El-Nino Characteristic Based on Reservoir Volumetric

by I Wayan Yasa

El-Nino Characteristics Based On Reservoir Volumetric

I Wayan Yasa[1)*], Moh. Bisri[2)*], Moch. Solichin[2)*], Ussy Andawayanti[2)*]

[1]Civil Engineering Faculty, Mataram University, West Nusa Tenggara, Indonesia
[2]Water Resources Engineering Departement, University of Brawijaya, Malang, Indonesia
[*] yasaiwayan68@gmail.com, mbisri.ub.ac.id, sholichin67@gmail.com,
uandawayanti.ub.ac.id

ABSTRACT

Reservoirs are built for various purposes such as storage water during the rainy season. The water fluctuation of the reservoir is strongly influenced by the climate indicating the inflow and outflow of the reservoir. The reservoir inflow is incoming water in the form of river and rain stream, while outflow reservoir is evaporation, seepage and water irrigation requirement. El-Nino is an event of low intensity of rain below the average and occurs over a long period of time. The current El-Nino is can only identified from the high evaporation and the low depth of rain, making it very difficult to predict the occurrence of EL-Nino. The reservoir storage has a measurable volume that can be used to predict the occurrence of El-Nino events very easily and very accurately. This study aims to identify the characteristics of El-Nino based on the volumetric changes of reservoirs in the ZOM region from the reservoir site. Semi-monthly data in the year of El-Nino occur are used in this investigation. The results showed that strong, moderate and weak El-Nino indicated by decreasing reservoirs volumetric of ≥50 %, 30-50%, and ≤ 30%, respectively.

Keywords: El-Nino, reservoir, volumetric

1. Introduction

The history of extreme droughts has occurred simultaneously with the phenomenon of anomaly rising sea surface temperatures in the tropical Pacific known as El Nino - Southern Oscillation (ENSO) in 1982/1983, 1986/1987, 1991/1992, 1997/1998, 2002 / 2003, and 2009/2010. El-Nino is a climate change phenomenon that caused various disasters in the Indonesian territory. The impact of drought affects various sectors especially agriculture, plantation, forestry, water resources, and environment. Drought monitoring and prediction is a very important activity to do, so that the impact of drought can be anticipated and minimized (Erna, 2014). Climate change events in the form of El-Nino are frequent but monitoring is only done based on low rainfall intensity and the rate of evaporation. The monitoring has a very weak accuracy because of the many influencing factors such as area factors, measuring tools and human resources. Drought is one type of natural disaster that occurs slowly (slow-onset disaster), has a very wide and cross-sectorial impact including economic, social, health, education, etc.

Drought is a natural phenomenon that cannot be avoided and is a normal variation of the weather. Greenhouse effect, deforestation and industrial development cause extreme climate change especially for Australia, Indonesia, India and Africa. El-Nino occurs globally and repeatedly affecting various aspects of agriculture, social and economic (Philander, 1989).

The global average temperature on the earth's surface has increased by 0.78 + 0.18 ^{o}C (1.33 + 0.32 ^{o}F) over the past hundred years, resulting in climate change . This is due to global warming on earth that significantly affect climate change and result in changes in temperature, air humidity, solar irradiance, wind speed, wind direction and rainfall. According to Las et.al (1999), the influence of El Nino is stronger against the rain in the dry season than in the rainy season. On average, the decrease in rainfall from normal due to the occurrence of El Nino can reach 80 mm per month while the increase of rain from normal due to the occurrence of La Nina less than 40 mm.

Reservoirs have several functions such as to accommodate water during the rainy season, flood control, domestic and non-domestic water sources, irrigation water supply and electrical energy sources. The reservoir is built in a watershed that has a maximum pool so that it can provide water for a long period of time. In the future, the reservoir function can be expanded as an indicator of regional drought. This is because the facilities and infrastructure of measuring instruments in the reservoir is completely available such as inflow measuring instrument and outflow reservoir, changes in water level, seepage of reservoir.

Changes in the water level of the reservoir are very dynamic depending of inflow and outflow. The decrease in water level of the reservoir will not always be the same in every period. The water condition of the reservoir will provide an overview of the climatic events and water availability of the area as indicated by the change in water volume of the reservoir. Analysis of water level reduction of the reservoir in a certain period can identify the occurrence of El-Nino event.

2. Material dan Methods

2.1. Materials

The data used in this research is water volume data of daily reservoir at several period of El-Nino event. The research location is Batujai reservoir located in Central Lombok Regency of West Nusa Tenggara Province, Indonesia.

