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Is flash flood cycle? A preliminary climate study on Teunom fluvial system

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Abstract. The atmospheric dynamics in the Teunom region have caused flashflood several times in last decade, especially in the Krueng Tenom river basin. This problem has been speculated for many scientists who predicted that such flashflood were caused by either regional climate change or the uncontrolled land use in this area. However, it should also be understood the possibility that flash floods may be caused by regional atmospheric cycle. Therefore, this study aims to understand how the climate approach on temperature and rainfall as meteorology process as a way to comprehend whether the flashflood cycle. The result of the research shows that flashflood is actually cyclical, however, due to micro climate change that happened and it is predicted that land use change or land conversion and illegal mining accelerates flashflood cycle so that early warning system is difficult to be implemented.

1. Introduction

The Krueng Teunom watershed is the main fluvial system in the Aceh Jaya area with an area of ~268,279 ha located at 4°26'00.94" up to 4°44'09.60" North and 95°48'17.31" up to 95°59'06.50" East and its upstream is in the border area of Pidie district (Figure 1). Forest degradation occurring in the upper reaches and around the Krueng Teunom watershed has caused flooding and abrasion of river banks during the rainy season [1] and the decrease in water volume during the dry season [2]. The area around the Krueng Teunom watershed in early January 2017 has already experienced two floods and in 2016 there were four big floods, one of which was flash flood. Floods in 2016 are more than twice the floods that occurred in 2012 to 2015. Meanwhile, between 1999 and 2011 only occurred three flash flood and on average once floods a year. Economic data showed a loss of Rp. ~ 8 billion due to floods that occurred in 2016 and some public facilities did not fully function to support the economic activities which impact the people in the region [3].

According to BPBD Aceh [4], the main cause of repeated floods in this area is the result of a narrowed river flow, sedimentation [5], and land conversion [6]. On the other hand, the data from



Meteorology, Climatology and Geophysics Agency [7] show that it has been a trend of increasing rainfall 0.3% per year especially the last five years. Furthermore, extreme weather due to warming of sea surface temperatures and Australia and Asia monsoon [8], [9] combined with land use change cause excess rainfall in this area so that the capacity of the river is saturated [10], therefore the water overflows and causes flooding [11].

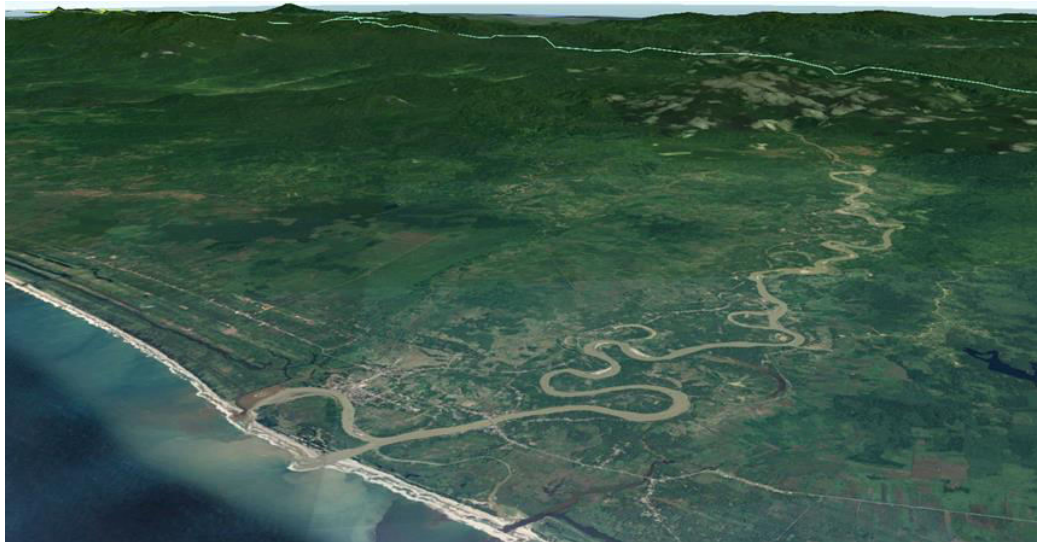


Figure 1. Spatial landscape of Kreung Teunom, Aceh Jaya (not scalable) (Google Earth Map)

In Teunom, the flood is the most common occurred along the river after heavy rainfall. The drainage system overflow in this area leads a major problem especially along a heavily populated areas where the major livestock and crops grow [12], [13]. The flooding pattern has also different from time to time and may last for weeks [14]. Severe thunderstorms and heavy rainfall mostly trigger flash flood that poses the greatest of live and significant property loss [15]. All of the problems believed to happen because of the changes on local climate trend as well as changes in land use and land conversion [16].

