÃO GONÇALO IRRIGATED PERIMETER - PB

Alexandra Chaves Braga[*], Célia Campos Braga[*], Bernardo Barbosa da Silva[**], Francineide Amorim Costa Santos [*]

* Federal University of Campina Grande, Campina Grande, Av. Aprígio Veloso, 882 , Bairro universitário, Campina Grande-PB-Brasil.Phone: 55+83 21011054
** Federal University of Pernambuco-UFPE, Department of Geographic Science, Av. Professor Morais Rego, s/n. Cidade Universitária, Recife-PE-Brasil. Phone: 55+81 21267375

Received 30 de July 2013; revised 11 October 2013; accepted 22 Set 2013

Abstract

The municipality of Sousa is cut by rivers Piranhas and River Fish, and holds a great potential for exploiting its water resources, aiming at the improvement of agriculture. The Irrigated São Gonçalo - PISG is located 15 km from the city of Sousa - PB located approximately 444Km from the capital João Pessoa. The weir São Gonçalo is inserted in the watershed of Alto de Piranhas, sub -basin of the Rio Piranhas in western Paraíba in northeastern Brazil, whose construction works started in 1932 and completed in 1936. Its hydro capacity is 44.6 million cubic meters, with the objective of attenuating the effects of drought suffered by the local population. The main objective of this work was to study the variability of NDVI obtained by the product MODA13 MODIS / Terra and monthly precipitation in March and September 2008 to 2012 with the aim of detecting possible changes in vegetation in the rainy months and dry region. For this we applied the algorithm SEBAL (Surface Energy Balance Algorithm for Land) which is one of the most used to extract information from satellite sensors. The study area includes areas of native vegetation (caatinga), rice cultivation and irrigated areas with fruit, especially the production of coconut and bananas. The results MODIS to month dry and wet area PISG show average for the three targets studied, ie consortia banana / coconut, rice and native vegetation NDVI values of 0.39, 0, 43 and 0.40 for the dry month and 0.63 , 0.62 and 0.77 for the rainy month . Given the results found that MODIS / Terra presented a mean correlation coefficient (r) of the order of approximately 0.88 and average error of 9% between NDVI and rainfall for the months of March and September. This shows that the rains are important in the development of vegetation, even in the case of irrigated period.

Keywords: Rainfall, vegetation index, MODIS-Terra.

Introduction

In recent years it has been discussed quite spare the changes in global climate, aiming to clarify issues about the real consequences of anthropogenic processes in global climate. Noble et al. (1991) in their work to Amazon showed that climate and local vegetation coexist in dynamic equilibrium that can be altered by major disruptions in any of the two components. The power of vision attributed to man is limited by only allowing it to capture electromagnetic energy in the visible spectrum (400-700 nm) region. The sensing is a useful tool in research directed to study the behavior of a large number of weather-related variables in general. This approach seeks to make the system more operational monitoring of vegetation parameters and different meteorological parameters, with the support of information collected meteorological and environmental satellites, such as Landsat / TM and AVHRR / NOAA, MODIS / Terra and Aqua, among others.

Multitemporal data obtained from remote sensing have been widely used for different purposes throughout the world . They stand out by examples , the work of Silva et al . (2005a) ; Silva et al. (2005b); Bezerra et al. (2008); Silva et al. (2009) who made use of Landsat sensor to estimate and validate different vegetation parameters and atmospheric . Galvíncio et al. 2008 used elevation data and NDVI images obtained from the CCD/CBERS-2 to quantify the percentage of vegetated areas with vigor and influenced by topography . Araújo et al . , 2009 used data from Landsat TM NDVI - 5 to assess the environmental impact of the Araripe region. Jensen (2009) states that the NDVI is important because from its application , the seasonal and interannual variations of vegetation contributing to its monitoring can be observed. Silva et al. (2011) used Landsat TM images of the 5 - Irrigated Perimeter of São Gonçalo - PISG to determine and map the albedo and radiation balance at different targets . The authors concluded that the soil with low vegetation albedo ranged between 32 and 38.7 % over the days and the radiation balance of the dam and irrigated orchard was superior to the other areas. Note also, the work of Silva and Galvíncio (2012) using Landsat TM images of the 5 sensor to evaluate the behavior of vegetation in different periods. The authors suggest that SAVI is more appropriate than NDVI in areas of caatinga . Dantas et al., (2013) with data from the AVHRR / NOAA to evaluate the performance of the vegetation in relation to rainfall in the 2010's to the Paraíba state. The authors showed NDVI is a good indicator of rainfall.

