Paper ID:016
1st National Conference on Water Resources Engineering (NCWRE 2018)
21-22 March 2018, CUET, Chittagong, Bangladesh
www.cuet.ac.bd

METEOROLOGICAL DROUGHT MONITORING USING SATELLITE IMAGERY: A CASE STUDY ON RAJSHAHI, NAOGAON AND JAIPURHAT OF BANGLADESH

S. Reza[*1], M. N. Islam[2] & M. M. Rahman[3]

*1*Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh, e-mail: salmanreza91@gmail.com*
2 Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh, e-mail: nahid.ruet@yahoo.com
3 Department of Urban & Regional Planning, Rajshahi University of Engineering & Technology, Rajshahi, Bangladesh, e-mail: mostafizur@ruet.ac.bd

ABSTRACT

Drought is considered as one of the major natural hazards that affect the environment and economy of a country. Different from other natural disasters, drought events appear slowly in time and their impacts generally span over a longer period of time. Weather data alone is not sufficient to monitor and evaluate the areas of drought, particularly when those data are rare and incomplete. Enhancement of weather data with satellite images to identify the location and severity of droughts are important for complete, up-to-date and comprehensive coverage of current drought conditions. The objective of this research is to monitor and understand meteorological drought using Standard Vegetation Index (SVI) and Vegetation Condition Index (VCI). Another objective is to measure the accuracy of two method's result by analyzing the changes in precipitation data. For this, SVI and VCI are derived from EVI and NDVI, which are obtained by analyzing MODIS (moderate-resolution imaging Spectroradiometer) data at 250m spatial resolution during July and August month of each year from 2000 to 2016 at 2 years interval. The study result shows the percentage of area affected by drought and its severity on the selected years. It also helps to understand how vegetation condition is being changed over time.

Keywords: Drought; MODIS; NDVI; VCI; SVI; EVI and Remote Sensing.

INTRODUCTION

Drought is one of the major threat to natural hazards which occurs at the time when the amount of precipitation is insufficient than the demands of natural habitats and the environment. The North-Western part of Bangladesh has been experiencing extremely hot weather and frequent drought conditions compare to the other parts of the country (Hassan & Mahmud-ul-islam, 2013). Especially, the districts under Barind Track suffer from frequent draught every year. The groundwater scarcity reveals that water level is declining gradually year-by-year, which creates the drought intensity higher (Shahid & Hazarika, 2006). Unfortunately, drought condition has received less attention and has less scientific research work compare to other calamities like flood or cyclone. The impact of drought can be much higher and can occur greater loss than flood, cyclone and storm surge (Alam et al., 2012; Paul, 1998; Shahid, 2008). For example, Drought incurred a huge loss of crop production in the country during the year of 1978-79, 1982 and 1997 (Paul, 1998 ; Ramsey et al., 2014). So, it is urgent to research more on drought and using scientifically method to get accurate scenario. Other than in-situ data, Remote sensing is a promising technology to monitor drought condition. In this paper it has aimed to reveal drought scenario through satellite imageries.

METHODOLOGY

Data Collection

To monitor the meteorological drought, two weeks maximum value composites (MVC) of NDVI from MODIS Imagery (for the year 2000, 2002, 2004, 2008, 2012, 2014 & 2016 in the month of July and August) along with land cover map have been used. The data is freely available to be downloaded from the Oak Ridge National Laboratory Distributed Active Archive Center (ORNLDAAC). For calculating SVI, we have used the Enhanced Vegetation Index (EVI) based on MODIS data at 250m spatial resolution as input. The only MODIS product providing EVI data is MOD13Q1 (on Terra satellite) and MYD13Q1 (on Aqua satellite). Here we have worked with the EVI band of MOD13Q1. The land cover map is made in ArcGIS software from Landsat 8 images. Unsupervised classification method was used to classify the region into to 3 land cover classes. Since, the main objective of the current study is to monitor meteorological drought impacts on natural vegetation (rain fed, rangeland & forest), these three classes were classified from the land cover map. Then, 3 land cover classes are reclassified into two class: range land (value o) and non-Range land (value 1). Also, precipitation data has been collected from "Bangladesh Water Development Board" to analysis objective two.

