Journal of Agrometeorology 21 (3) : 382-384 (September 2019)

Short communication

Change trends of rainfall features for the Long Xuyen Quadrangle, Vietnam

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The Long Xuyen Quadrangle (LXQ) is one of the two main agricultural production regions in the Mekong Delta of Vietnam beside the Plain of Reeds region (Dinh *et al.* 2012; Mainuddin *et al.* 2013). It is a coastal plain with relatively low terrain, therefore, facing high risks of waterlogging due to extreme rainfall events; flooding due to strongly influenced by flow field from the upper Mekong River on the flood season and, saline intrusion leading to irrigation water shortage due to drought in recent years (Lee and Dang 2018). For example, during 2014-2016, Viet Nam recorded a worst drought event in over 90 years, considered as the 'Big Drought' with 83 percent of the territory of Vietnam has been affected by drought leading to the lack of irrigation water due to saline intrusion, costing the Vietnamese economy approximately $674 million (UNDP 2016). In addition, the collapse of the Xe-Pian Xe-Namnoy dam, Laos in 2018 after maximum rainfall event leading to the flood water levels increase rapidly at Tien and Hau River and is hampered the ongoing harvest of the summer-autumn rice crop in the study area.

The aim of this research, therefore, is to analysis and assesses heavy rainfall indices applying the Mann-Kendall test and Sen's slope estimate such as a typical case in potential crop growing area to provide early warnings and to minimize their negative effects for study area in the period 1985-2015.

The Long Xuyen Quadrangle is located within latitudes of 09°57'–10°42'N and longitudes of 104°290-105°290E with relatively low terrain, flat and in ranging from 0.25 to 2.0 m above mean sea level. The study area is a coastal delta with a total area of land approximately of 470000 hectares, was divided into the provinces of An Giang, Kien Giang and Can Tho (Vu et al. 2018**)**. The climate in study area has high temperature and less variation over the months of the year (25.8-28.8°C); abundant rainfall with approximately of 1980 mm. The ninety percent of annual rainfall concentrated in the rainy season, leading to waterlogging and hampering the ongoing harvest of summer-autumn crop. In contrast, the dry season only receives 10 percent of annual rainfall, leading to frequently suffers from droughts and water scarcity (Lee and Dang 2019).

Rainfall trends detection

Based on the preliminary analysis of the rainfall characteristics in the study area, including the rainfall intensity and material damage caused to aspects of life, rainfall indices such as the number of rainfall days above 20 mm (R20), the number of very heavy rainfall days above 50 mm (R50) and the number of maximum rainfall days above 100 mm (R100) were selected. This study was performed based on rainfall data at 9-gauge stations belonging to the study area for the period 1985-2015 to detect the heavy rainfall trends across the study area. The rainfall data of 9-gauge stations were selected based on the length of data series with missing data of less than 10% to ensure the reliability of the statistical analysis.

The statistical methods such as the Mann-Kendall test and Sen's slope estimate have been widely used in the hydro-meteorology and environment sectors to detect their monotonous trends (Xu *et al.* 2015; Lee and Dang 2019). In order to detect the monotonic trends of heavy rainfall trends, three heavy rainfall indices were assessed based on the Mann-Kendall test and Sen's slope estimator with significance level 95%. It means that the null hypothesis of no trend is rejected if $|Z_S| > 1.96$.

The analyzed results of the extreme rainfall events across the Long Xuyen Quadrangle during the period 1985-2015 were conducted applying the Mann-Kendall test and Sen's slope estimator, with a significance level of 95%.

The trend line moves downward for seven out of nine stations and hence there is a downward trend in the number of rainfall days above 20 mm during the period 1985-2015. Specifically, a slight downward trend was recorded at stations namely Xuan To, Cho Moi, Thoai Son, Long Xuyen and Tri Ton, with Z_s values in the range of -0.157 to -1.351, while a

Table 1: Statistical results of the number of rainfall days above 20 mm; 50 mm and 100 mm during the period 1985-2015

Station	R20			R50			R100		
	Z_S	p-value	β	Z_S	p-value	β	R100	intensity (mm day^{-1})	Year
Chau Doc	0.893	0.232	-0.333	-0.535	0.158	-0.114	7	150.5	2000
Chau Phu	-0.157	0.312	-0.286	0.356	0.454	0.051	7	159.8	2000
Xuan To	-1.351	0.044	0.000	0.000	0.071	0.114	9	166.4	2000
Rach Gia	0.000	0.067	-0.500	0.248	0.500	0.095	6	116.5	1998
Cho Moi	-0.783	0.012	-0.400	0.357	0.059	0.217	8	115.2	2004
Thoai Son	-0.860	0.500	-0.200	0.018	0.409	0.082	5	236.8	2000
Long Xuyen	-0.936	0.108	-0.333	0.096	0.199	0.031	14	173.3	2000
Tri Ton	-0.518	0.303	-0.375	-0.798	0.329	-0.035	26	197.5	2003
Ha Tien	-2.372	0.403	-0.083	-4.893	0.340	-0.192	77	368.7	1992

significant downward trend was observed at Ha Tien station with peak value Z_s=-2.372. In contrast, a slight upward trend was also observed at Chau Doc station, with value Z_s = 0.893 while at Rach Gia station detected no upward or downward trend (Table 1).

Regarding the number of very heavy rainfall days above 50 mm, with the exception of Xuan To station which recorded no upward/downward trend, over the entire study area detected no significant tendency for change, while a slightly upward trend was occurred at five out of nine stations such as Chau Phu, Rach Gia, Cho Moi, Thoai Son and Long Xuyen, with Z_s values varying from 0.018 to 0.579 (Table 1).

In contrast, a slight downward trend was occurred at Chau Doc and Tri Ton stations, with Z_s values in range of -0.535 to -0.798. Especially, a significant downward tendency similar as the number of rainfall days above 20 mm was also observed at Ha Tien station (Z_s = -4.893) (Table 1).

Analyzed results of the number of maximum rainfall days above 100 mm in the period 1985–2015 show that a mean value of the number of maximum rainfall days above 100 mm over the entire study area approximately of 17.66 days/31 years. The highest number of maximum rainfall days above 100 mm, up to 77 days/31years, occurred in the Ha Tien coastal station. In contrast, the lowest number of maximum rainfall days above 100 mm, down to 5 days/31years (Table 1), was also recorded in the Tri Ton inland station.

The statistical results also indicate that the number of maximum rainfall days above 100 mm decreased from the coastal stations such as Ha Tien and Rach Gia to the inland stations namely Tri Ton, Chau Phu and Chau Doc (down to 10 days/31 years). In the study period (1984-2015), the mean number of maximum rainfall days above 100 mm approximately of 2.48 days/year, with risk peak 368.7 mm/day was recorded at Ha Tien station, implying that the Ha Tien region has a higher risk of maximum rainfall problems, leading to the inundation of planting crops.

From results of the number of maximum rainfall days above 100 mm (Table 1), it can be inferred that Ha Tien region is facing a very high risk of maximum rainfall day, leading to heavy waterlogging and flooding compared to other regions.

This study can help to improve the understanding of heavy rainfall problems over the entire study area and support agricultural activities to minimize the negative effects caused by maximum rainfall events. The absence of a significant upward trend was found in the extreme rainfall events and these can be beneficial for agricultural activities and, aquaculture seafood.

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Received : January 2019 : Accepted : August 2019