In addition to the reasons mentioned above, climate variability is not provided a major source of risk and failure to agriculture. The high accident rate in Brazilian agriculture, most often caused by the weather forecast, the main one being, drought or excess rain, led the Ministry of Agriculture to create the Program for Agricultural Zoning (Cunha and Assad, 2001). One of the main factors for the success of this program is to develop mathematical models that combine the characteristics of culture to local climatic conditions, based on the data of temperature and rainfall.

Given the numerous applications making use of remote sensing for different purposes, the purpose of this work is to find a functional relationship between NDVI obtained from MODA13 product of MODIS / Terra sensor with rainfall observed in three distinct targets in the irrigated area of São Gonçalo - PISG at Souza -PB .

Material and Methods

Study Area

The Irrigated São Gonçalo - PISG is located 15 km from the city of Sousa - PB (6.84 ° S, 38.32° W, 234m) which is approximately 444 km from the capital João Pessoa. The weir is located in Sao Goncalo watershed Alto Piranhas, subbasin of the Rio Piranhas in the west of Paraíba in northeastern Brazil (Figure 1), whose construction works started in 1932 and completed in 1936. With hydro capacity 44.6 million cubic meters, aiming to mitigate the effects of drought suffered by the local population. The climate is classified as semiarid, DDA typology, according to the classification of Thornthwaite and Matther (1958) second Varejao - Silva et al.(2006). The rainy season is concentrated in the February-May period, with annual average temperatures, precipitation of 25.3 °C, 831 mm respectively. The predominant soils are Oxisols and Inceptisols and natural vegetation is classified as Caatinga Contact

- Seasonal Forest and Pioneer Formations with fluvial influence (SEI, 2008). The study area comprises the areas of native vegetation and irrigated areas, especially the production of coconut and bananas and rice.

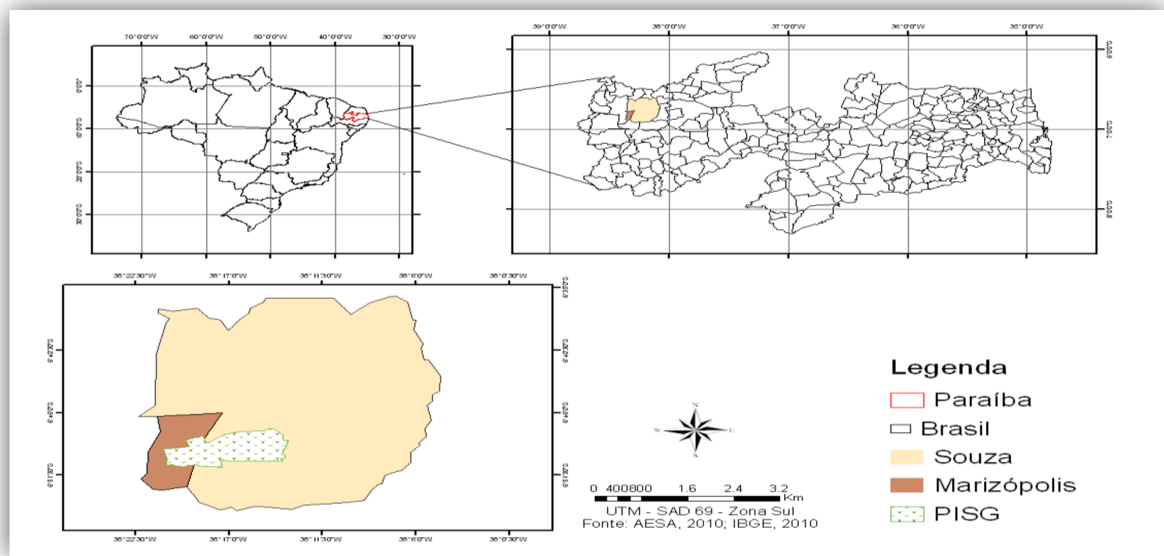

Figure 1. Localization study area, Perímetro Irrigado São Gonçalo - PISG in Sousa-PB.

MODIS / Terra and Aqua Image

The MODIS sensor on board the Terra satellite was launched on December 18, 1999 as part of the Earth Observing System (EOS) program funded by NASA's ESE program (Earth Science Enterprises), designed to acquire data on the interaction land, ocean and atmosphere. The MODIS is an instrument developed by the Goddard Space Flight Center (GSFC) NASA's Beyond TV LAND, MODIS is aboard the AQUA satellite and together the two instruments can acquire images of the Earth 1-2 days.

