Journal of Agrometeorology 20 (4) : 275-279 (December 2018)

Evaluating drought events under influence of El-Nino phenomenon: A case study of Mekong delta area, Vietnam

SEUNG KYU, LEE[1] and TRUONG AN, DANG[2]

[1]Sustainable Management of Natural Resources and Environment Research Group, Faculty of Environment and Labour Safety, Ton DucThang University, Ho Chi Minh City, Vietnam
Email: leeseungkyu@tdt.edu.vn
[2]VNUHCM- University of Science; 227 Nguyen Van Cu Str., 5 Dist., Ho Chi Minh City, Vietnam
Email: dtan@hcmus.edu.vn

ABSTRACT

The spatio-temporal variability of meteorological droughts in the Mekong delta area of Vietnam were analysed to detect drought events using the standardized precipitation index (SPI) at different time scales based on 32-year (1984-2015) monthly rainfall data. The degree and intensity of drought in the years of El Nino phenomenon during the study period were also analysed. The results confirmed that the frequency of drought scales decreased while their spatial distribution tends to increase with main scales including moderate and severe droughts.During the period of study, 1990-1992 drought stage was defined the most extreme drought with 11 out of 13 provinces of the study area experienced the extreme drought as the peak value of SPI12 was -2.63 and the duration of the drought lasted for 29 months.

KEYWORDS : Climate variability, El-Nino,drought, water scarcity, SPI

Drought is defined as the main natural hazards that is intimately related the ENSO phenomena (FAO, 2016; Bayissa *et al.,* 2018). In Vietnam, 2016 was the worst drought year in over 90 years under the influence of EL-Nino phenomenon with nearly 83 percent of Vietnam's territory was affected by the drought. Mekong delta of Vietnam is suffering serious socio-economic problems especially in agricultural sectors due to increasing salinity intrusion and droughts leading to water scarcity due to climate change impact in recent years.

There have been various indices developed to characterise the drought and its intensity namely Palmer Drought Severity Index (PDSI), Multivariate Standardized Precipitation Index (MSPI), Surface Water Supply Index (SWSI), Standardized Runoû Index(SRI), Reconnaissance Drought Index (RDI), Standardized Precipitation Evapotranspiration Index (SPEI), Evapotranspiration Deficit Index (ETDI), Soil Moisture Deficit Index (SMDI) and Standardized Precipitation Index (SPI) which have been widely used in different the regions of the world (Asadi *et al.,* 2015; Barua *et al.,* 2009; Bayissa *et al.,* 2018; Chaudhari and Dadhwal, 2004).

Bayissa *et al.,* (2018) applied six drought indices viz. SPI, SPEI, ETDI, SMDI, ADI and SRI to assess and monitor droughts for the Upper Blue Nile Basin, Ethiopia. Among various drought indices, the SPI has been widely applied to evaluate and monitor drought (Bayissa *et al.,* 2018; Kwak *et al.,* 2016; Yu *et al.,* 2017). The advantage of the SPI compared to other drought indices is that it requires only rainfall as the input data.Looking to the drought related problems in Mekong delta of Vietnam, the present study was undertaken to estimate the spatial and temporal distribution of the meteorological drought using standardized precipitation index (SPI).

MATERIALS AND METHODS

Study area

The Mekong delta area lies in the southern of Vietnam and also known as the largest rice warehouse in Vietnam (Dan *et al.,* 2015) with the total land area of approximately 1.7 million hectares covering to the thirteen provinces (MNRE, 2016). The study area is one of the two largest plains in Vietnam next to the Red delta and is located with in latitudes of 8°34'-11°10'N and longitudes of 104°25'-106°48'E (Fig. 1) with relatively low terrain, flat and ranging from0.3-2.0 m above sea level.

Agricultural production in the Mekong delta area is evaluated such as the dominant sector with rice production is approximately 5.0 million tons per year based on abundant irrigation fresh water from the upper Mekong river and local

