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Drought Index Analizes With Rainfall Patern Indicators Use SPI Method (Case Study Bangga Watershed)

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ABSTRACT
Irregular weather and climate changes caused by El – Nino effect drought in some areas, including in Indonesia. The location of this study lies in the Bangga watershed. The purpose of this study was to determine rainfall patterns, drought level, the worst drought that occurred and the prediction for the future. One method for analysis of drought is using SPI (Standardized Precipitation Index). This method aims to calculate the value of a drought index that would indicate the level of the existing drought in a region. Data used are monthly rainfall from two station for 23 years (year 1993-2015). After analyzing the drought, the projection made with software Makesens 1.0. The study results showed that the worst drought in Bangga watershed occurred in April 2015 with drought index -3516 for one monthly SPI, -2815 for three monthly SPI, -3254 for six monthly SPI, -2171 for nine monthly SPI, and - 2922 for twelve 12 monthly SPI. Once projected until 2050, generally Bangga watershed experiencing dry conditions with the worst drought in July with a value of -3.83 for one monthly SPI, -3.65 for three monthly SPI, -3.44 for six monthly SPI, -2.6 for nine monthly SPI and -2.32 for twelve monthly SPI.
Keywords: Standardized Precipitation Index (SPI), Drought Level Index, Makesens 1.0.

I. INTRUDUCTION

Irregular climate and weather changes give much impact to life. Climate change causing unbalanced between wet and dry season. The El – Nino Phenomenon causes long dry season, the water availability is reduced and cause drought. La – Nina is a natural Phenomenon where the wet season becomes longer, and excessive rainfall resulted in the availability of abundant water that can cause flooding.

The El – Nino Phenomenon in Indonesia caused drought in some areas, and should not be seen as a minor problem because drought have been a threat that often disrupt agricultural production systems [1]. El – Nino also ever effect extensive forest fire in Indonesia.

Geographically, Indonesia is a maritime continent which resulted not all part of its region affected by El – Nino. In some regions, particularly in Central Sulawesi, El – Nino that occurred in 2015 generally have no drought potential or prolonged heat but it cause decreased and temperature increased and Even Discharge of water in some rivers also decreased, paddy fields still can be irrigated by using a rotational system. Although the impact only occurred in some areas and not signifant, but El – Nino must be alert causes drought in years- incoming years and prejudicial to human life. earliest signs of drought is the reduction precipitation under the normal conditions, then with the reduced supply of water in the storage The earliest signs of drought is the reduction precipitation under the normal conditions, then with the reduced supply of water in the storage reservoir or river as well as the Watershed which is a unity with the river and tributaries. Central Sulawesi has a lot of river basin areas spread across several river basin with different characteristics. One is the Bangga Watershed which is include in the basin Palu - Lariang.

Bangga Watershed is located at the west of Palu River and above the Bangga village consist of the mountain, hills and plains that have a large area and tends to tropical weather so its vulnerable to the drought phenomenon that could affect the water availability and social economic impact to all people who lives in this area. Therefore, it is necesarry to make a study to detect a drought level in Bangga Watershed and predict a drought that could prevail in coming years also use as an early warning system of drought

There are many methods of drought analysis, and in this research is used Standarized Precipitation Index (SPI) with rainfall patern indicators which is more flexible and simple to use than the other methods. This method is a model to measuring rainfall deficit at different time periods based on normal conditions. The drought that used in this methods is a meteorogical drought that occurred based normal condition in a season.

The aim of this research are :

1. To determine the pattern of rainfall patern in the Bangga Watershed
2. To determine the drought index at Bangga Watershed in year 1993 to year 2015
3. To determine the drought level index and the worst drought that occurred in Bangga Watershed
4. To predict the drought that might occur in year 2020, year 2030 and year 2050

II. STUDY LITERATURE

2.1 Drought Definition

Various definitions of drought have been put forward by the other researchers such us [2], drought is deficiency of rainfall in a long period, and that cause bad impact on vegetation, animals and humans. Drought is also closely related to the reduction in rainfall, air temperature is above normal, low soil moisture and surface water supplies are insufficient. Drought can be defined with very little rainfall in a very long period of time so it cause a material adverse effect on living creatures, especially in fulfilling the needs of water for various purposes.

