**Statistical analysis of Runoff Coefficient in Yom Basin in**

**the Northern of Thailand**

Pawee Klongvessa1, Srilert Chotpantarat1,\*

1) Department of Geology, Faculty of Science, Chulalongkorn University

Pathumwan, Bangkok, 10330, Thailand

\* Corresponding author

E-mail: [csrilert@gmail.com](mailto:csrilert@gmail.com)

Tel: +66-22185442

## Abstract

Yom River basin, the basin in the northern part of Thailand, has experienced problems of flood during the wet season and drought during the dry season. These problems have happened because this area has not enough storage capacity which causes incoming rainfall to become runoff and evacuate the area quickly. Moreover, deforestation has been the problem which causes the storage capacity and infiltration capacity of the soil to reduce even more. This paper investigated a trend of runoff coefficients in each part of the area in the period of 1980-2009. Determinations of annual rainfall and runoff trends were also involved. Linear trends of ten years average data were calculated to represent the magnitude of change of the data and Mann-Kendall test was applied to check if the change was significant.

The result showed that a region with a significant increasing in rainfall was around the boundary between the north and central part of Yom basin as same as a region with a significant increasing in runoff. The runoff coefficient in the central part of Yom basin significantly increased. Mae Mok subbasin, the mountainous subbasin southern part of yom basin, also has a non-significant but considerable high increasing trend.

**Keywords**: Yom River Basin, Annual Rainfall, Annual Runoff, Runoff Coefficient, Moving Average, Mann-Kendall Test

## 1. Introduction

Flood has been widely known as a disaster which causes damage to both properties and lives in many areas all over the world. Yom basin (Figure 1), a basin in the northern part of Thailand with an area of about 21,795 km2 (Thien, 2005), has also been one of the area where floods usually occur during the wet season. There were big floods occurred in 1995 and 2011 which causes severe damages. Interestingly, this area also experiences a scarcity of water during the dry season even though there has been too much water during the wet season. This is because of the basin has not enough storage capacity to keep the incoming water in the wet season for the usage in the dry season. When the water get into the area, it becomes runoff and flows through the area, and then it evacuates through the outlet at the south of the basin. Moreover, there has also been a deforestation in the area. Many areas of forests has been changed to agricural areas which can cause the infiltration and storage capacity of soils to reduce even more and lead the problem to be worse. This research investigated trends runoff coefficient in each area of Yom basin during the period of 1980-2009. High runoff coefficient represent the area where rainfall flow out quickly, so a location where the runoff coefficient is the location where the rainfall flow out more quicky than in the past which could be a result of land use changes, usually be the deforestration. However, rainfall and runoff are also the crucial parameter to determine the runoff coefficient, so this research also involved investigations of annual rainfall and runoff trends.

Insert [Figure 1]

## 2. Materials and methods

Rainfall data during the period of 1980-2009 was collected from stations of Thai Meteorological Department and Royal Irrigation Department which data from 37 stations are available in Yom basin and surrounding.

Runoff data during the period of 1980-2009 was collected by stations of the Royal Irrigation Department at each outlet of subbasins in Yom basin. However, runoff data in some subbasins are not available. In this case runoff data could be estimated from the data of a nearby subbasin with the similar characteristics as the following equation

Where represents the runoff data of the subbasin the runoff data of which is available, represents the area of the subbasin the runoff data of which is available, represents the runoff data of the subbasin the runoff data of which is unavailable, and represents the area of the subbasin the runoff data of which is unavailable

There were still some cases that the runoff data could not be estimated since there was no nearby subbasin with the similar characteristics. In this case, the subbasin the runoff data of which could not be estimated was merged with the nearby subbasin the data of which was available. According the availability of the data, 11 subbasins of Yom basin were merged into 7 areas.

Insert [Figure 2]

Runoff coefficients were determined as the ratio of runoff to rainfall. The runoff data for each area was available and ready to be used to determine the runoff coefficient. However, rainfall data for each area should be calculated which could be done by Thiessen Polygon method (Singh, 1992). This method divides the area into parts by the closet station for each point in the basin and uses an average rainfall weighted by a size of each part to represent the average rainfall for the area.