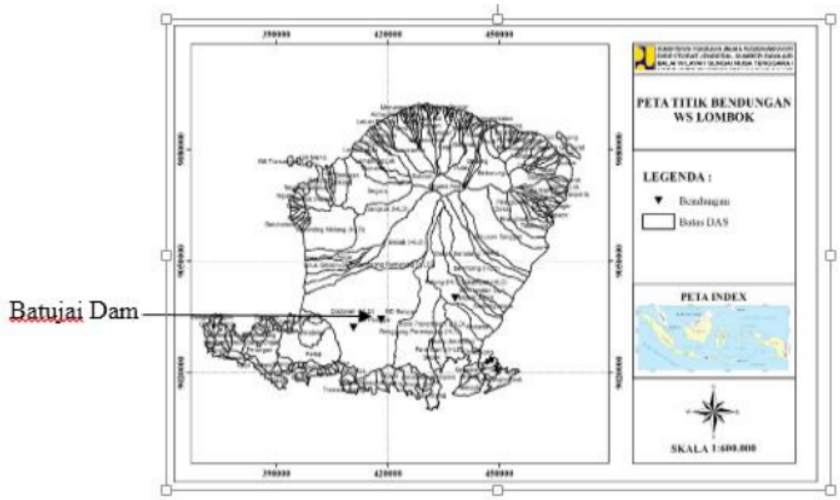

Figure 1. Map of Batujai reservoir location

2.2. Methods

Analysis of El-Nino characteristics using fixed threshold method is 50% reservoir volume condition of effective volume of reservoir. El-Nino is characterized in three categories i.e. weak, moderate and strong. The range used for El-Nino weak if the reservoir volume deficit is smaller than 30%, moderate volume deficit reservoir volume between 30% - 50%, while El-Nino strong reservoir deficit volume is greater than 50%. Statistical analysis is used to determine the parameters such as:

1. Threshold (Xo), is a limit value determined based on analytical requirements in accordance with the selected distribution.
2. Xo is Q50 because it is a normal Q with a probability of 0.5. or is a median.

The magnitude of the reliable value of a hydrological even can be determined using the following equation:

$$P = \frac{m}{n+1} \quad (1)$$

Where:

P : probability

n : amount of data.

m : serial number of data

In determining the El-Nino characteristics of the reservoir volumetric data, the frequency analysis is performed by grouping the data. The steps of frequency analysis performed are as follows:

a. Determining the maximum and minimum values of the reservoir volume data

b. Determining the number of classes using the Sturgerss equation:

$$k = 1 + 3{,}3 \log n \quad (2)$$

c. Determining the interval of data classes

d. Determining the lower class limit

e. Determine the middle value of the class in each class

3. Results and Discussion

Based on the results of volumetric analysis of reservoirs indicate the occurrence of El-Nino phenomenon in the Batujai by the reservoir volume deficit. The data used are reservoir volume at the time of El-Nino. The occurrence of El-Nino is shown in Table 1.

Table 1. The occurrence of El-Nino

El-Nino			
Weak	Moderat	Strong	Very Strong
1951-1951	1963-1964	1957-1958	1982-1983
1952-1953	1986-1987	1965-1966	1997-1998
1953-1954	1987-1988	1972-1973	2015-1016
1958-1959	1991-1992		
1968-1969	2002-2003		
1969-1970	2009-2010		
1976-1977			
1977-1978			
1-79-1980			
1994-1995			
2004-2005			
2006-2007			

Source : ggweather.com/enso/oni/htm

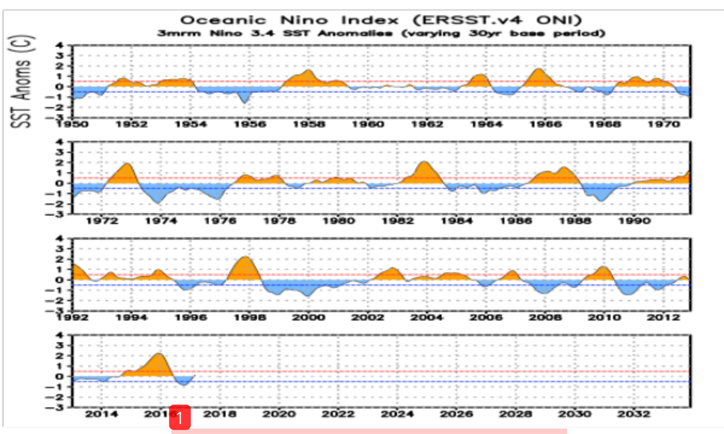

Figure 2. El-Nino and La-Nina Years
Source: National Weather Service, 2017

3.1. Weak El-Nino's characteristics

Since the construction of the Batujai dam, the weak El-Nino incident occurred in 1977-1978, 1979-1980, 1994-1995, 2004-2005 and 2006-2007. The decrease in reservoir volume ranges from 1x106 m3 to 3x106 m3 or an average of less than 30%. The time of El-Nino is weak for almost a year and will return to normal the following year unless El-Nino continues. The water volume of the reservoir at the time of weak El-Nino never reaches the reservoir's effective volume but always above the average volume. Indication of El-Nino weak is denoted if the maximum volume deficit from the reservoir is 30%. The average decrease in volumetric reservoirs during this period is shown in Figure 3.