The sensor has 36 spectral bands with wavelengths ranging from 0.4 to 14.4 m and spatial resolution of 250 1,000 meters. The bands 1 and 2 has a spatial resolution of spectrum bands 250 m, 3 and 7 500 m bands from 8 to 36 m 1000, providing global coverage with revisit time of 1 to 2 days and ground scanning area 2330 Km has heliossíncrona with altitude polar orbit of 705 km, velocity of 6.7 km / s, equatorial crossing at about 10:30. This sensor measures the proportion of the planet's surface that is covered by clouds almost every day. An important feature of this sensor is that the data is available georeferenced and corrected for atmospheric effects. Currently, there are 44 data products that are included in calibration, atmosphere, land, cryosphere and ocean. More information about the MODIS products can be found in Justice et al. (2002), Anderson et al. (2003) and Bisht et al. (2005).

Ten images generated by the Thematic Mapper MODIS satellite, in orbit 216 and paragraph 65 in acquired (http://modis.gsfc.nasa.gov/) were used. These images correspond to the passage of at 10:30, on days 61 and 245 of 2008 and 60 244 2009, 60 244 and 2010 60 and 244 2011 and 61 245 and 2012. Processing of images was performed as ERDAS software Imagine 9.2, Leica Geosystems and the image processing used the ACRGIS software version 13. was used if rainfall data (EFSA, 2012) to assess the variability in the NDVI PISG region.

Obtaining the NDVI

The product of the MODIS vegetation (represented by MOD13) provides two vegetation indices, besides the reflectance bands of red, near infrared and blue (used in the calculation of EVI). Index Normalized Difference Vegetation has been widely used by give a strong signal of vegetation and offer a nice contrast to other targets surface Parkinson (1997). The NDVI represents the stage of development of vegetation, and it is very important for research addressing environmental issues. According to Rouse et al (1973) NDVI is calculated by the following expression :

$$IVDN = \frac{IVP - VIS}{IVP + VIS}$$

VIS is the reflectance in the visible spectral band, while NIR is the reflectance in the near infrared spectral band. The NDVI is a sensitive indicator of the amount and condition of the vegetation and its magnitude reflects the level of photosynthetic activity of vegetation, besides being an estimator of biomass. Their values vary from -1 to +1, and for vegetated areas varies between 0 and 1, while for water bodies and clouds NDVI is generally less than zero.

To find the relationship between NDVI estimated by MODIS / Terra and rainfall used the method of least squares linear regression. Ie , $Y = \alpha + \beta X$ the linear model chosen to fit the data pairs (Xi Yi) of the sample . Is denoted by a and b the estimated α and β, respectively. The estimate of Y model adjusted composing and b of the linear regression equation of the line is given by

$$\hat{Y} = a + bX \qquad (1)$$

where the coefficients a and b of the regression, Y is dependent and the independent variable X variable. Found that the linear correlation coefficient r between MODIS / Terra and rainfall data , through the expression :

$$r = \frac{\sum xy}{\sqrt{(\sum x^2)(\sum y^2)}} \qquad (2)$$

Where: $x = X - \bar{X}$ and $y = Y - \bar{Y}$

The quantity r is dimensionless and ranges between $-1 \le r \le 1$. We performed the Student r test to assess the statistical significance of the data for a significance level = 0.05 . Further details of the methodology are in Spiege , 1978 and Wilks , 2006.

Results and Discussion

Rainfall in the Sousa city is characterized by sparse and erratic rainfall, the rainy season covers the months from February to May (Brito and Braga, 2003; EFSA , 2012)

The vegetation indices among other things highlight the spectral behavior of vegetation in relation to soil and other Earth surface targets (Moreira, 2005). The NDVI is used to show the dynamic behavior of vegetation in three distinct targets of the irrigated area of São Gonçalo - PISG. The estimates biomass index can range from -1 to 1, with values less than 0 corresponds to regions containing water and clouds do not precipitate. Values between 0 and 0.2 occur in regions with high soil exposure, and greater than 0.2 in vegetated regions, Figure 2.

Figure 3a to 3j Thematic maps show the spatial variability of NDVI for days 61 and 245 of 2008 and 60 244 2009, 60 244 and 2010 60 and 244 2011 and 61 245 and 2012 for the month of March (rainy) and dry September of the experimental field PSIG region.