The investigation of rainfall, runoff, and runoff coefficient trends was done by determinations of linear trend of ten years moving average (McPherson, 1990) of the data to represent the magnitude of changes, and then whether the changes were significant was determined by Man-Kendall (MK) test (Mann, 1945; Kendall, 1975; Wang et al., 2012; Klongvessa and Chotpantarat, 2014) at 10% confidence interval against the null hypothesis that there was no change of the data.

In MK test, the test statistics was determined as the following

Where is number of data, and is the data at the time and , respectively, and sign function () is defined by

When the amount of the data () is at least 10, the the test statistics is assumed to be normally distributed with the mean () and variance () as follows,

Where is the number of tied groups, and is the data in the th tied group.

The test statistics is then standardized into by

At a significant level of or confidence interval of %, the null hypothesis is when exceeds of the standard normal distribution. A positive value of represents an increasing trend while a negative value of represents a decreasing trend.

## 3. Results and discussion

Annual rainfall significantly increased around the boundary between the north and central part of Yom basin with the rate of 14.1 mm to 31.3 mm per year while others area show the rate of change of -3.0 mm to 18.8 mm per year. That area with the significant increasing in annual rainfall coincided with the mountainous area where orographic uplift could occur and caused rainfall in the area (Ahrens, 2007).

Insert [Figure 3]

Annual runoff significantly increased in the central part of Yom basin with the rate of 10.0 mm per year and Huay Mae Sin subbasin which is in the south part of Yom basin but adjacent to the central part with the rate of 6.7 mm per year while others area show the rate of change of not more than 6 mm per year. The area with the significant increasing in annual runoff coincided with the area with the increasing in rainfall, so the increasing in rainfall could cause the increasing in runoff in the area.

Insert [Figure 4]

In order to exclude the effect of rainfall on runoff, trends of runoff coefficient were determined. The result showed a significant increasing in runoff coefficient in the central part of the basin with the rate of 0.006 per year. Mae Mok subbasin, the mountainous subbasin southern part of yom basin, also has a non-significant but considerable high increasing trend with the amount of 0.004 per year while others subbasin did not show an increasing trend for more than 0.003 per year. It could be infer that the change in rainfall in the central part of the basin was not only the cause of the increasing in runoff. The another main cause of that increasing could be a landuse change. In Mae Mok subbasin, even though the runoff was increasing, there was no significant change in the runoff coefficient, so the main cause of the increasing of the runoff could be the increasing in rainfall. However, Mae Mok subbasin was possibly another subbasin which a landuse change caused the runoff coefficient to increase.

Insert [Figure 5]

## 4. Conclusions

Yom basin has experience the problem of flood and drought due to its low storage capacity. The land use change, particularly deforestation, causes the problems to be worse since it reduce the storage and infiltration capacity of soils which causes the runoff coefficient to increase. Less infiltration capacity causes the rainfall to become runoff more, and less storage coefficient causes the runoff to flow through the area and evacuate more quickly which cause the flood to be more severe during the wet season and the drought to be more severe during the dry season. The effect of land use change was obvious in the central part of the basin and Mae Mok subbasin also shown the considerably increasing in runoff coefficient due to the deforestation.