Data Preparation and Processing for Calculating VCI

The Data analysis for calculating VCI has been divided into three phases as follows:

- Data processing using ENVI software
  Step-1: Band math recalculation to value -1 to 1 and recalculating from MVC values to NDVI value range
  Step-2: Layer Stacking (composition of nine maps to one map) and change map projection
  Step-3: Resizing the NDVI-MVC images to the study area
  Step-4: Masking out data with the study area
  Step-5: Masking out 'not vegetation' data via land cover data
- Calculating Vegetation Condition Index using the Eq. (1) given below;

  $$\mathbf{VCI = (NDVI_{cur} - NDVI_{min}) / (NDVI_{max} - NDVI_{min})} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots(i)$$
- Visualization and Analysis in ArcGIS software

Data Preparation and Processing for Calculating SVI

Following steps have been followed to calculate SVI

Step 1: MOD13Q1 EVI HDF (time series) data have been converted into GeoTIFF using the software named MRT (MODIS reprojection tools).

Step 2: In this step, data have been prepared for automatic map generation. It includes creating one folder where all converted data has been stored. Then each of day of the year (DOY) data has been renamed manualy or using total commander software. This will help to choose the relevant data for the region of interest.

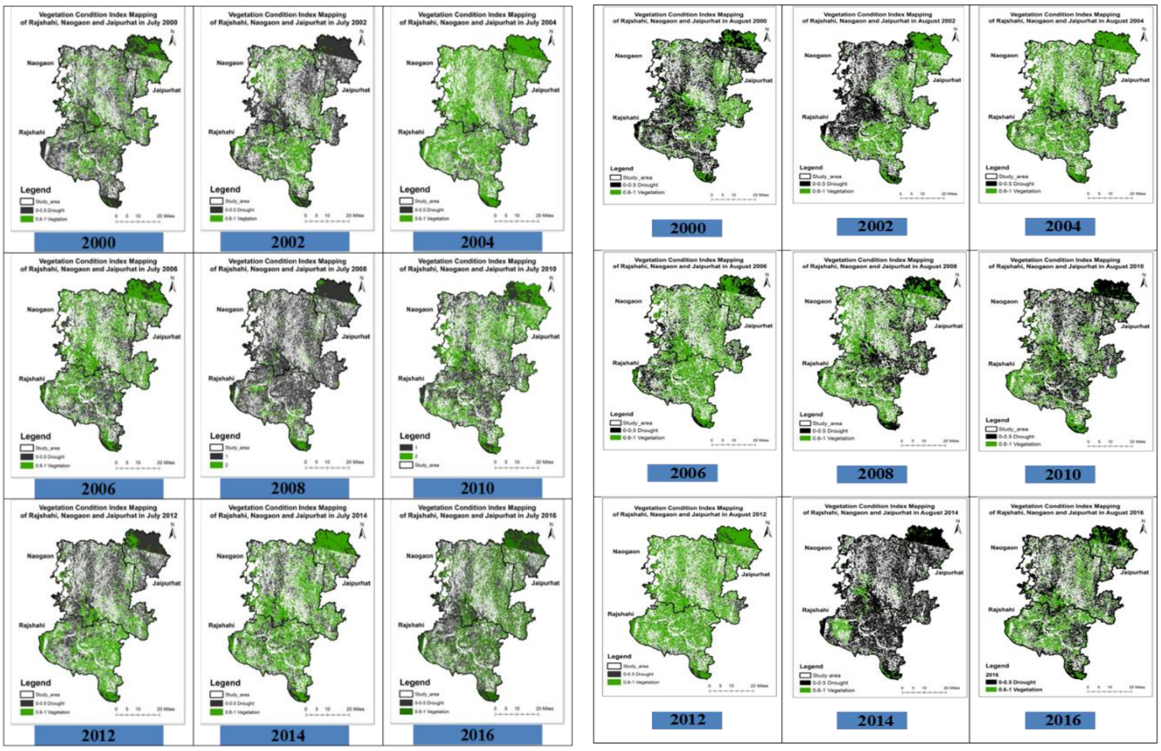
Step 3: Here layer stacking for each DOY, has been resized and masked with country shape file.