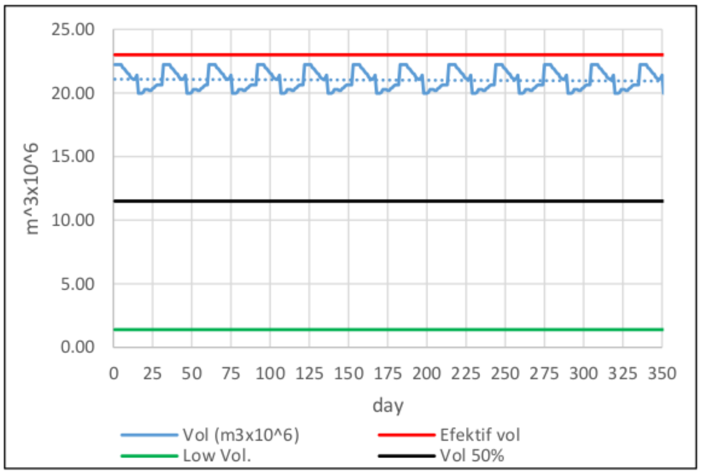

Figure 3. Graph of volumetric fluctuation of the reservoir at the time of weak El-Nino.

3.2. Moderat El-Nino's characteristics

The moderate El-Nino events occurred in the years between 1986-1987, 1987-1988, 1991-1992, 2002-2003, 2009-2010. In the moderate El-Nino period the volumetric drop pattern of the reservoir is very different from the weak El-Nino. In this period the decline began to occur in April and the most extreme in August. The reservoir's volumetric deficit in this period is not up to 50%. The pattern of decreasing the water volume of the reservoir occurs slowly and in certain periods the decrease is very extreme. The moderate El-Nino events will greatly influence the pattern of reservoir operations especially in times of extreme decline. The characteristic of moderate El-Nino is indicated by volumetric retention of reservoirs ranging from 30% - 50%.

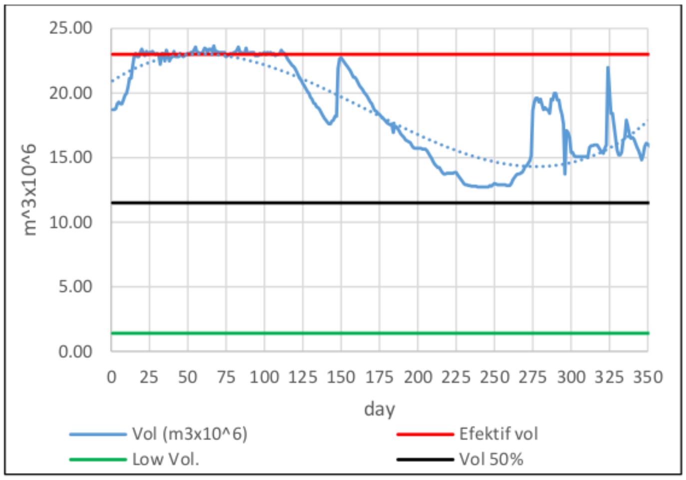

Figure 4. Graph of volumetric fluctuation of the reservoir at the time of moderate El-Nino.

3.3. Very strong El-Nino characteristics

The very strong El-Nino phenomenon occurred in 1982-1983, 1997-1998 and 2015-2016. Strong El-Nino has caused a very extreme drought in a very long period of time. Surface water sources are becoming shrinking and inflow reservoirs are very small. The decrease in reservoir volume is under the average volume of the normal reservoir and almost reaches the volume of the dead reservoir. The decrease in reservoir volume reaching 50% indicates that El-Nino has been very strong.

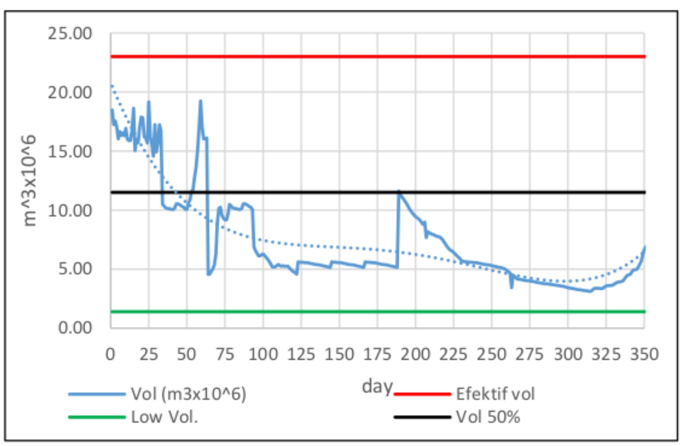

Figure 5. Graph of volumetric fluctuation of the reservoir at the time of very strong El-Nino.

Conclusion

Based on the results of the analysis, several points can be concluded in the following:

1. Long-term volumetric fluctuations in reservoirs can provide an accurate prediction of potential regional water resources and regional climate change.
2. Prediction of El-Nino event characteristics can be observed from the volumetric decrease of the reservoir. The decrease in water volume of the reservoir reaches 30% indicating weak El-Nino, 30% - 50% decrease is moderate El-Nino and a decrease above 50% indicates is very strong El-Nino

Acknowledgments

The authors wish to thank Departemant of Public Works West Nusa Tenggara Province for data throughout the study. We do appreciate to anonymous reviewers and editor for their valuable comments and suggestions

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