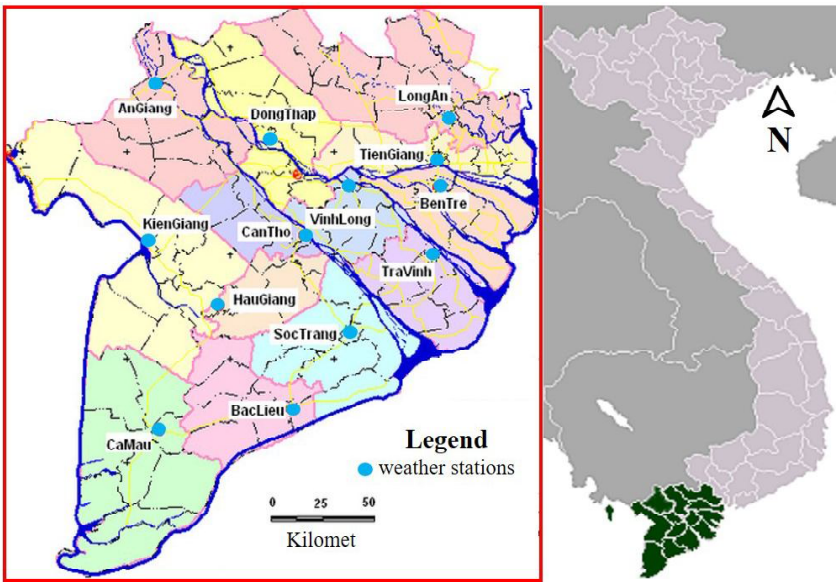

Fig. 1: Locations of weather stations in Mekong data area Victnam

Table 1:Mean annual rainfall and standard deviation (SD) in Mekong delta area

Name	Rainfall (mm)	SD (mm)	Longitude (E)	Latitude (N)
An Giang	1370	81	105°08'09	10°33'24
Can Tho	1586	112	105°33'20	10°08'16
HauGiang	1847	109	105°38'28	09°45'33
Tien Giang	1397	89	106°20'37	10°22'36
Dong Thap	1360	80	105°37'58	10°27'21
Vinh Long	1489	97	105°57'32	10°14'41
SocTrang	1848	121	105°58'26	09°36'13
Bac Lieu	1895	125	105°45'22	09°34'40
KienGiang	2154	126	105°12'01	09°54'23
Ca Mau	2394	139	105°07'35	09°10'15
TraVinh	1539	97	106°20'04	09°57'04
Ben Tre	1505	110	106°24'44	10°19'53
Long An	1643	110	106°10'35	10°54'26

rainfall (FAO 2016;RCSA 2016). The average temperature varies from 25.3-28.6°C (Dinh *et al.,* 2012) and average annual rainfall is approximately 1700 mm (Table 1). Mekong delta is located in monsoon tropics region with two main wind seasons namely north east and south west. North east monsoon wind runs from November to April while south west monsoon wind runs from May to October (Dan *et al.,* 2015; Vu *et al.,* 2018). North east monsoon wind is characterized by dry, hot and little rainfall while south west monsoon wind brings abundant rainfall.

Average rainfall data series for 32 years (1984-2015) of 13 stations in the study area were collected from the Southern Regional Hydro-meteorological Center of Vietnam (SRHCV).

The SPI developed by McKee *et al.*(1993)for multiple time scales (e.g., 1-, 3-, 6-, 9-, 12-, 24- and 48 months) and successfully applied to many parts of the world has been used in the present study.Based on the classification scale for SPI values, a positive valueof the SPI implies that rainfall at study area is higher than mean rainfall while a negative value of the SPI indicates the contrary (McKee *et al.,* 1993). A region will be considered as drought if the SPI value of the area approaches -1.0 or smaller (Table 2).

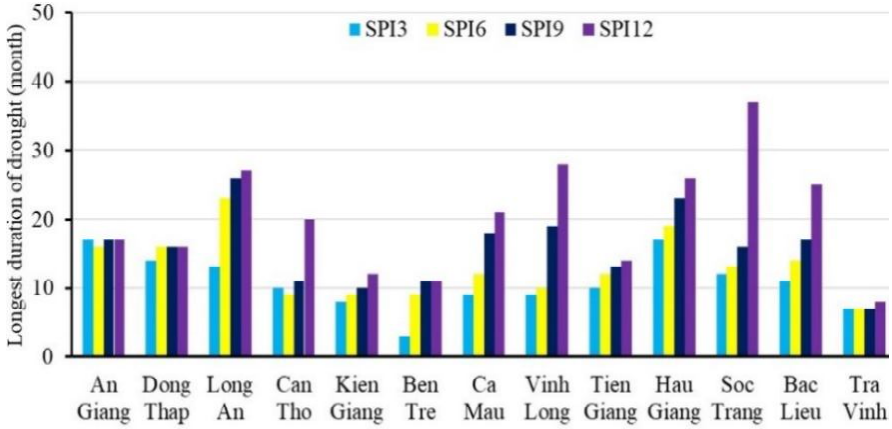

Fig. 2 : The longest duration of drought corresponding to droughts time scales

Table 2: Classification scale for SPI values

SPI values	Category
0 to -0.99	Near normal
-1.0 to -1.49	Moderate drought
-1.5 to -1.99	Severe drought
<-2.0	Extreme drought

RESULTS AND DISCUSSION

Temporal distribution of drought events

The temporal drought events across the entire study area using the SPI for 3-, 6-, 9- (not shown) and 12-month time scales were proceeded to identify peak intensity droughts, appearance period and the longest duration during study period. Four significant drought events recorded were 1990-1992, 2002-2003, 2010-2011 and 2014-2015 years.

