Australian Journal of Basic and Applied Sciences, 9(20) June 2015, Pages: 358-363

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Pluviometric Influence in the Indexes of NDVI and NDWI Vegetation for the Municipality of Guarapuava-PR, South Region of Brazil

Bruna Nascimento de Vasconcellos Schiavo, Marieli Sabrina Ruza, Ângela Maria Klein Hentz, Ana Beatriz Schikowski, Ana Paula Dalla Corte, Carlos Roberto Sanquetta

Federal University of Paraná, Department of Forest Engineering. Address: 900, Prefeito Lothário Meissner Avenue, Jardim Botânico, 80212-170, Curitiba, Paraná, Brazil

ARTICLE INFO

Article history:
Received 16 April 2015
Accepted 12 June 2015
Available online 1 July 2015

Keywords:
Remote sensing, Forestry, Correlation, Landsat 8.

ABSTRACT

The techniques of remote sensing have been essential in the studies of environmental monitoring. The present work had as objective to analyze the correlation that exists between the index of NDVI and NDWI vegetation with the intensities of precipitation different in each season of the year, in the municipality of Guarapuava-PR, Brazil. We used images from the Landsat 8 sensor TM satellite, and monthly pluviometric data available by SIMEPAR, from the period of September 2013 to August 2014, the data were processed in the software ENVI 4.7. Initially, we made the radiometric calibration, then, we obtained the monochromatic reflectance of each band, and we calculated the index of NDVI and NDWI vegetation. The raining period, composed by the winter and autumn, presented a monthly average precipitation of 254,64mm, then the NDVI and NDWI indexes were of 0,83 e 0,64 respectively. The dry period, composed by the summer and the spring, presented a monthly average precipitation of 176,16mm, and the indexes of NDVI and NDWI vegetation were of 0,52 and 0,53 respectively. We verify that the highest coefficient of correlation between the precipitation and the indexes of vegetation were in the raining season, when it was r=0,91 to NDVI and r=0,76 to NDWI, so that the increasing of precipitation results in higher indexes of vegetation. The indexes of NDVI and NDWI vegetation were considered efficient to analyze the spectral answer of the vegetal covering studied**.**

To Cite This Article: Bruna Nascimento de Vasconcellos Schiavo, Marieli Sabrina Ruza, Ângela Maria Klein Hentz, Ana Beatriz Schikowski, Ana Paula Dalla Corte, Carlos Roberto Sanquetta. Pluviometric influence in the indexes of NDVI and NDWI vegetation for the municipality of Guarapuava-PR, Brazil. ***Aust. J. Basic & Appl. Sci.,*** *9(20): 358-363, 2015*

INTRODUCTION

The Index of Vegetation is considered a technique of processing images that aims to optimize the exploration of the data of remote sensing. It is used the reflectance of the targets in these spectral bands in order to obtain a product in which the answer of the vegetation is highlighted. This is possible due to the vegetation that presents low reflectance in the visible band (as a result of the absorption of the electromagnetic radiation by the pigments photosynthetically actives in the leaf) and high for the near infrared (due to the spreading of the electromagnetic radiation in the internal structure of the leaf) (Rosemback e*t al.* 2010).

The uninterrupted availability of the orbital images allows regular analysis of the vegetation in global level, including the evaluation of phenological aspects of the vegetation and the detection of changes in the use and cover of the soil. Thus, the strict correlation between the space-time dynamics of the vegetation and the indexes of vegetation corroborates the potential of them in the monitoring of the vegetal covering on the extensive areas (Risso *et al.* 2009).

The pluviometric regime is the main climate characteristic that determines the development of the plants in tropical regions, in contrast with the temperate regions, in which the beginning and the end of the station of growing are defined by the seasonal regime of the air temperature (Oliveira *et al.* 2000).

The indexes of NDVI and NDWI vegetation are directly related to the biophysical parameters of the vegetation. The NDVI was the first index of vegetation developed and proposed by Rouse et al. (1974), it has been widely explored in several approaches, such as in studies of the vigor of vegetation, in the coefficient of agriculture cultures, mapping the use and occupation of the soil, deforestation, climate changes among others (Araújo, 2006).