In scenes studied the increase in green hue indicates higher values of NDVI. The lighter shades correspond to areas of exposed soil and urban areas. In general, areas with irrigated crops banana / coconut rice and the PISG and adjacencies are highlighted by dark green tint. In March, rainy season is observed larger areas with high NDVI (Fig. 3). The vegetation has naturally presents higher values of NDVI, due to the high absorption of electromagnetic radiation in the range of wavelength of the red chlorophyll in green leaves, combined with high reflectance in the near-infrared range, due to the presence of chlorophyll and turgidity of healthy leaves. Ferreira et al. (2012) found NDVI values higher than 0.40, for regions with strong presence of fruit growing on the banks of the São Francisco River in Petrolina - PE. Elsewhere in the region to cover the savanna in the dry season the author obtained values lower than 0.30 and the rainy season NDVI values that ranged from 0.40-0.50. In some situations these results are similar to those found in this research. Lillesand et al. (2007) and Nicácio (2008) found NDVI values between 0.48 and 0.82 for regions with strong presence of fruit growing on the banks of the São Francisco River in Petrolina. Folhes (2007) observed in irrigated areas of horticulture NDVI values that ranged between 0.7 and 0.9.

The image of the DSA 60, 2011 (G) there is a higher concentration of index values greater than 0.5 vegetation, this can is linked to more rainfall occurred in the area this year. In subsequent stock indexes decline, was already expected due to the remoteness of the rainy season.

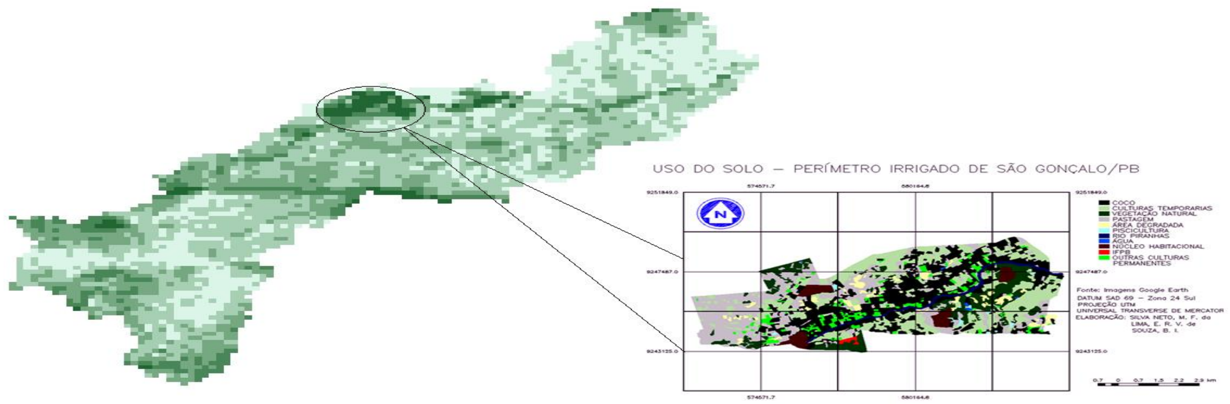

Figure 2 – Land use in São Gonçalo-PISG.

Table 1 shows the values of NDVI for three (03) targets of the study area are shown. The average monthly NDVI for the driest month was 0.37; 0.43; 0.39 in the consortium banana / coconut, rice and native vegetation respectively. In the rainy season these values are higher, ie, 0.63 ; 0.62; 0.77. It can be seen that the target showed higher NDVI was the native vegetation. This can be explained because the predominant natural vegetation of the area is scrub that develops rapidly after the rains. Statistical analysis showed that the area of banana/coconut had a standard error of estimate was 0.04 with linear correlation coefficient equal to 0.89, implying a coefficient of determination r2 = 0.79, shown in Table 2. The linear model, therefore, explains 79 % of the total variance. The significance of the linear correlation coefficient (r) was based on the Student (t) test for the significance level of $\alpha = 0.05$. In other rice area r = 0.85 and r = 0.88 indigenous vegetation, namely one determination coefficient of 0.75 and 0.77 respectively. It can be seen that Figure 4 illustrates the temporal variability of NDVI for orchards banana / coconut, rice and natural vegetation in relation to rainfall and Figure 5 which shows the correlations in the three targets studied. This shows whether or not the irrigated areas NDVI 's rainy year 2011 were highest and lowest in 2010 (Table 1) .