## 5. Acknowledgement

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**Figure captions**

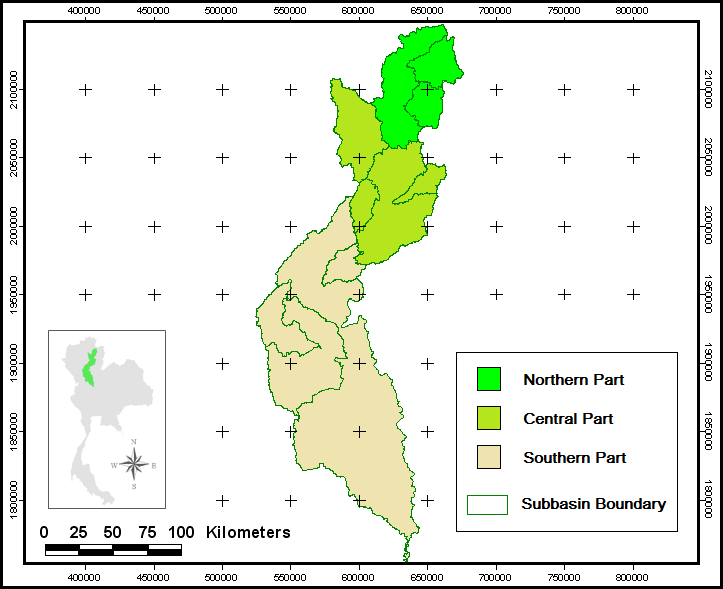
**Figure 1** Subbasins of Yom Basin

**Figure 2** Areas of 7 Merged Subbasins

**Figure 3** Trend of Annual Rainfall in Yom Basin

**Figure 4** Trend of Annual Runoff in Yom Basin

**Figure 5** Trend of Runoff Coefficient in Yom Basin

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Mae Kam Mee

Central Yom River

Huay Mae Sin

Lower Yom River

Upper Yom River

Nam Ngow River

Mae Ta

Mae Mok

Mae Ramphan

Nam Phee River

Nam Kuan River

Figure 1

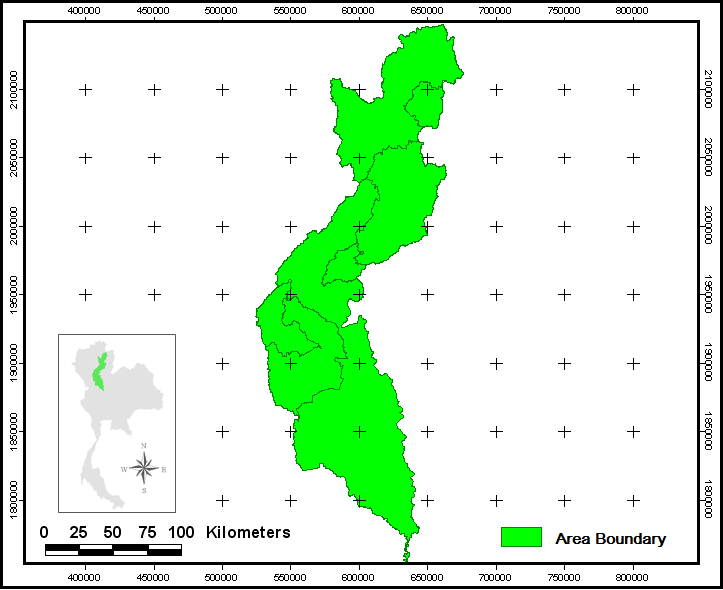
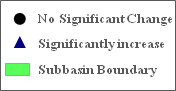
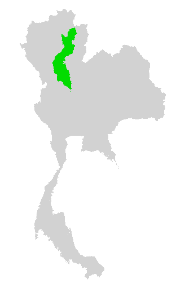