Corresponding Author: Bruna Nascimento de Vasconcellos Schiavo, Federal University of Paraná, Department of Forest Engineering. Adress: 900, Prefeito Lothário Meissner Avenue, Jardim Botânico, 80210-170, Curitiba, Paraná, Brazil.
Tel:+55(41)33604264. E-mail:brunaslg@hotmail.com

Australian Journal of Basic and Applied Sciences, 9(20) June 2015, Pages: 358-363

The NDWI (Normalized Difference Water Index), presented by Gao (1996), is related to the content of water presented in the leaves. Then, it is of utmost importance in the studies referring to the vigor of vegetation, changes in the biomass and hydric stress of the plants (Jensen, 2009).

Several studies have presented positive results in relation to the applicability of the indexes of vegetation to classify the global distribution of the vegetation in connection of the weather, infer variability of biophysical parameters of the vegetation with production of python mass, index of foliar area and use of the land (Xavier e Vetorazzi, 2004).

In a way that there is a physiological answer of the plants before disturbs, like the variability of the temperature of the air and precipitation (Huntingford *et al.* 2013).

The present work aimed to analyze the correlation that exists between the indexes of NDVI and NDWI vegetation with different intensities of precipitation in each season of the year, in the municipality of Guarapuava – PR, Brazil.

MATERIAL AND METHOD

Characterization of the study area:

Guarapuava is located in Parana state, in the South area of Brazil, in the parallel 25° 23’ 26’’ South latitude and meridian of 51° 27’ 15’’ longitude West of Greenwich, as we can see in Figure 01. It has average altitude of 1,120m and a total area of 3,112 km^2, and population of 166,195 habitants according to Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística – IBGE, 2010).

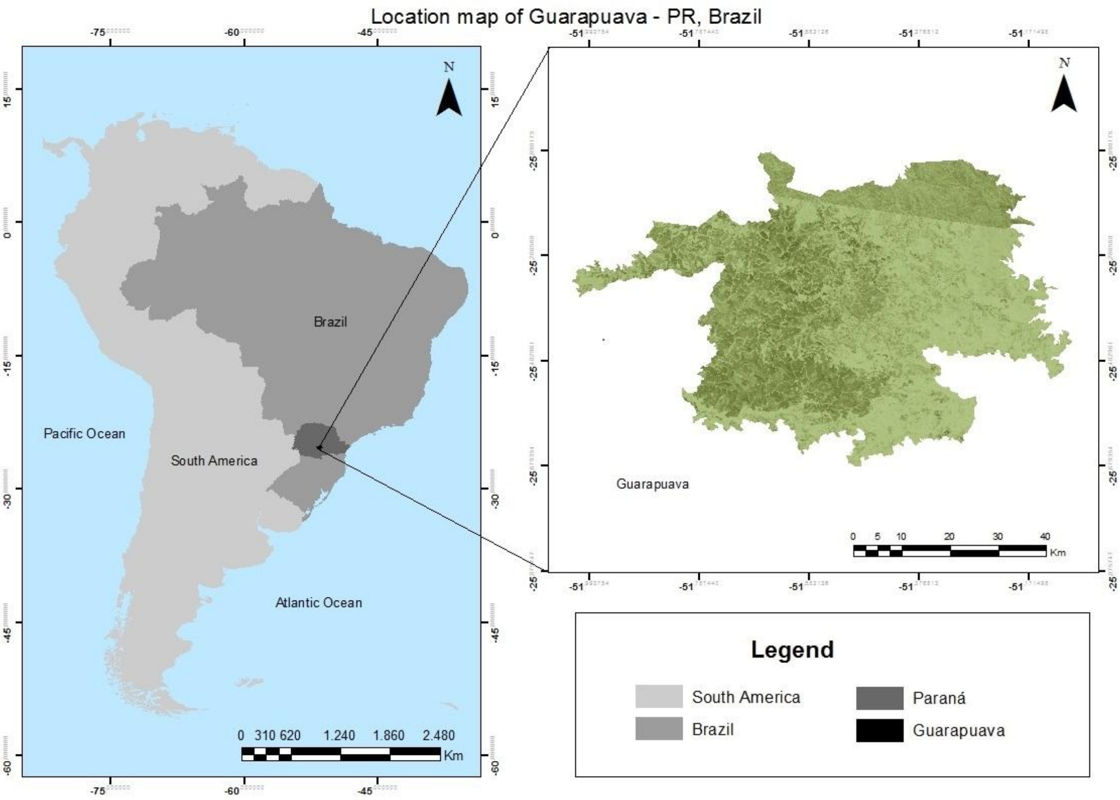

Fig. 01: Location Map of Guarapuava-PR, Brazil.