Table 1 –NDVI value month obtained with MODIS for three pointsin São Gonçalo Irrigated Perimeter-PISG

Image (date)	NDVI			Month rainfall
	BANANA/Coconut	Rice	Nativa Vegetation	(mm)
3/2/2008	0.564	0.555	0.766	162.7
9/2/2008	0.359	0.48	0.443	5.5
3/1/2009	0.716	0.686	0.82	198.7
9/1/2009	0.385	0.486	0.441	29.7
3/1/2010	0.531	0.546	0.708	77.7
9/1/2010	0.32	0.371	0.37	0
3/1/2011	0.71	0.683	0.812	404.2
9/1/2011	0.449	0.45	0.407	3.7
3/2/2012	0.641	0.644	0.788	218
9/2/2012	0.419	0.373	0.338	0

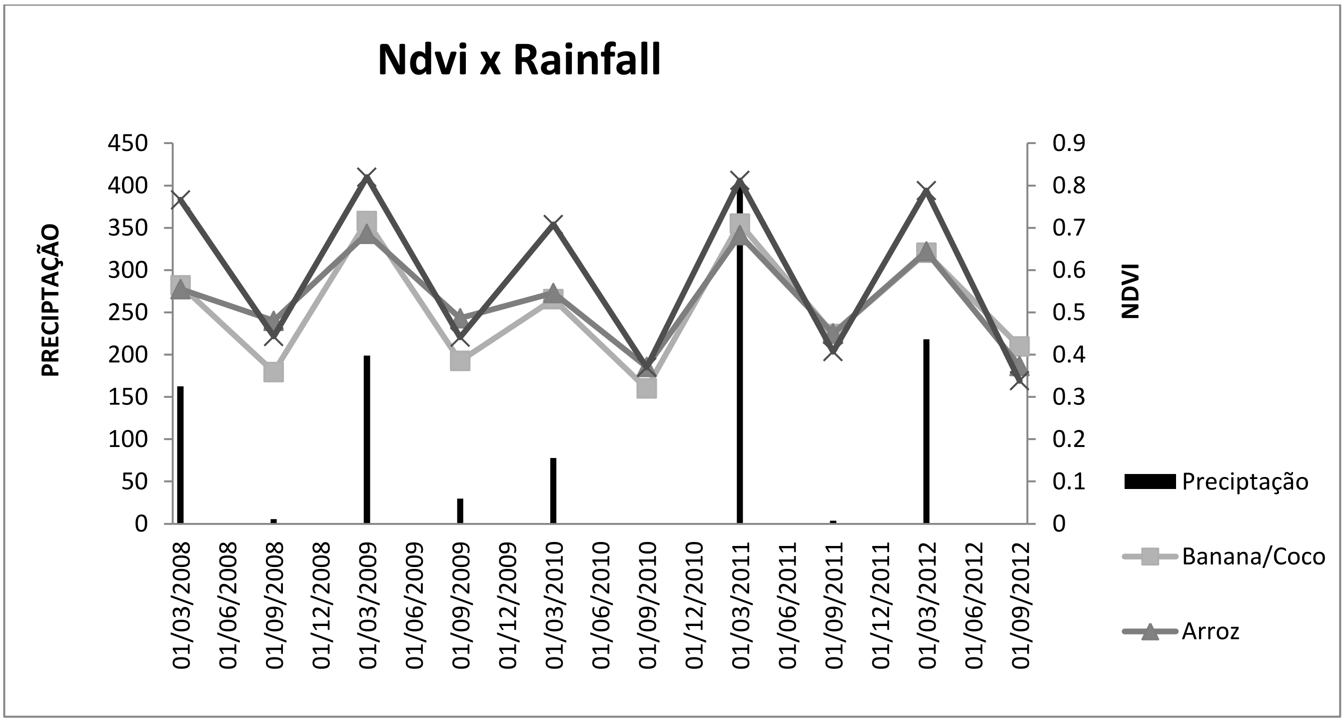

Figure 3 – Month NDVI and rainfall for three points during 2008 e 2012 in São Gonçalo irrigated perimeter.