Figure 2

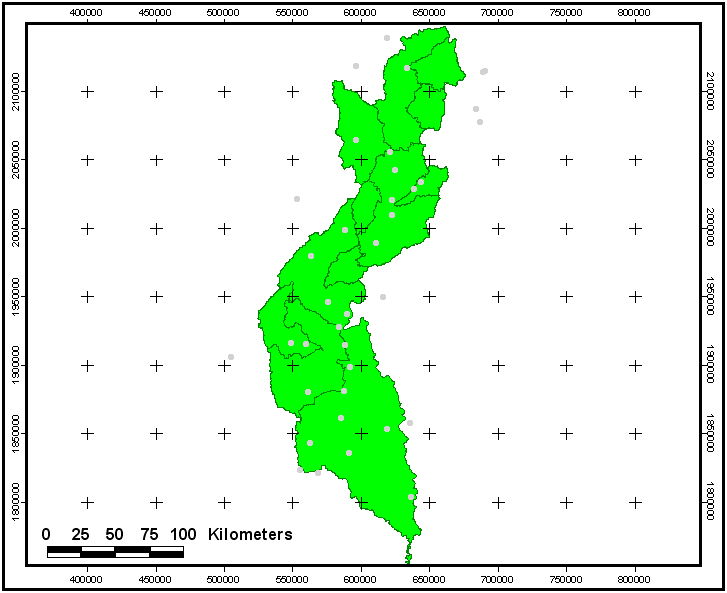




**Significantly increase**

**Subbasin Boundary**

**No Significant Change**



**+12.0 (0.9%)**

**+10.8 (0.8%)**

**+12.1 (1.0%)**

**5.5 (+0.5%)**

**+3.3 (0.3%)**

**+7.4 (0.6%)**

**+10.1 (0.7%)**

**+15.5 (1.3%)**

**+8.3 (0.7%)**

**+31.3 (3.6%)**

**+6.6 (0.6%)**

**+12.1 (1.1%)**

**+4.7 (0.4)**

**+3.7 (0.4%)**

**+21.8 (2.0%)**

**+14.1 (1.1%)**

**+29.2 (1.8%)**

**+6.0 (0.4%)**

**+8.5 (0.6%)**

**+6.5 (0.6%)**

**+5.2 (0.5%)**

**+11.6 (1.1%)**

**+14.2 (1.3%)**

**-3.0 (0.3%)**

**+8.2 (0.7%)**

**+9.2 (0.8%)**

**+8.1 (0.8%)**

**+4.4 (0.3%)**

**+2.9 (0.3%)**

**+11.9 (1.2%)**

**+18.8 (1.6%)**

**+18.1 (1.7%)**

**+10.0 (0.8%)**

**-1.1 (0.1%)**

**+2.6 (0.2%)**

**+13.5 (1.2%)**

**+10.9 (0.8%)**

Figure 3

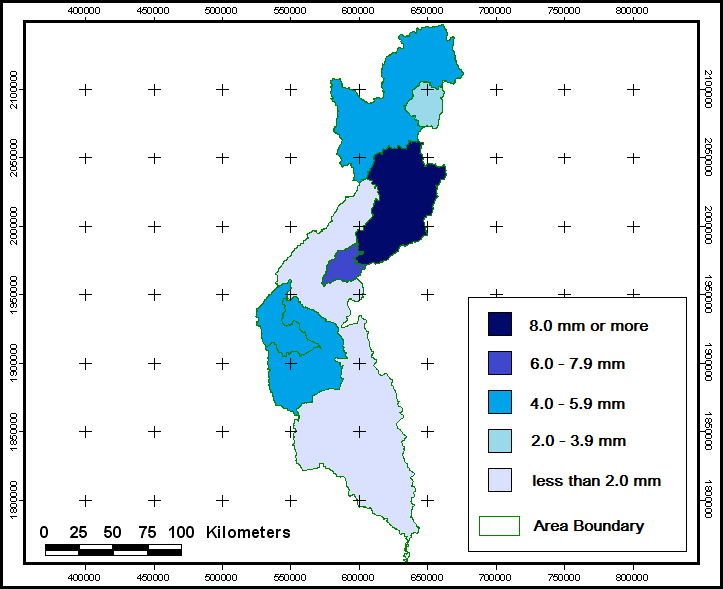


Figure 4

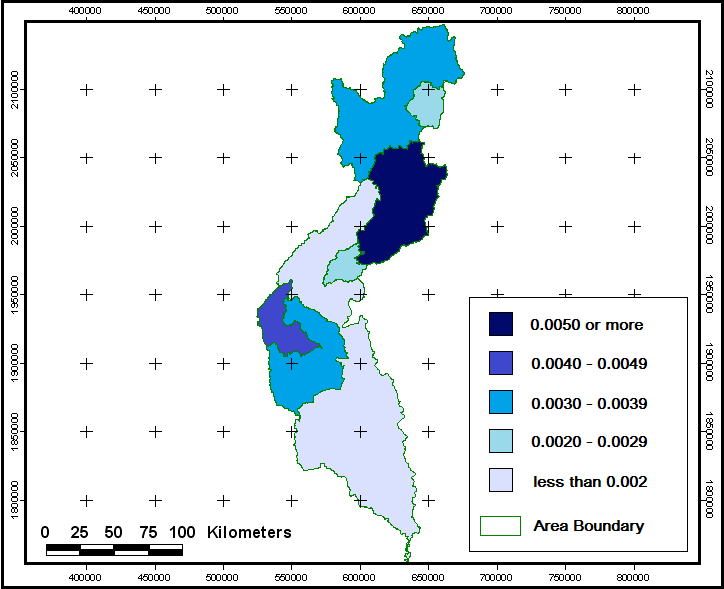


Figure 5