Drought can be categorized into four types: meteorologists drought, hydrological drought, agricultural drought, and socioeconomic drought [2]
1) Meteorologists drought is defined as the lack of normal rain or expected for a certain period of time
2) Hydrological drought is defined as a lack of surface water and groundwater supply in the lake and reservoirs, streams and groundwater levels.
3) Agricultural drought occur after meteorologists drought. This dryness associated with reduced water content in the soil (soil moisture) so it is not nearly enough to meet the water needs of crops.
4) Socio-Economic drought associated with a reduced supply of economically valuable commodity than normal as a result of drought meteorologists, agricultural and hydrological.

2.2 Drought Index analyzes

Drought meteorological constitute early indication of the drought, so it is necessary to do an analysis to determine drought level. The results of this analysis can be used as an early warning of impending drought farther [3].
The kinds of drought index analyzes that have been done are as below :

1. Decile

According [4], decile (D) is the point, score or value that divides the entire frequency distribution of the data that investigated into 10 parts each of 1/10 N. Another definitions, decile defined as a point that limits to 10% the lowest frequency in the distribution. The third decile is a point that limits to 30% the lowest frequency in the distribution.

2. Palmer Drought Severity Index

Palmer drought index method uses the concept of water balance. Palmer's analysis uses two layers consist of soil top layer and bottom layer. Input data in this method are rainfall, soil water capacity and potential evapotranspiration. Potential evapotranspiration suspected of average temperature - to the Thornthwaite method. The advantages of this method in addition to generating the index value, the coefficient also climate parameters, namely evapotranspiration coefficient, coefficient of recharge, runoff coefficient (run off) and the coefficient of soil moisture loss. In this analysis, drought index classification is divided into 11 classes with an index of zero as a normal state[5].

3. Standardized Precipitation Index

Standardized Precipitataion index (SPI) methods is an index that used to determine deviations of the normal precipitation in a long period (monthly, bimonthly, quarterly, and so on). Where if rain after shrinking will lead to the reduced of water content in the soil and flow rate [6].

4. Theory of Run

This method was first developed by Yjevich in August 1967. In 2014 the Ministry of Public Works make the mannual drought index calculation use method run. This method aims to calculate drought indices as the duration of the drought, the longest and largest number of drought on scattered location of station in a region. Theory of run was a comparative between Long and the amount of water deficit. The calculations Priciples of this methods were follow a process variable date [3].

2.3 Standardized Precipitation Index Methods

SPI is designed to measure a deficit of precipitation in some span of time. This timescale reflects the impact of drought on water resources of different required by the various decision-makers. Meteorological and soil moisture conditions (agriculture) respond to precipitation anomalies on a relatively short span of time, for example 1 to 6 months, while discharge rivers, reservoirs, and groundwater responds to a long-term precipitation anomalies of the order of six months to twenty-four months or more , SPI one month to six months for the agricultural drought, and SPI six months to twenty-four months or more for hydrological drought analysis and application [7]. In the calculation of Standardized Precipitation Index (SPI) for a location, required monthly precipitation data with a sufficiently long period of time. Ideally, the data needed at least 20-30 years of monthly values, with optimal data 50-60 years or more [7]. Because of time series needed for the calculation of the SPI is quite long, so to match the time series precipitation data as climatology, the gamma distribution was selected. This distribution is defined on the frequency or probability density function [8].

$G(x)=\int g(x)dx=1\beta\alpha\Gamma(\alpha)\int t\alpha-1e-x/\beta dxx0x0$ (2.1)

Equation(2.1) for x> 0, where
α> 0, is the shape parameter
β> 0, is the scale parameter
x> 0, is the amount of Precipitation

$\Gamma(\alpha)=\int y\alpha-1e-ydy\infty 0$ (2.2)

Γ (α) = a gamma function

SPI calculation includes matching the gamma probability density function against frequency distribution from the the amount of precipitation for each station. α and β were estimated for each rainfall station by using the following formula:

Γ (α) = a gamma function

$\alpha=14(1+\sqrt{1+4A3})$ (2.3)

$A=\ln(xr)-\Sigma\ln(x)/n$ (2.4)

or

$$\alpha = \frac{xr^2}{S^2} \quad (2.5)$$

$$\beta = \frac{xr}{\alpha} \quad (2.6)$$

For x> 0 Where,
n = number of observations of precipitation
xr = precipitation average
x = the amount of precipitation

Because of the gamma function is undefined for x = 0, whereas the distribution of precipitation likelihood consists from the zero value, then the cumulative probability becomes:

$H(x)=q+(1-q).G(x)$ (2.7)

Where q is the probability of zero.