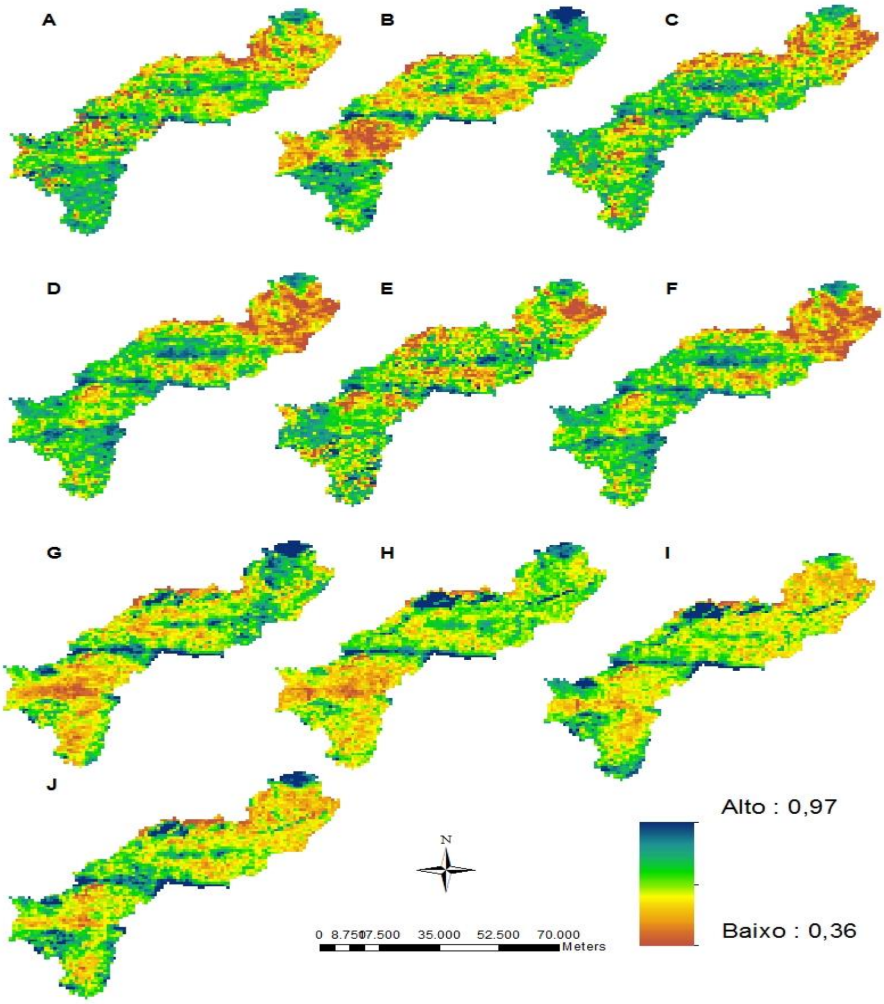

Figure 4 – Temathic maps NDVI spatial variation with MODIS-Terra in São Gonçalo irrigated perimeter-PISG.

Table 2 – Errors value of the three points in São Gonçalo Irrigated Perimeter- PISG

Points	a	b	R^2	Standard error
Banana/Coconut	0,0011	0,4035	0,7955	0,04
Rice	0,0008	0,4436	0,7721	0,03
Nativa Vegetation	0,0013	0,4465	0,7302	0,21