Step 4: It includes rescaling and set fill values and invalid data range to NA.

Step 5: After that, mean and standard deviation of Enhanced Vegetation Index (EVI) has been calculated. Then, standard vegetation index has been calculated using the following formula

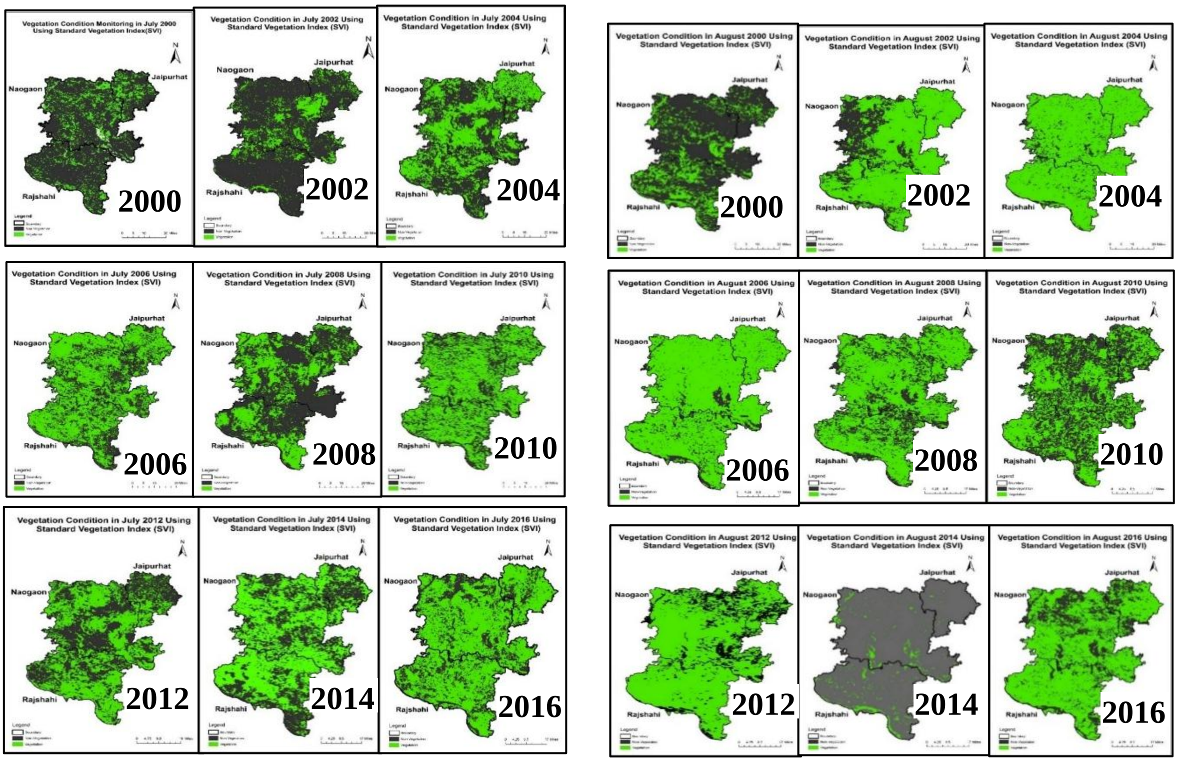
$$SVI = (EVI-EVI_{mean}) / EVI$$

R-studio software has been used to complete step 5 and ArcGIS software has been used in order to visualize the obtained map