The climate of Guarapuava is classified as mesothermic-humid subtropical, it does not have a dry season, with fresh summers and moderate winter. The pluviosity presents itself well distributed during the year, with average precipitations annual around 1961 mm, presenting considerable extreme variations and the average temperature annual is around 16 and 17,5 ºC (Thomaz e Vestena, 2003)

In relation to the local geological basis, there are rock outcroppings belonging to the Formation Serra Geral (Geral Mountains) standing out the basalts and the porphyries riodacite, besides the alluvial sediments associated to flood plains in the valley floors (MINEROPAR, 1992)

The predominant pedological unit is the Alic A Latosol (Latossolo Bruno Álico A), occurring also the associations of Alic Cambisol, litolic soils, in the steeper slopes and in the position of alluvial plain.

The municipality together with other 17 municipalities forms the micro region Campos de Guarapuava that occupies the first place in the ranking of natural forests of the Paraná state, with 15.22% of areas covered by forests, and the Mixed

Ombprophylous Forest is the main formation of vegetation (Cordeiro 2005).

The terrain of the forest area presents three variations very distinctive, with the gently-wave in the superior portion, medium wave in the medium portion, and plain in the inferior portion that borders the Xarquinho river (Guarapuava, 2006)

Data processing:

The monthly data of precipitation of the study area were obtained through the Meteorological System of Paraná (Sistema Meteorológico do Paraná - SIMEPAR). The data were studied considering the precipitation accumulated in each month, and after distributed by seasons of the year.

We used images of the Thematic Mapper (TM) sensor on board the Landsat-8 satellite, with spatial resolution of 30m, in the period between September 2013 and August 2014 obtained in the site of U.S. Geological Survey.

For delimiting the study area we used the vetorial limit of the municipalities of Paraná, providing by the Brazilian Institute of Cartography and Statistics (IBGE, 2010)

Initially we performed the radiometric calibration, that is the process of converting the digital number (ND) of each pixel of the image, in spectral monochromatic spectral radiance ($L_{\lambda i}$). The data were processed in software ENVI 4.7.

In this study we used the relation proposed by Markham & Baker (1986) for implementation of radiometric calibration:

$$L\lambda i = ai + bi - \frac{ai}{255xND} \qquad (1)$$

Where:

a_i and b_i = minimum and maximum spectral radiances (Wm-2 sr-1 m -1) detected by TM sensor

ND= intensity of the pixel (whole number of 0 to 255)

i =bands 1, 2...,11 of Landsat 8-TM.

The index of vegetation by normalized difference (NDVI), proposed by Rouse et al. (1973), was calculated from the following equation:

$$NDVI = \frac{(\rho NIR - \rho R)}{(\rho NIR + \rho R)} \qquad (2)$$

Where:

ρNIR = Bands of Near Infrared

ρR= Bands of Red

The NDWI was calculated for each pixel using the reflectivities of the bands in the near infrared and of the medium infrared according to what was proposed by Gao (1996) in the following equation:

$$NDWI = \frac{\rho IV - \rho MIR}{\rho IV + \rho MIR} \qquad (3)$$

Where:

ρIV= Band of Near Infrared

ρMIR = Band of Medium Infrared

We performed analysis of Pearson correlation between the indexes of NDVI and NDWI vegetation with the precipitation.

RESULTS AND DISCUSSION

From this seasonal averages classified by the seasons of the year, during the period from September, 2013 to August, 2014, we observed that the winter was the period that presented major pluviometric index, with an average precipitation of 297.5mm, so it was the season that presented major values for the indexes of NDVI and NDWI vegetation, according to what it can be observed in Figure 02. The autumn was the second season to present the major values of precipitation and indexes of vegetation.