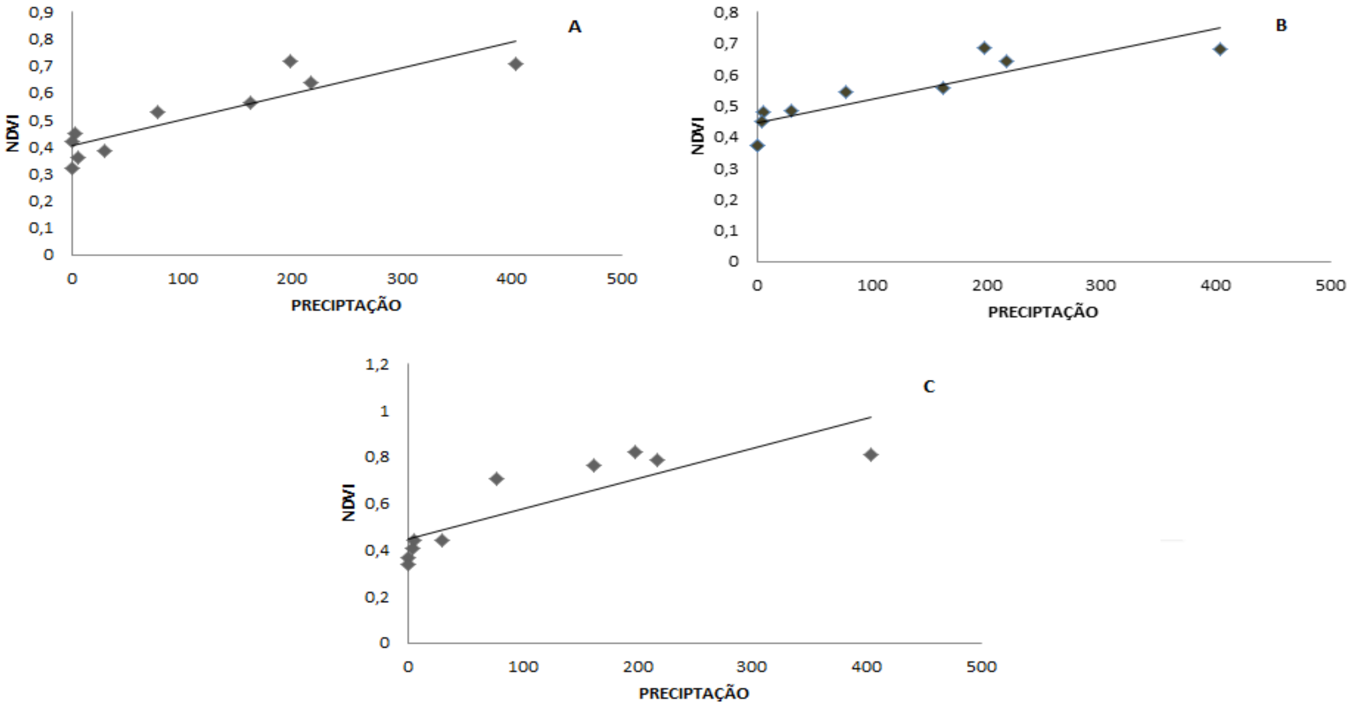

Figure 5 – Correlation between NDVI and rainfall for three points: **A** – Banana/coconut, **B** – rice and **C**- nativa vegetation in São Gonçalo Irrigated Perimeter.

Conclusions

The use of remote sensing, particularly with MODIS-Terra, is a practical and low operating cost to obtain spatial estimates of NDVI. It was found that the MODIS-Terra sensor was useful for evaluating the performance of vegetation index in cultures of banana / coconut rice and native vegetation in the area PSIG for both the dry season and rainy. The functional relationship between NDVI rainfall showed a coefficient of correlation (r) for the three targets of approximately 0.88 and a mean error of 9%, thus showing the importance of rain on the development of vegetation in the study area.

Acknowledgements

The CAPES for research funding. Our gratitude to INMET, for providing data from their automatic station São Gonçalo - PB.

References

AESA- 2012. Agência Executitva de Gestão das Águas do Estado da Paraíba. Monitoramento. Disponívelem<http://site2.aesa.pb.gov.br/aesa /monitoramentoClimatologiaPeriodoChuvoso. dmetodo=exibirAnosAnteriores>. Acesso em 18.set.2012.

Anderson, L. O.; Latorre, M. L.; Shimabukuro, Y. E.; Arai, E; Júnior, O. A. de C. 2003. Sensor MODIS: uma abordagem geral. INPE-10131-RPQ/752, São José dos Campos, SP. Instituto Nacional de Pesquisas Espaciais, 58p.

Araujo, A. L., et al., 2009 "Variação do NDVI na Chapada do Araripe com dados Landsat 5 – TM". Simpósio Internacional de Climatologia, Canela – RS.

Bezerra, B. G; et al 2008. "*Estimativa da evapotranspiração real diária utilizando-se imagens digitais TM - Landsat 5"*. Revista Brasileira de Meteorologia, volume 23, n.3, pp. 305-317.

Bisht, G.; Venturini, V.; Islam, S.; Jiang, L. 2005. Estimation of the net radiation using MODIS (Moderate Resolution Imaging Spectroradiometer) data for clear-sky days. Remote Sensing of Environment, v.97, n.1, p.52–67.

Braga, C.C.; Brito, J.I.B.; Sansigolo, C.A e RAO; T. V. R. 2003.Tempo de resposta da vegetação às variabilidades sazonais da precipitação no Nordeste do Brasil. Revista

Brasileira de Agrometeorologia, Santa Maria-RS, v.11, n.1, p. 149-157.

Brito, B. I. J. ; Braga, C. C. 2005. Chuvas no estado da Paraíba em 2004.Boletim da Sociedade Brasileira de Meteorologia, Vol. 29, n.1, p. 27 – 32.

Cunha, G. R.; Assad, E. D. 2001.Uma visão geral do número especial da RBA sobre zoneamento agrícola no Brasil. Revista Brasileira Agrometeorologia. V.9, n. 3 (No Especial: Zoneamento Agrícola), p.377-385.

Dantas, M. P; Braga, C. C; Oliveira, G. B; Souza, L. F.; Amanjás, J. C. 2103. Análises Espacial do IVDN n Estado da Paraíba baseado em Seres de dados do sensores AVHRR/NOAA. In: XVI Simpósio Brasileiro de Sensoriamento Remoto, Foz do Iguaçu-PR. Anais: Foz do Iguaçu. INPE, Brasil. p. 1923-1929.