July **August**

Fig.1: Vegetation Condition Index Mapping of Study Area (2000-2016)



July **August**

Fig.2: Standard Vegetation Index Mapping of Study Area (2000-2016)

RESULT AND DISCUSSION

Data has been analyzed according to objective 1 and objective 2. These are discussed below:

Analysis of Objective- 01

Yearly drought scenario in terms vegetation growth (following VCI and SVI method) for the month of July and August have been presented in the Fig.1 and Fig.2. A comparison of vegetation area changes has been also presented in the Table-1.

Table 1: Difference between VCI and SVI and their ranking

Year	Vegetation Area (%) in the month of July		Vegetation Area (%) in the month of August		Two months Average Vegetation Area (%)		Vegetation Area Ranking	
	VCI method	SVI method	VCI method	SVI method	VCI method	SVI method	VCI method	SVI method
2000	36.85	20.14	37.07	24.37	36.9556	22.25464	3	1
2002	32.33	16.77	50.29	75.08	41.30876	45.92453	4	3
2004	80.97	47.99	76.67	91.24	78.81895	69.61492	9	7
2006	57.99	64.27	70.30	88.67	64.14788	76.47132	7	9
2008	11.88	38.07	56.51	73.52	34.19813	55.79581	1	4
2010	48.72	68.20	38.36	52.63	43.5397	60.41485	5	5
2012	41.84	52.01	87.46	82.23	64.65103	67.11993	8	6
2014	63.82	59.56	9.31	4.73	36.56201	32.1464	2	2
2016	61.28	72.01	45.75	74.79	53.51723	73.39991	6	8

From the above of Table-1. it is seen that the vegetation growth is comparatively low in the year 2000, 2002 and 2008 from other years in July. It is also seen that the vegetation growth is comparatively low in the year 2000, 2010 and 2014 from the other years in August.

By this, it is very difficult to understand the severity of drought by finding out the lower vegetation growth in July and August. To solve this problem, the vegetation growth of two months by each method is ranked according to the lower vegetation to higher vegetation. That means the ranking is provided from 1 to 9 which actually denotes to lower vegetation to higher vegetation. Besides, lower vegetation indicates the higher severity of drought. So, the ranking 1 to 9 also means the higher severity of drought to lower severity of drought in that area.

It is seen that the VCI and SVI are ranked from 1 to 9 separately. VCI and SVI rankings are respectively 3 and 1 in 2000, 4 and 3 in 2002, 1 and 4 in 2008 and 2 and 2 in 2014. Other VCI and SVI rankings are 5 or above 5 which denote higher vegetation. As the lower vegetation's were in 2000, 2002, 2008 and 2014 according to ranking, those years could be higher drought severity in the study area.

Analysis of Objective- 02

According to vegetation condition index method and standard vegetation index, the vegetation condition data is compared to the precipitation data. On the following Table-2, drought severity is ranked using the value from 1 to 9; where the value 1 means severe drought condition, on the contrary value 9 means less severity of drought that means vegetation condition is very good. In this case; percentage of vegetation condition obtained by standard vegetation index and vegetation condition index and amount of average rainfall during July and August month is used. The result showed that 2000 and 2014 are the two years when drought severity was the most compared to the other years in the studied area.