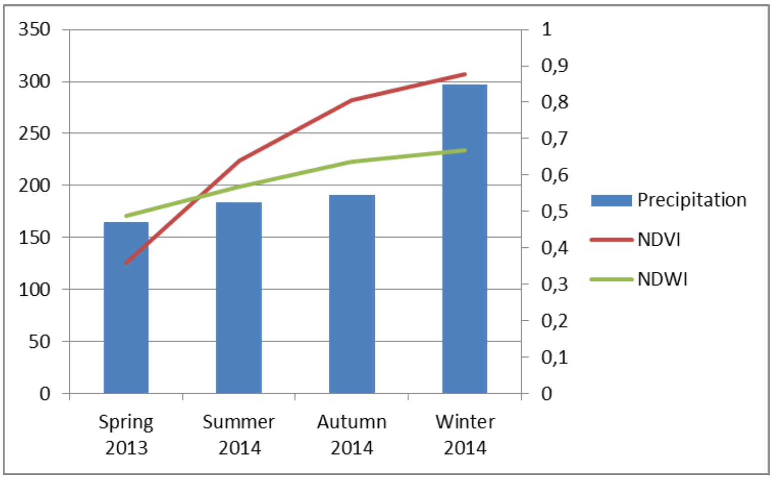

Fig. 02: Seasonal Variability of the indexes NDVI and NDWI vegetation and of precipitation in the municipality of Guarapuava-PR, Brazil.

Australian Journal of Basic and Applied Sciences, 9(20) June 2015, Pages: 358-363

The winter and autumn seasons were considered as the rainy period with monthly average of 254.64mm of precipitation, so they presented the highest values for the indexes of NDVI and NDWI vegetation, which were of 0.83 and 0.64 respectively.

The summer and spring were considered the dry period, presenting an average monthly precipitation of 176.16mm, and the indexes of NDVI and NDWI vegetation were of 0.52 and 0.53 respectively.

The analysis of the indexes of vegetation between the dry and rainy seasons permit to evidence the vigor of vegetation in different times, providing to relate the changes to climate and time factors with such indexes.

It is possible to observe that it occurs a similarity between the behavior of the indexes of vegetation and the precipitation, because the increasing of the precipitation result in the major values of the indexes of NDVI and NDWI vegetation.

From the mapping of the indexes of vegetation (Figures 03 and 04) it is possible to visualize the regions that present major values in both indexes, characterized by the green color in the map and with values next to +1, thus they present higher content of humidity and of pigments of chlorophyll responsible by the process of photosynthesis and by the high reflectance of vegetation in the length of wave of green and the absorption in red in the band of visible of the electromagnetic spectrum. The critical zones of content of humidity present values next to -1, and they are represented by the red color in the map.