In the policy document of the Department of Public Works and the Provincial Water Resources Office of Aceh, Krueng Teunom watershed is a category of degraded basin and one of a top priority to be treated and it needs a high priority to improve its condition. Therefore, this purpose of this paper is to understand how the local climate approach on temperature and rainfall as meteorology process as a way to comprehend whether the flashflood cycle.

2. Research Method

This study will be based primarily on secondary data collected in the Teunom River study area. The data collected was intended to have a better understanding of the processes that contributed to the development of environmental features that may also improve the ability to explain phenomena observed in nature.

To evaluate the weather, either temperature or rainfall, the data from BMKG and NASA climate stations was used. The 20 years temperature and rainfall data will be evaluated and analysed using linear regression. By applying this method, the temperature and rainfall related to climate change can be characterized and construed. The development of method suitable for the collection of data that contribute to understanding these processes is a still-evolving science because temperature and weather are complex processes. Therefore the rainfall and temperature data are fundamental requirement for proper management of climate for early warning system. To analyse the temperature and rainfall trend in the Krueg Teunom study area, the 12 stations for 20 years of records were collected. The data is readily available at BMKG and NASA in the area of study. From these data, the temperature and rainfall trend can be investigated and analysed.

3. Result and Discussion

The results show that there is an increase in temperature trend over the last 20 years as shown in Figure 2. The anomaly temperature data also shows that the cycle of temperature change over the last 10 years is sharper (0.6%) than the previous 2 decade changes (0.2%) showing trend sinusoidal. This means that there is a temperature rise of about 0.013°C every year starting from 2009. The rising in temperature lead to changing in weather pattern.

Weather patterns that determinain the amount of rain, however, the amount and time over wich precipitation occurs for any given area is not constant. Even though the water cycle is a balnce system, sometime the quantity flowing into one area is greater than the capacity of the system to hold it with in natural confines. This can be seen in the Teunom area (Figure 1) and rainfall data (Figure 3), where combination factors along with extraordinary precipitation lead to flooding.

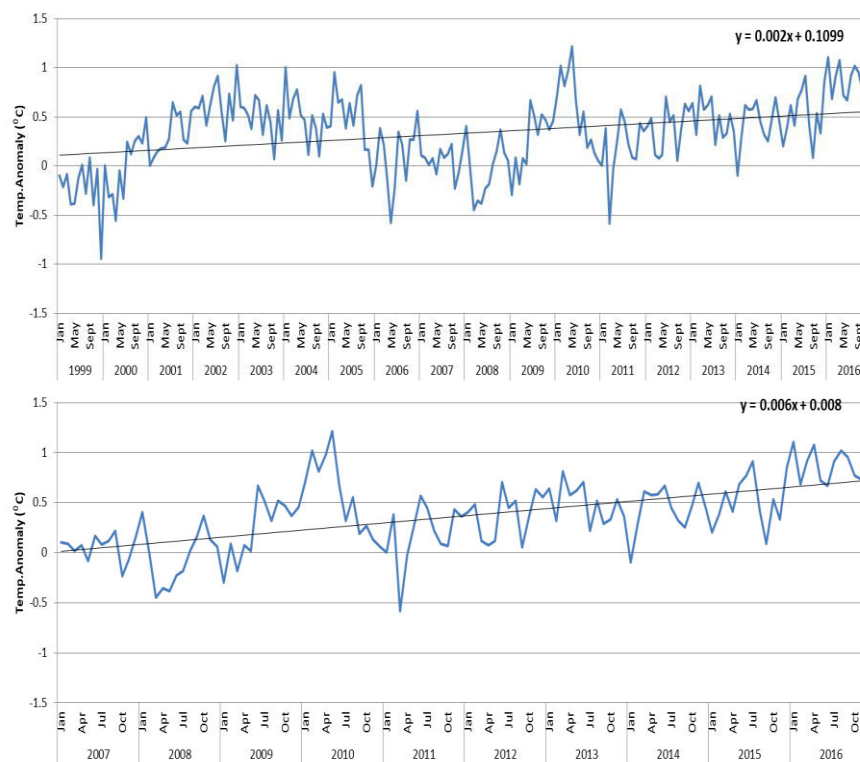


Figure 2. The anomaly temperatures change in Teunom over the last 20 and 10 years