If m is the number of zeros from the the entire time series, then q can be estimated by m/ n. Cumulative probability H (x) is then transformed into a normal standard with average (mean) of 0 and a difference of 1, or using the following formula:

The calculation of Z or SPI for 0 <H (x) ≤ 0.5

$$Z = -\left[t - \frac{C_0 + C_1.t + c_2.t^2}{1 + d_1.t + d_2.t^2 + d_3.t^3} \right] \quad (2.8)$$

With,

$t = V\ Ln\ (1/\ (h(x))^2)$ (2.9)

the calculation of Z or SPI for 0,5 < H(x) ≤ 1,0

$$(2.10)\ Z = +\left[t - \frac{C_0 + C_1.t + c_2.t^2}{1 + d_1.t + d_2.t^2 + d_3.t^3} \right]$$

With,

$t = V\ Ln(1/(1-(h(x))^2)$ (2.11)

where :
c0 = 2,515517 , d1 = 1,432788
c1 = 0,802853 , d2 = 0,189269
c2 = 0,010328 , d3 = 0,001308

The values of c0, c1, c2, d1, d2, d3 given in the above equation, is widely used for constant SPI [8]. Drought acuity index based on SPI which is an analog sharpness SPI drought by SPI values can be seen in the following table.

Table. 1. Drought level based on SPI Value

SPI Values	Classification
2.00	Extremely wet
1.5 -1.99	Very wet
1.00-1.49	Moderately wet
-0.99 -0.99	Near normal
-1.00 –1.49	Moderately dry
-1.5—1.99	Severely dry
-2.0 - <-2.00	Extremely dry

2.3 Mann Kendall – Sen's Methods (Makesens)

Mann - Kendall test Methods is used to evaluate whether there is a tendency in the data span of hydrology [9]. Using the Mann Kendall Test to assess their tendency to rain. According [10], Mann Kendall calculation is as follows:

$$S=\sum_{k=1}^{n-1}\sum_{j=k+1}^{n} sign(X_j - X_k) \quad (2.12)$$

$$\sigma s=\sqrt{n(n-1)(2n+5)/18} \quad (2.13)$$

$$Z=\begin{cases}(S-1)/\sigma s......jika.....S>...0\\ 0.....................jika....S=...0\\ (S+1)/\sigma s.......jika...S<....0\end{cases} \quad (2.14)$$

Where: Xj and Xk is data value "j" and "k", j> k
σs = variant
n = number of data

After the Mann-Kendall test ,to predict the future use non-parametric Sen'S methods. Both methods are combined so-called Makesens method.

III. RESEARCH METHODS

The location of this research is the Bangga Watershed and was a Miu sub watershed that located on the western Palu river and above the Bangga village composed of mountains and hills. administratively, its located in the district of South Dolo, Sigi Central Sulawesi. Bangga Watershed geographically located at 01º14'00 " South Hemisphere and 119º55'30" East Hemisphere.

Bangga watershed drainage area of 69.04 km². The Location study can be seen in the map below:

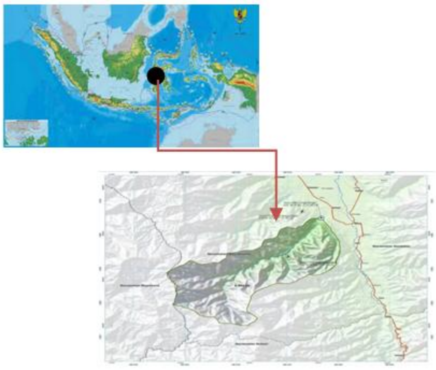

Figure 1. Location of research

The data used in this research are secondary data from Bangga Top and Bottom station consisting of a topographic map and precipitation data (year 1993 till year 2015). To complete this study can be carried out the following stages:

a. Calculate the value of a drought index by using SPI
b. Calculate the value of the parameter Sens using Mann Kendall Model
c. After obtaining the parameter sens, made projections to forecast drought in year 2020, year 2030 and year 2050.

IV. RESULT AND DISCUSSION

4.1 SPI Drought Index

To find an area experiencing climate change such as drought in Bangga Watershed, it is necessary to seek a drought index first. In this study using SPI (Standardized Specification Index) methods for one month, three months, six months, nine months and twelve months periods. The recapitulation for one month SPI is described in Table 1.