Among the major events as mentioned above, drought in 1990-1992 stage was considered as the most extreme drought. Nearly eighty-three percent of the study area (the exception of KienGiang and Ca Mau provinces) occurred with a peak value recorded -2.63 at HauGiang province with duration of the drought was 29 months (Fig.2).

For 2002-2003 stage, six out of 13 provinces experienced severe and extreme droughts with peak SPI value of -3.57 at Dong Thap province and lasting in 14 months at Tien Giang province. While for 2010-2011 stage, three provinces experienced severe drought including An Giang, KienGiang and HauGiang while three provinces (Vinh Long, SocTrang and Ca Mau) recorded extreme

Table 3: The occurrence of moderate, severe and extreme droughts based on the SPI12

Province	No. of average drought events per year			Max	Year
	Moderate	Severe	Extreme	intensity	
An Giang	1.05	0.43	0.40	-2.99	2002
Can Tho	1.09	0.40	0.40	-2.70	2010
HauGiang	0.65	0.31	0.37	-2.66	1991
Tien Giang	0.34	0.59	0.46	-3.57	2003
Dong Thap	1.59	0.53	0.06	-2.16	2002
Vinh Long	1.06	0.59	0.15	-2.33	2015
SocTrang	1.09	0.75	0.28	-2.25	1990
Bac Lieu	1.03	0.93	0.06	-2.23	1990
KienGiang	1.37	0.59	0.09	-2.04	2010
Ca Mau	1.25	0.75	0.09	-2.30	2010
TraVinh	0.65	0.43	0.21	-3.16	1986
Ben Tre	1.40	0.59	0.15	-2.84	2010
Long An	1.09	0.71	0.18	-2.39	2015

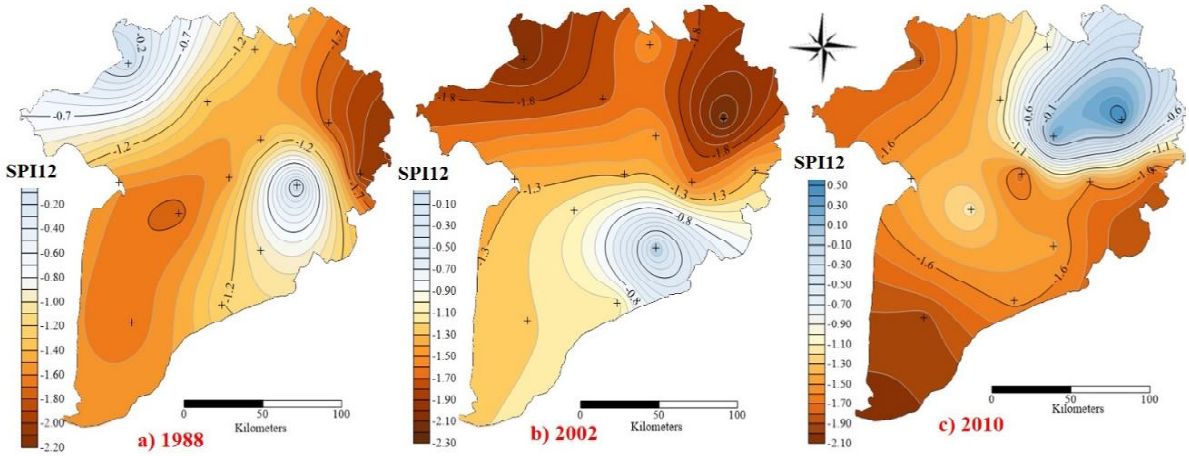

Fig.3: Spatial distributions of drought in the years of El-Nino phenomenon

drought with peak SPI value of -2.30 and lasting in 11 months at Ca Mau province. For 2014-2015 stage, the exception of Tien Giang province did not recorded drought, 12 out of 13 remaining provinces found severe and extreme droughts with peak SPI value of is -2.39 and lasting in 24 months at Long An province (Fig.2).

Table 3 shows the number of drought events occurred across the entire study area. In the period of 1984-2015, moderate, severe and extreme droughts were occurred 1.05 times per year, 0.58 times per year and 0.22 times per year respectively. Meanwhile, inland provinces recorded more extreme drought occurrence than the coastal provinces.The results showed that in study area moderate drought occurred more than one time per year and extreme drought occurred less than moderate and severe droughts. This confirms that inland provinces received less water vapor compared to coastal provinces, so extreme drought frequently occurred.