Rainfall data that occurred in Teunom for the last 15 years shows that the rainfall cycles appearances normal; however, there is little change when combined with El-nino signal (Figure 3). It can be seen that the rainfall cycle is anomalous in the last ten years which is marked by the presence of extreme rain (rain above normal) accompanied by extreme drought. It is estimated that this situation causes the occurrence of extreme and the flash floods is not well cycled. This situation is exacerbated by the use and conversion of land in the unrolled Teunom area. Therefore, this situation has created local microclimate change in Teunom and its surrounding areas.

The trend in Figure 3 shows that rainfall fluctuations were very uneven over the past seven years (starting in 2009), causing floods to occur at any time of the year. This non-periodic flood is indicated by a red circles (Figure 3) compared to the 2009 flood event (yellow circle in Figure 3) [3]. When viewed from the global Elnino (ENSO) trend, it is difficult to correlate the number of floods in the Teunom area due to the small area coverage. The results of the field survey and data from the Aceh

Jaya government [3] show that there is a large utilization of forest land into plantations which are generally oil palm. Forests in the Teunom region, which for the last ten years have been around 82% of the area of Teunom, now account for about 23% [3]. Therefore, this land use is suspected to be the cause of non-cyclical floods as happened ten years earlier. Land use (land conversion) is also estimated to have caused local climate change in the Teunom area as shown in Figure 2.

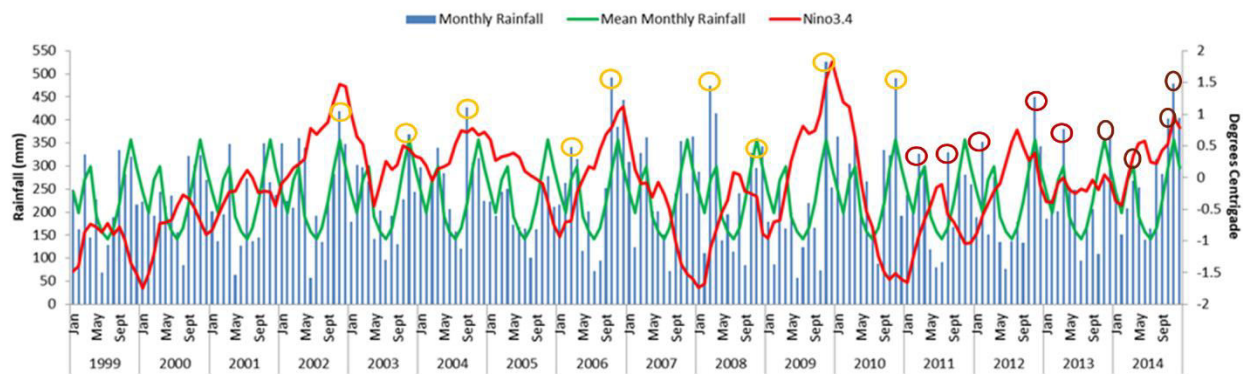


Figure 3. The graph of monthly and mean monthly rainfall of Teunom combined with El-Nino trend

Most flash flood are caused by repeatedly slow moving thunderstorms over the same area. In the last 15 years, the repeated of thunderstorms with high intensity in Teunom area triggered cycle of flash flood as it shown in Figure 3. Even though the flash flood is a natural phenomenon, the cause of this run off may come from the changes in local micro climate trigger by human intervention. The micro climate change that occurs in Teunom area is a result of the many changes in land use and land cover that used to be functioned as a buffer and now it has been converted into plantation land. Hence, the change in land use and land cover is actually the result of economic interests that are not based on local wisdom. Therefore, changes in the rainfall cycle and irregular temperature increases will have implications for the difficulty of implementing early prevention of flashflood disasters that occur.

4. Conclusion

It is concluded that flash flood is actually cyclical, however, due to micro climate change that happened and it is predicted that land use change and land conversion accelerates flash flood cycle so that early warning system is difficult to be implemented.

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