Table.1 Recapitulation of 1monthly SPI Index Value

Num	Year	January		Pebruary		March		April		May		June	
		SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL
1	2	3		4		5		6		7		8	
1	1993	-2.357	ED	-1.712	ED	-1.712	SD	-1.712	SD	-1.359	SD	-0.613	NN
2	1994	0.953	NN	0.110	NN	2.112	ED	0.928	NN	2.117	EW	-1.095	MD
3	1995	1.535	VW	0.738	NN	1.864	VW	0.072	NN	0.456	NN	-1.144	MD
4	1996	1.024	MW	0.526	NN	0.524	NN	0.870	NN	0.657	NN	-0.930	NN
5	1997	-0.372	NN	-0.420	NN	0.541	NN	1.144	MW	-0.906	NN	-0.628	NN
6	1998	-1.526	SD	-0.870	NN	0.144	NN	1.068	MW	0.021	NN	-0.601	NN
7	1999	-2.068	ED	-0.363	NN	-0.095	NN	0.675	NN	0.097	NN	-1.868	SD
8	2000	2.061	EW	-0.587	NN	-0.690	NN	0.151	NN	0.196	NN	-1.028	MD
9	2001	0.987	NN	-1.024	MD	-0.004	NN	0.832	NN	0.429	NN	-0.293	NN
10	2002	0.364	NN	-0.604	NN	-2.263	ED	-1.712	SD	-0.589	NN	-1.346	MD
11	2003	-0.373	NN	-0.856	NN	0.241	NN	0.875	NN	0.122	NN	-1.264	MD
12	2004	0.673	NN	-1.020	MD	-0.343	NN	0.418	NN	0.746	NN	-0.853	NN
13	2005	-1.381	MD	-0.603	NN	0.552	NN	-0.058	NN	0.253	NN	-1.092	MD
14	2006	-0.105	NN	-0.745	NN	-1.445	MD	0.743	NN	-0.024	NN	-0.731	NN
15	2007	0.438	NN	0.222	NN	0.692	NN	0.917	NN	1.334	MW	-0.151	NN
16	2008	-0.225	NN	-0.539	NN	0.923	NN	0.967	NN	0.307	NN	-0.705	NN
17	2009	0.049	NN	-1.712	SD	0.553	NN	0.174	NN	-0.239	NN	-0.678	NN
18	2010	0.804	NN	-0.567	NN	-0.380	NN	-1.712	SD	-1.712	SD	-1.972	SD
19	2011	0.410	NN	-0.793	NN	0.222	NN	-0.618	NN	-0.828	NN	-0.916	NN
20	2012	-0.447	NN	-0.490	NN	-0.792	NN	0.682	NN	-1.109	MD	-0.279	NN
21	2013	0.182	NN	-0.282	NN	0.442	NN	0.439	NN	0.285	NN	-0.375	NN
22	2014	0.099	NN	-0.228	NN	0.079	NN	-1.240	MD	1.706	VW	-0.707	NN
23	2015	-2.357	ED	-1.712	SD	-1.054	MD	-3.516	ED	-1.066	MD	-1.296	MD

Num	Year	July		August		September		Oktober		November		December	
		SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL
1	2	9		10		11		12		13		14	
1	1993	1.901	VW	-0.012	NN	0.311	NN	0.983	NN	0.898	NN	0.766	NN
2	1994	-0.201	NN	1.231	MW	-0.651	NN	1.004	MW	0.992	NN	1.079	MW
3	1995	1.150	MW	1.462	MW	2.298	EW	1.931	SD	1.127	MW	-0.652	NN
4	1996	0.220	NN	1.035	MW	1.019	MW	0.752	NN	-0.323	NN	-0.282	NN
5	1997	1.116	MW	-2.249	ED	-1.920	SD	-1.400	MD	1.805	MW	-0.071	NN
6	1998	1.952	VW	0.043	NN	0.888	NN	0.023	NN	-1.210	MD	-0.908	NN
7	1999	-0.306	NN	0.148	NN	0.438	NN	1.251	MW	-1.349	MD	-1.247	MD
8	2000	-0.071	NN	-0.252	NN	0.170	NN	-0.025	NN	0.001	NN	-0.681	NN
9	2001	-1.249	MW	-1.594	SD	0.206	NN	-0.091	NN	-1.934	SD	-0.144	NN
10	2002	0.192	NN	-1.216	MD	0.447	NN	-0.340	NN	1.064	MW	0.255	NN
11	2003	-0.288	NN	-0.097	NN	-1.250	MD	0.911	NN	0.105	NN	-0.655	NN
12	2004	0.356	NN	-3.304	ED	-0.060	NN	-1.701	SD	-1.275	MD	-1.239	MD
13	2005	-0.225	NN	-0.038	NN	0.578	NN	0.915	NN	-0.909	NN	-0.198	NN
14	2006	0.313	NN	-0.264	NN	0.122	NN	-2.293	ED	-0.035	NN	0.325	NN
15	2007	-0.676	NN	1.530	MW	0.011	NN	0.809	NN	-0.167	NN	0.897	NN
16	2008	0.317	NN	-0.464	NN	-1.712	SD	-1.712	SD	0.200	NN	-0.772	NN
17	2009	-1.062	MD	0.321	NN	-0.730	NN	0.463	NN	-0.194	NN	1.142	MW
18	2010	0.658	NN	1.687	VW	0.352	NN	-0.298	NN	-1.002	MD	0.441	NN
19	2011	-1.133	SD	1.197	MW	0.674	NN	-0.572	NN	1.301	MW	0.628	NN
20	2012	-1.071	MD	0.490	NN	-0.280	NN	0.568	NN	1.553	MW	2.274	EW
21	2013	0.740	NN	0.087	NN	1.282	MW	0.601	NN	0.272	NN	1.121	MW
22	2014	-0.405	NN	-0.232	NN	-2.062	ED	-1.400	MD	-0.994	NN	0.361	NN
23	2015	-1.587	SD	-2.315	ED	0.112	NN	-0.773	NN	-0.013	NN	-1.97	SD