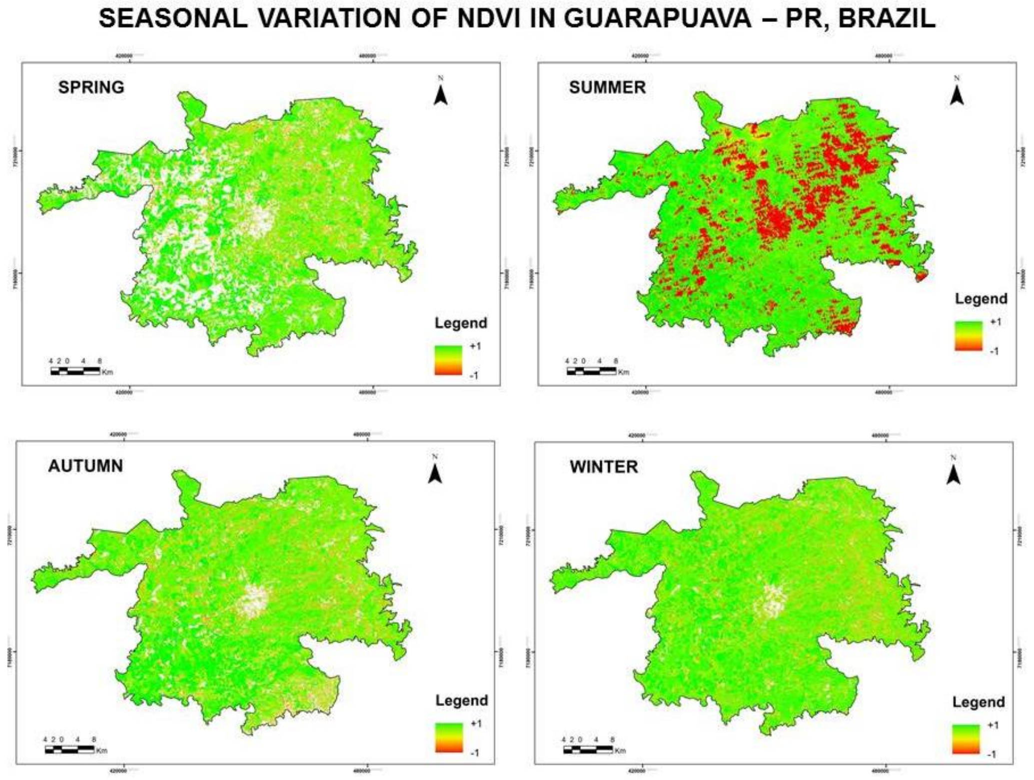

Fig. 03: Seazonal variation of NDVI in Guarapuava, PR, Brazil.

The NDVI characterizes itself by the answer being in function of the presence of active photosynthetically vegetation related to the biomass and to the content of chlorophyll presented. Thus, the lowest values of this index characterize the vegetation as being stressed, whether by water scarcity, by soil exposure with the deforestation and the degradation of the vegetation.

The NDWI is related to the content of water presented in the leaves, where the negative values represent areas with dry vegetation and positive values for green vegetation. Thus, it is extremely important in remote sensing for detection of water in liquid state in the vegetation from the space, reflectance of the properties of green vegetation, dry vegetation and soil, and the property of absorption and dispersion of atmospheric gases and aerosols.

We verified that the major coefficient of correlation between the precipitation and the indexes of vegetation was in the rainy season, being r=0.91 for NDVI and r=0.76 for NDWI, in a sense that the increasing of precipitation results in higher indexes of vegetation.

However, we observed that the precipitation was well distributed during the period, with little variation between the dry and rainy seasons.

It is not possible to establish a direct relation between the peaks of daily precipitation and increasing of the indexes of vegetation, so that the vegetation tends to answer less to short periods of dry or rain in abundance.

Studies have analyzed the correlation that exists between the vegetation cover and the climate variability, by relating the NDVI index of vegetation with meteorological data. The correlation is confirmed in several regions of the planet, which demonstrates the reliability in such observations. (Rosemback *et al.*, 2010)