Spatial distribution of drought events in relation to El-Nino events

The spatial distributions of SPI3, SPI6, SPI9 (not shown) and SPI12 drought time scales under the influence of the years of El-Nino phenomenon(1988, 2002 and 2010) are presented in Fig.3. In 1988, an El-Nino event occurred across the entire study area, 9 out of 13 provinces experienced drought. In southern coastal provinces recorded only severe drought while inland provinces (Long An and Tien Giang) recorded extreme drought with risk peak value was -2.20 (Fig.3a). In 2002, El-Nino recorded covering the study area with extreme drought occurrence in the northeastern and northwestern provinces with a peak value of -2.30 (Tien Giang) (Fig.3b). While for El-Nino phenomenon of 2010 year, extreme drought appeared at KienGiang and Ca Mau provinces where they are considered the most abundant rainfall in the area with risk peak value -2.10 (Fig.3c). In general, drought has tended to shift from inland provinces to the coastal areas in the years of El-Nino phenomenon, they have not been recorded droughts in the past due to rainfall is always higher than inland provinces.

CONCLUSION

The study identified four major drought stages during 1990-1992, 2002-2003, 2010-2011 and 2014-2015. For 1990-1992 stage,11 out of 13 provinces experienced the extreme drought with risk peak -2.63 and lasting in 29 months. On average, the moderate, severe, and extreme droughts appeared 1.05 times per year, 0.58 times per year and 0.22 times per year, respectively. In general, drought events across the study area showed that climate change is the major factor to impact on drought rather than El-Nino phenomenon.

ACKNOWLEDGEMENTS

The author would like to thank the Southern Regional Hydro-meteorological Center of Vietnam (SRHCV) for providing database.

REFERENCES

Asadi, Z. M. A., Sivakumar, Band Sharma, A. (2015). Droughts in a warming climate: a global assessment of SPI and RDI, *J. Hydrol.,* 526:183–195.

Barua, S., Perera, B. J. C and Ng, A. W. M. (2009). A comparative drought assessment of Yarra River Catchment in Victoria, Australia. In: Interfacing modelling and simulation with mathematical and computational sciences: 18th IMACS World Congress, MODSIM09, Cairns, Australia 13-17 July 2009: proceedings.

Bayissa, Y., Maskey, S., Tadesse, T., van Andel, S. J., Moges, S., van Griensven, AandSolomatine, D. (2018). Comparison of the performance of six drought indices in characterizing historical drought for the upper Blue Nile Basin, Ethiopia. *Geosci.,* 8:81; doi:10.3390/geosciences8030081.

Chaudhari, K.N. and Dahwal, V.K. (2004). Assessment of impact of draught. 2002 on production of major *kharif* and *rabi* crops using standardized precipitation index. *J. Agrometeorol. 6* (special issue) : 10-15.

Dan, N. H., Thoi, N. Kand Dung, B.T.N. (2015). Evaluation of paddy land use in the Mekong River Delta. *J. Sci. Devel.,* 13(8):1435-1441.

Dinh, Q., Balica, S., Popescu, IandJonoski, A. (2012). Climate change impact on flood hazard, vulnerability and risk of the Long Xuyen Quadrangle in the Mekong Delta. Int. *J. River Basin Manage.* 10 (1):103–120.

Food and Agriculture Organization (FAO). (2016). El Niño event in Viet Nam: Agriculture, food security and livelihood need assessment in response to drought and salt water intrusion. Assessment Report, p.75.

Kwak, J. W., Kim, S. J., Jung, J. W., Singh, V. P., Lee, D. Rand Kim, H. S. (2016). Assessment of meteorological drought in Korea under climate change, *Advances in Meteorol.,* http://dx.doi.org/10.1155/2016/1879024.

McKee, T. B., Doesken, N. Jand Kleist, J. (1993). The relationship of drought frequency and duration to time scales. In proceedings of the eight conferences on applied climatology, Anaheim, CA, USA, American Meteorological Society: Boston, MA, USA, pp. 179–184.

Ministry of Natural Resources and Environment (MNRE). (2016). Climate change scenarios and sea level rise for Vietnam. Publishers resources, environment and map of Vietnam.

Research Centers in Southeast Asia (RCSA). (2016). The drought and salinity intrusion in the Mekong River Delta of Vietnam. Assessment Report, p.55.

Vu, D. T., Yamada, Tand Ishidaira, H. (2018). Assessing the impact of sea level rise due to climate change on seawater intrusion in Mekong Delta, Vietnam. *Water Sci. Technol.,* Doi: 10.2166/wst.2018.038.

Yu, X. Y., Zhao, G. X., Zhao, W. J., Yan, T. T and Yuan, X. J. (2017). Analysis of precipitation and drought data in Hexi Corridor, Northwest China. *Hydrol.,* doi:10.3390/hydrology4020029.

Received : May 2018 ; Accepted : November 2018