Tabel 2. Recapitulation of 3 monthly SPI Index Value

Num	Year	Jan - March		April - June		July - Sept		Okt - Dec	
		SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	TK
1	2	3		4		5		6	
1	1993	-1.712	SD	-1.434	MD	1.052	MW	1.084	MW
2	1994	1.783	VW	2.287	EW	0.350	NN	1.289	MW
3	1995	2.104	EW	0.752	NN	2.171	EW	1.243	MW
4	1996	1.263	MW	1.077	MW	0.963	NN	-0.080	MD
5	1997	0.353	NN	-0.312	NN	-0.628	NN	0.716	NN
6	1998	-0.718	NN	0.626	NN	1.315	MW	-1.113	MD
7	1999	-0.772	NN	-0.428	NN	-0.025	NN	-0.413	NN
8	2000	0.491	NN	0.549	NN	-0.266	NN	-0.421	NN
9	2001	0.282	NN	0.593	NN	-1.201	MD	-1.100	MD
10	2002	-0.720	NN	-0.425	NN	-0.328	NN	0.497	NN
11	2003	-0.019	NN	-0.155	NN	-0.822	NN	-0.115	NN
12	2004	-0.276	NN	0.187	NN	-0.713	NN	-2.101	ED
13	2005	-0.320	NN	-0.519	NN	-0.020	NN	-0.202	SD
14	2006	-0.413	NN	-0.168	NN	-0.102	NN	-0.599	NN
15	2007	0.975	NN	1.241	MW	0.648	NN	0.551	NN
16	2008	0.184	NN	0.788	NN	-0.949	NN	-1.049	MD
17	2009	-0.158	NN	-0.603	NN	-0.664	NN	0.532	NN
18	2010	0.270	NN	-0.307	NN	1.306	MW	-0.541	NN
19	2011	0.236	NN	-1.490	MD	0.554	NN	0.760	NN
20	2012	-0.230	NN	-0.536	NN	-0.367	NN	2.104	NN
21	2013	0.511	NN	-0.728	NN	0.826	NN	0.783	NN
22	2014	-0.142	NN	0.613	NN	-1.149	MD	-0.960	NN
23	2015	-2.192	ED	-2.815	ED	-1.498	MD	-0.985	NN