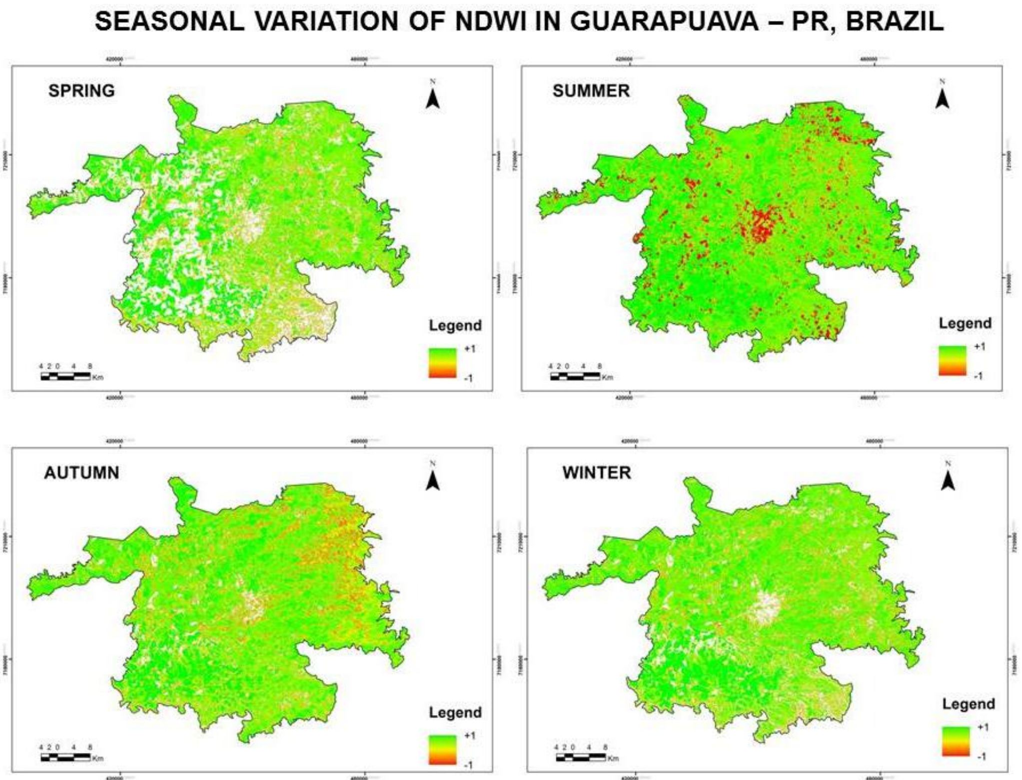

Fig. 04: Seazonal variation of NDWI in Guarapuava – PR, Brazil.

Research developed by Moreno (2014), analyzed the correlations inter-annuals between the indexes of vegetation and the humidity tenor of the leaves of seven types of forest physiognomies. It was obtained values of correlation between 0.7 and 0.8, however, it was considered necessary to improve the methodology for accompanying the temporal variations related to the hydric stress.

Kawabata *et al.* 2001, performed an analysis of the seasonal variation of NDVI from the temperature data and the precipitation, from the seasonal observations, and data of images from the NOAA satellite, in a period of 12 years. The areas that presented a higher correlation between the global data, in the north hemisphere were the regions that presented average and high latitudes, in the south hemisphere they would be the tropical regions and the arid and semi-arid zones.

Gonzaga *et al.* 2011, analyzed the behavior of NDWI in periods of different pluviometric intensities in Sertão Alagoano, and obtained a coefficient of correlation by Pearson of 0.52, 0.70 and 0.93, for the dry period, moderate and raining, indicating a progressive increasing in the relation between the variables with the elevation of the pluviometric totals.

By analyzing the Brazilian territory as a whole, we observe a vegetable cover very distinguished, and climate variations. Phenomena as *El Niño* and *La Niña*, for example, they act in an inverse way in the rainy regime in the north and south of the country. Biomes as Amazon and Atlantic Rainforest have been widely investigated, however, the studies performed in the South Region, formed by the states of Rio Grande do Sul, Santa Catarina and Paraná, are still very punctual, or focused for the agricultural production. (Rosemback *et al.* 2010)

The results obtained enabled to analyze the areas of greater and minor vegetative vigor, influenced directly by the variation of precipitation in each season of the year. The values of the indexes of NDVI and NDWI vegetation were consistent with the values available in the scientific literature, so that, they showed themselves efficient for analyzing the spectral answer of Guarapuava, south region of Brazil.

Conclusion:

The analysis of the indexes of NDVI and NDWI vegetation from the images of the Landsat 8 Satellite

Australian Journal of Basic and Applied Sciences, 9(20) June 2015, Pages: 358-363

showed itself satisfactory, because it provided information about the behavior of the vegetation according to the seasons of the year.

It was verified that exists a direct relation between the precipitation and the indexes of NDVI and NDWI vegetation.

Thus, we consider the results useful for possible studies of the interaction clime –vegetation, from the data obtained through the techniques of Remote Sensing.

ACKNOWLEDGMENT

The authors thank to the National Council of Scientific and Technological Development (Conselho Nacional de Desenvolvimento Científico e Tecnológico – CNPQ) and the Coordination for the Improvement of Higher Education Personnel (Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES) for granting scholarships.

REFERENCES

Araújo, T.L. Estimativa da temperatura e do saldo de radiação à superfície terrestre em Maceió-Al utilizando imagens TM/LANDSAT 5 (2006). Dissertação (Mestrado em Meteorologia) - Programa de Pós-Graduação em Meteorologia. Universidade Federal de Alagoas, Maceió-Al. 86f.

Cordeiro, J. Levantamento florístico e caracterização fitossociologica de um fragmento de Floresta Ombrófila Mista em Guarapuava, Paraná. Dissertação de mestrado em Botânica. Universidade Federal do Paraná, 2005.