Ferreira, S. M. J. ; Ferreira, F. S. H.; Silva, A. H.; , Santos, M. A.; Galvíncio, D. J.; 2012. Análise Espaço-Temporal da Dinâmica da Vegetação de Caatinga no Município de Petrolina – PE, Revista Brasileira de Geografia Física 04 (2012) 904-922.

Jensen, J. R.; 2009. Sensoriamento Remoto do Ambiente: uma perspectiva em recursos terrestres. 2ed. São José dos Campos: Parêntese, 604 p.

Justice, C. O.; Townshend, J.R.G.; Vermote, E.F.; Masuoka, E.; Wolfe, R. E.; Saleous, N.; Roy, D.P.; Morisette, J.T. 2002. An overview of MODIS Land data processing and product status. Remote Sensing of Environment, v.83, n.1-2, p.3–15.

Lillesand, T., R.W. Kieffer, and J. Chipman. 2007. Remote Sensing and Image Interpretation. 6th ed., John Wiley and Sons, New York, US.

Moreira, M.A. 2005. Fundamentos do Sensoriamento Remoto e Metodologias de Aplicação. Universidade de Viçosa: Editora UFV, 3ª edição, 320p.

Nicácio R. M.(2008). Evapotranspiração real e umidade do solo usando sensores orbitais e a metodologia SEBAL na bacia do rio São Francisco. Rio de Janeiro: COPPE-UFRJ, 2008. 320p. Tese doutorado.

Nobre, C.A.; Sellers, P.J.; Shukla, J. 1991. Amazonian deforestation and regional climate change. Journal of Climate, v.4, p.957–987.

P. Folhes.,M. (2007). Modelagem da evapotranspiração para a gestão hídrica de perímetros irrigados com base em sensores remotos. Tese de Doutorado do Curso de Pós-Graduação em Sensoriamento Remoto, orientada pelos Drs. João Vianei Soares e Camilo Daleles Rennó, aprovada em 2 de abril de 2007.

Parkinson, C. L. 1997. “Earth from above”. University Sciences Books, Sansalito. Land vegetation, 107-111.

Rouse, J.W.; Haas, R.H.; Schell, J.A.; 1973. Deering, D.W. Monitoring vegetation systems in the great plains with ERTS. In Earth Resources Technology Satellite- 1 Symposium,3, 1973. Proceedings. Washington, v.1, Sec. A, p. 309-317.

Silva, B. B. da; Braga, A. C. ;Braga, C. C.;Oliveira, M. M. L.; Galvíncio, J. D.;Montenegro, S. M. G. L. 2012. Evapotranspiração e estimativa da água consumida em perímetro irrigado do semiárido brasileiro por sensoriamento remoto. Pesquisa Agropecuária Brasileira (1977. Impressa), v. 47, p. 1218-1226.

Silva, b. B. da; Braga, a. C.; Braga, c. C. 2011. Balanço de radiação no perímetro irrigado São Gonçalo – PB mediante imagens orbitais. Revista Caatinga, v.24, n.3, p.145-152.

Silva, B. B., et al (2009). Obtenção do albedo e IVDN em áreas heterogêneas do estado do Ceará com imagens. In: XIV Simpósio Brasileiro de Sensoriamento Remoto, Natal, RN, p.475-482.

Silva, B. B.; et al (2005b). “*Determinação do albedo de áreas irrigadas com base em imagens do LANDSAT 5- TM”.* Revista Brasileira de Agrometeorologia, v. 13, n. 2, pp. 11 -21.

Silva, b. B.; Lopes, g. M.; Azevedo, p. V. (2005a). “*Balanço de radiação em áreas irrigadas utilizando imagens Landsat 5 – TM”*. Revista Brasileira de Meteorologia, volume 20, n.2, pp. 243-252.

Spiegel, M. R. 1978. Probabilidade e Estatística. Coleção Schaum. São Paulo: Mc Graw-Hill do Brasil.

Thornthwaite, C. W., et al (1944). The water balance. Centerton, N J: Drexel Institute of technology – laboratory of climatology. 104 p. Publications in climatology, vol.8, n.1.

Varejão-Silva, M. A. 2001. Meteorologia e Climatologia. 2.ed. Brasília-DF: PAX Gráfica e Editora.

Varejão-Silva, M. A.; 2006. Meteorologia e climatologia. Ministério da Agricultura e Abastecimento, Instituto Nacional de Meteorologia, 2ª Ed. (versão digital), 463p.

Wilks, D. S. 2006. Statistical Methods in the Atmospheric Sciences. 2. ed. London, Academic Press, 649p.