Table 3. Recapitulation of 6,9,and 12 montly SPI index Value

Num	Year	6 Month SPI				9 Month SPI		12 Month SPI	
		January - June		July - December		January - September		January - December	
		SPI Value	DL	SPI Value	DL	SPI Value	DL	SPI Value	DL
1	2	3		4		4		4	
1	1993	-2.494	ED	0.423	NN	-1.230	MD	-0.827	NN
2	1994	0.324	NN	0.142	NN	1.010	NN	0.969	NN
3	1995	-0.042	NN	1.208	MW	1.327	NN	1.224	MW
4	1996	-0.495	NN	-0.184	NN	0.521	NN	0.243	NN
5	1997	-0.618	NN	-0.688	NN	-0.943	NN	-0.751	NN
6	1998	-0.671	NN	-0.299	NN	-0.179	NN	-0.570	NN
7	1999	-1.298	MD	-0.994	NN	-1.200	MD	-1.298	MD
8	2000	-0.133	NN	-1.150	MD	-0.449	NN	-0.671	NN
9	2001	-0.231	NN	-2.072	ED	-0.790	NN	-1.112	MD
10	2002	-1.273	MD	-0.676	NN	-1.315	MD	-1.101	MD
11	2003	-0.773	NN	-1.157	MD	-1.126	MD	-1.085	MD
12	2004	-0.732	NN	-2.198	ED	-1.059	MD	-1.525	SD
13	2005	-1.124	MD	-0.886	NN	-1.082	MD	-1.143	MD
14	2006	-0.989	NN	-1.133	MD	-1.024	MD	-1.201	MD
15	2007	0.483	NN	-0.093	NN	0.329	NN	0.217	NN
16	2008	-0.185	NN	-1.894	SD	-0.688	NN	-1.013	MD
17	2009	-1.074	MD	-0.821	NN	-1.302	MD	-1.080	MD
18	2010	-0.670	NN	-0.119	NN	-0.184	NN	-0.467	NN
19	2011	-1.190	MD	-0.040	NN	-0.862	NN	-0.676	NN
20	2012	-1.083	MD	0.334	NN	-1.197	MD	-0.393	NN
21	2013	-0.214	NN	0.134	NN	-0.105	NN	-0.079	NN
22	2014	-0.439	NN	-1.964	SD	-0.951	NN	-1.223	MD
23	2015	-3.254	ED	-2.171	ED	-3.113	ED	-2.922	ED

From the calculation of the SPI, the result that SPI drought index showing a tendency to dry and wet conditions in accordance with the value stated in the table level SPI drought. At SPI 1 Monthly, the index value of extreme drought or extremely dry in April 2015 with the index value -3516. This corresponds to the pattern of rainfall in the Bangga watershed of the month with the rainfall deficit. At the 3-monthly SPI index worst drought occurred in the period from April to June 2015 with the index value -2815. Extremely wet in the period April to June 1994 index value of 2287. the SPI 6-monthly, the index value indicates a severe drought that is in the period from January to June 2015 with the SPI value -3254. At SPI 9 monthly, the index value of the worst drought occurred in 2015 with a score of -3113.

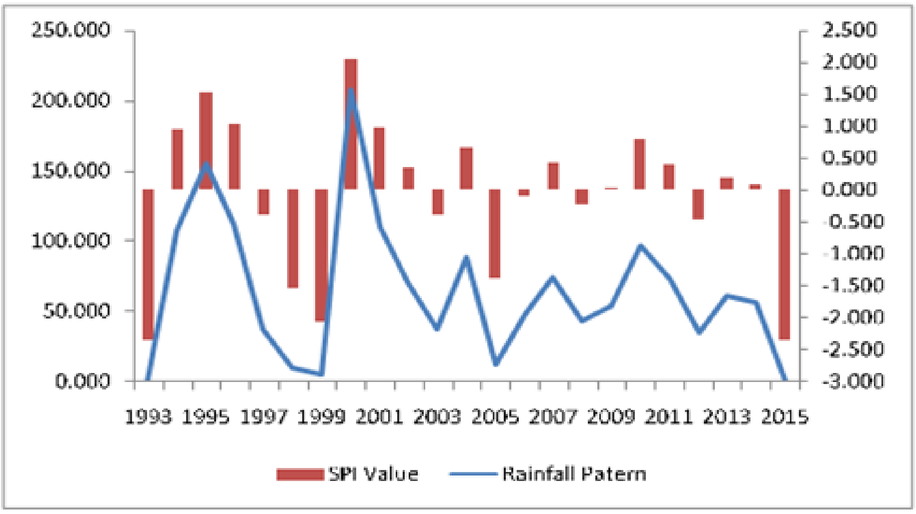

Figure.2 Relation between Rainfall Pattern and SPI Value

From the graph above, it can be seen the relationship between rainfall pattern with a drought index for one month, where in 1993, 1999 and 2015 rainfall patterns show a lack of rainfall in the Bangga watershed and SPI values shows the state extremely dry with the worst drought in 1993 and 2015. While high rainfall occurred in 1995, 1996 with the highest rainfall month of January in 2000 and SPI values indicate extremely wet conditions during the year. correspondence between rainfall patterns and the value of SPI also looks at SPI 1, 3, 6, 9 and 12 monthly.