Gao, B., 1996. NDWI - a normalized difference water index for remote sensing of vegetation liquid water from space. Remote Sens. Environ., 58: 257-266.

Gonzaga, E.P., V.V. Santos, Nicácio, R.M. Análise do comportamento do NDVI e NDWI em períodos de diferentes intensidades pluviométricas no sertão Alagoano. Anais XV Simpósio Brasileiro de Sensoriamento Remoto- SBSR, Curitiba, PR, Brasil, 2011, INPE, p.1738.

Guarapuava - Prefeitura Municipal – Secretaria Municipal do Meio Ambiente. SEMAFLOR. (http://prefeituramunicipaldeguarapuava/).

Huntingford, C., P. Zelazowski, D. Galbraith, L.M. Mercado, S. Sitch, R. Fisher, *et al*., 2013. Simulated resilience of tropical rainforests to CO2 - induced climate change. Nature Geoscience, 6: 268-273. http://dx.doi. org/10.1038/ngeo1741.

Jensen, J.R., 2010. Sensoriamento Remoto do Ambiente: Uma perspectiva em recursos terrestres. Tradução: José Carlos Neves Epiphanio. São José dos Campos, SP: Parêntese, 2009. IBGE -Instituto Brasileiro de Geografia e Estatística, (http://ibge.gov.br).

Kawabata, A., I. Ichii, Y. Yamaguchi, 2001. Global monitoring of interannual changes in vegetation activities using NDVI and its relationships to temperature and precipitation. International Journal of Remote Sensing, 22(7): 1377-1382.

Markham, B.L., J.L. Barker, 1986. Landsat MSS and TM post-calibration dynamic ranges, exoatmospheric reflectances and at satellite temperatures, EOSAT Landsat Tech. Note, 3-8.

MINEROPAR, Minerais do Paraná, 1992. Geologia de planejamento: Caracterização do meio físico da área urbana de Guarapuava. Curitiba: MINEROPAR,

Moreno, A., F. Masseli, M. Chiesi, L. Genesio, F. Vaccari, G. Seufert, M.A. Gilabert, 2014. Monitoring water stress in Mediterranean semi-natural vegetation with satellite and metereological data. International Journal of Applied Earth Observation and Geoinformation, 26: 246-255.

Oliveira, A.D., J.M.N. Costa, R.A. Leite, 2000. Probabilidade de chuvas e estimativas de épocas de semeadura para cultura de arroz de sequeiro, em diferentes regiões do Estado de Minas Gerais, Brasil. Revista Brasileira de Agrometeorologia, Santa Maria, 8(2): 295-309.

Risso, J., R. Rizzi, R.D.V. Epiphanio, B.F.T. Rudorff, A.R. Formaggio, Y.E. Shimabukuro, S.L. Fernandes, 2009. Potencialidade dos índices de vegetação EVI e NDVI dos produtos MODIS na separabilidade espectral de áreas de soja. Anais XIV Simpósio Brasileiro de Sensoriamento Remoto, Natal, Brasil, INPE, pp: 379-386.

Rosemback, R., N.J. Ferreira, Y.E. Shimabukuro, J.C. Conforte, 2010. Análise da dinâmica da cobertura vegetal na região Sul do Brasil a partir de dados MODIS/TERRA. In: Revista Brasileira de Cartografia, 62: 560-4613.

Rouse, J.W., R.H. Haas, J.A. Schell, D.W. Deering, 1973. Monitoring vegetation systems in the Great Plains with ERTS. Proc. Third Earth Resources Technology Satellite-1 Symposium, Goddard Space Flight Center, NASA SP-351, Science and Technical Information Office, NASA, Washington, DC, 309-317.

Thomaz, E.L., L.R. Vestena, 2003. Aspectos Climáticos de Guarapuava-PR. Guarapuava: UNICENTRO.

Xavier, A.C., C.A. Vettorazzi, 2004. Monitoramento do índice de área foliar em nível de bacia hidrográfica por meio do NDVI derivado de imagens Landsat- 7/ETM+. Scientia Agricola, Piracicaba, 61(3): 243-252.