Table 2: Ranking of drought severity based on precipitation data, standard vegetation index and vegetation condition index (Average value for the month of July and August has been considered)

Year	Precipitation (mm)	Vegetation Area (%)		Drought Ranking		
		VCI method	SVI method	VCI method	SVI method	Precipitation
2000	181.25	36.9556	22.25464	3	1	2
2002	280.7	41.30876	45.92453	4	3	7
2004	300.05	78.81895	69.61492	9	7	8
2006	209.05	64.14788	76.47132	7	9	4
2008	381.65	34.19813	55.79581	1	4	9
2010	164.7	43.5397	60.41485	5	5	1
2012	275.5	64.65103	67.11993	8	6	6
2014	201.3	36.56201	32.1464	2	2	3
2016	254.65	53.51723	73.39991	6	8	5

Following findings are obtained after analyzing the data;

- According to the analysis of objective one, the lower vegetations were in 2000, 2002, 2008 and 2014 where 2000 and 2014 were more drought severe years according to objective two.
- As 2000 and 2014 being common years according to the analysis of objective one and two, were the most drought-prone years with respect to the precipitation data of the studied area
- At that year's precipitation was comparatively low than the other years that means vegetation growth condition was low. As the precipitation rate was low during monsoon season in 2000 and 2014, it caused drought in the study area. Its effect might fall on the next year too.

For future meteorological drought monitoring and identifying its severity; following recommendation can be given;

- Conducting the prediction research on precipitation anomalies, soil moisture condition, evapotranspiration in future will help in monitoring drought through the understanding of vegetation.
- VCI and SVI can be two effective methods to measure the severity of drought in future.
- This type of research for investigating the drought severity should consider more factors, such as human activities, temperature, and so on for the more accurate result.

CONCLUTION

This research has explored the influence of precipitation anomalies on vegetation. By understanding the relationship between Standard Vegetation Index, Vegetation Condition Index, and precipitation anomalies, the potential impacts of drought on vegetation, especially in barind regions are estimated. The quantitative analyses presented in this study have illustrated the relationship between precipitation and vegetation. This paper highlights an overall approach to meteorological drought monitoring using satellite imagery and GIS techniques. Though there remains some limitation in our research, it is expected that these can be minimized by subsequent contribution and future development of science

ACKNOWLEDGEMENT

We would like to express our profound gratitude to Bangladesh Water Development Board for providing precipitation data which helps us to analyze and compare the drought scenario derived from satellite images.

REFERENCES

1. Alam, AT; Rahman, MS; Saadat, AH and Huq, M. 2012. Gamma Distribution and its Application of Spatially Monitoring Meteorological Drought in Barind, Bangladesh. *Journal of Environmental Science and Natural Resources*., 5(2):287-293.
2. Hecheltjen, A. 2014. Recommended Practice Drought monitoring using the Vegetation condition Index (VCI). Available at: http://www.un-spider.org/advisory-support/recommended-practices/recommended-practice-drought-monitoring/in-detail [Accessed 10 January 2017].
3. Hecheltjen, A. 2016. Practice: Drought monitoring using the Standard Vegetation Index (SVI). Available at: http://www.un-spider.org/advisory-support/recommended practices/recommended-practice-agricultural-drought-monitoring-svi [Accessed 10 January 2017].
4. Hassan, MS and Mahmud-ul-islam, S. 2013. Drought Vulnerability Assessment in the High Barind Tract of Bangladesh Using MODIS NDVI and Land Surface Temperature (LST) Imageries. *International Journal of Science and Research (IJSR).*, 4(02):55-58.
5. Paul, BK. 1998. *Coping mechanisms practiced by drought victims (1994/5) in North Bengal,*
6. *Bangladesh.* Applied Geography. pp. 355–373
7. Ramsey, S; Subbia, AR; Bass, S and Juergens, I. 2014. Livelihood Adaptation to Climate Variability and Change in Drought-prone Areas of Bangladesh. Available at: http://mynaogaon.blogspot.com/2009/02/raninagar-upazila-naogaon-district-with.ht [Accessed 15 October 2017].
8. Shahid, S and Hazarika, MK. 2006. Groundwater Drought in the Northwestern Districts of Bangladesh. *Water Resource Manage.*,24:1989–2006.
9. Shahid, S. 2008. Spatial and Temporal Characteristics of Droughts in the Western Part of Bangladesh *Hydrol. Process*., 22:2235–2247.