To determine the drought projected in the future, the SPI index value needs to be analyzed first using the Mann-Kendall with the help of Software MAKESENS 1.0. Then to determine the prediction of drought used non-parametric methods Sens assuming a linear trend. The results of calculations are presented in the following table:

Table. 4. Recapitulation of Sens Parameters

Number	SPI Periods	Sens Parameter		
		Q	B	Z
I	**1 Monthly SPI**			
1	January	-0.04	0.73	-0.82
2	February	-0.02	-0.40	-0.50
3	March	-0.04	0.65	-0.90
4	April	-0.04	0.94	-1.61
5	May	-0.02	0.36	-0.74
6	June	0.01	-0.97	0.63
7	July	-0.08	0.74	-2.22
8	August	-0.01	0.09	-0.32
9	September	-0.03	0.46	-1.11
10	October	-0.06	0.64	-2.25
11	November	-0.01	0.08	-0.11
12	December	0.05	-0.42	1.16
II	**3 Monthly SPI**			
1	January - March	-0.03	0.47	-0.85
2	April - June	-0.08	0.91	-2.22
3	July - September	-0.06	0.41	-1.85
4	October - December	-0.03	0.17	-0.85
III	**6 Monthly SPI**			
1	January - June	-0.03	-0.49	-1.00
2	July- December	-0.06	-0.16	-1.27
IV	**9 Monthly SPI**			
1	January - September	-0.04	-0.50	-1.27
V	**12 Monthly SPI**			
1	January - December	-0.03	-0.58	-1.27

To find out more projection Drought Index for 1 month, 3 months 6 months 9 monthsand 12-months, then made tables and graphs of historical data and projections. Examples projections are presented as follows:

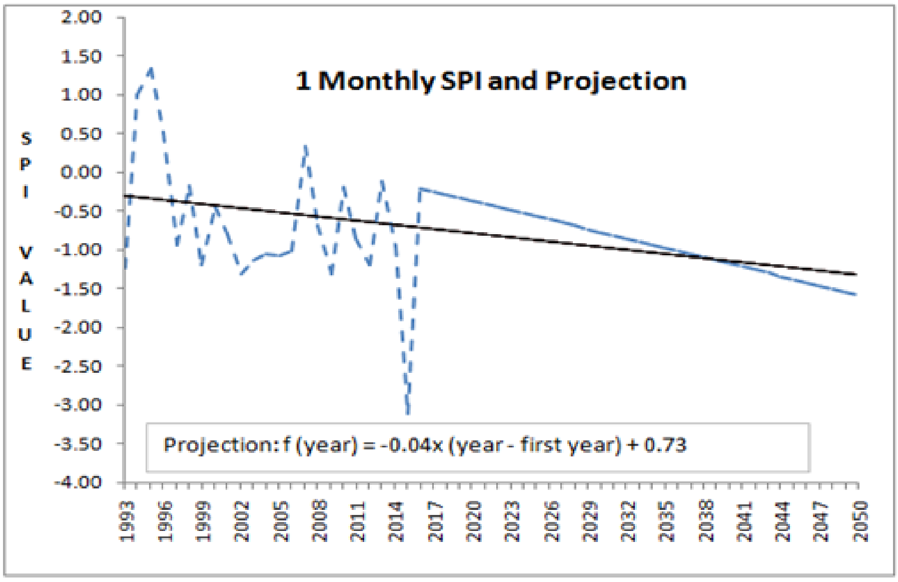

Figure 3. Sen's Projection in January for 1 Monthly SPI

The graph above shows that based on the historical data, 1-month SPI drought index in January has decreased every year but not significant, as in year 2020 with an index value of -0.37 with normal conditions, in year 2030 the index value of -0.77 with normal conditions and year 2050 with the value of the index -1.58 shows extremely dry conditions. Generaly 1-month SPI drought index decreased except in June and December which increased the index by 0:01 and 0:05 per year.

Table .5. The equation of Sen's Projection

Number	SPI Periods	Equation of Projection	The Average Changes
I	**1 Monthly SPI**		
1	January	f(year) = -0,04 x (year - first year)+0.73	0.04
2	February	f(year) = -0,02 x (year - first year) - 0.40	0.02
3	March	f(year) = -0,04 x (year - first year)+0.65	0.04
4	April	f(year) = -0,04 x (year - first year)+0.94	0.04
5	May	f(year) = -0,02 x (year - first year)+0.36	0.02
6	June	f(year) = 0.01 x (year - first year) - 0.97	0.01
7	July	f(year) = -0,08 x (year - fisrt year)+0.74	0.08
8	August	f(year) = -0,01 x (year - first year)+0.09	0.01
9	September	f(year) = -0,03x (year - fisrt year)+0.46	0.03
10	October	f(year) = -0,06 x (year - fisrt year)+0.64	0.06
11	November	f(year) = -0,01 x (year - first year)+0.08	0.01
12	December	f(year) = 0,05 x (year - first year) - 0.42	0.05
II	**3 Monthly SPI**		
1	January-March	f(year) = -0,03 x (year - first year) + 0.47	0.03
2	April - June	f(year) = -0,08 x (year - first year) + 0.91	0.08
3	July - September	f(year) = -0,06 x (year - first year) + 0.41	0.06
4	October - December	f(year) = -0,03 x (year - first year) - 0.81	0.03
III	**6 Monthly SPI**		
1	January - June	f(year) = -0,03 x (year - first year) - 0.49	0.03
2	July - December	f(year) = -0,06 x (year - first year) - 0.16	0.06
IV	**9 Monthly SPI**		
1	January - September	f(year) = -0,04 x (year - first year) - 0.50	0.04
V	**12 Monthly SPI**		
1	January - December	f(year) = -0,03 x (year - first year) - 0.58	0.03

Table. 6. The Result of Sen's Projection

Num	SPI Periods	Projection					
I	**1 Monthly SP**	**2020**	**DL**	**2030**	**DL**	**2050**	**DL**
1	January	-0.37	NN	-0.77	NN	-1.58	SD
2	February	-0.86	NN	-1.03	MD	-1.36	MD
3	March	-0.48	NN	-0.9	NN	-1.73	SD
4	April	-0.24	NN	-0.67	NN	-1.54	SD
5	May	-0.28	NN	-0.52	NN	-0.99	NN
6	June	-0.63	NN	-0.51	NN	-0.26	NN
7	July	-1.43	MD	-2.23	ED	-3.83	ED
8	August	-0.20	NN	-0.3	NN	-0.51	NN
9	September	-0.41	NN	-0.73	NN	-1.38	MD
10	October	-0.85	NN	-1.4	MD	-2.51	ED
11	November	-0.16	NN	-0.25	NN	-0.43	NN
12	December	0.81	NN	1.26	MW	2.17	ED
II	**3 Monthly SPI**						
1	January-March	-0.32	NN	-0.61	NN	-1.19	MD
2	April - June	-1.25	MD	-2.05	ED	-3.65	ED
3	July - September	-1.01	MD	-1.32	MD	-1.94	SD
4	October - December	-1.17	MD	-1.76	SD	-2.93	ED
III	**6 Monthly SPI**						
1	January - June	-1.25	MD	-1.34	MD	-2.1	ED
2	July - December	-1.71	SD	-2.29	ED	-3.44	ED
IV	**9 Monthly SPI**						
1	January - September	-1.49	MD	-1.86	SD	-2.6	ED
V	**12 Monthly SPI**						
1	January - December	-1.41	MD	-1.71	SD	-2.32	ED

Based on projected results for SPI drought index values in the table above, at year 2020 for one monthly SPI the condition are relatively normal except in July which will have dry conditions. 3-monthly SPI relatively dry except during the period from January to March. For SPI 6-monthly, 9 monthly and 12-monthly dry conditions expected to occur by the worst drought in SPI 6-monthly period from July to December.

The projection SPI drought index value in 2030 for SPI 1 monthly, relatively in a normal condition, in July and October will experience dry conditions and tends to damp in December. At the 3-monthly SPI, its will experience dry conditions and extremely dry, and normal occur in the period from January to March. For SPI 6-monthly, 9 monthly and 12 monthly will experience very dry conditions with the worst drought in the 6-monthly period in July-December.

The projection in year 2050 for SPI 1 Monthly, the conditions are relatively dry with the worst drought in July, while in December there will be conditions of extremely wet, for a period of 3 months, 6 months, 9 months and 12 monthly predicted will have extremely dry with the worst drought in SPI 3-month period from April to June with an index value of -3.65.

Projections drought index for Bangga Watershed generally the graphed decreased so that the value of a drought index also decreased and the conditions become dry and extremely dry, except in SPI 1 monthly period in June and in December increased indicating that during this period the value of the index rose and conditions turn out to be normal or wet. When projecting a drought index is applied to Watershed else, then decline and the increase can be changed according to the drought index calculation and projection of the index value Watershed.

V. CONCLUSION

From the analysis of drought index with the SPI (Standardized Precipitation Index) method obtained the following results:

1. Rainfall Patterns in Bangga Watershed using the average rainfall for 1 month, 3 months 6 months, 9 months and 12 months proportional to the value of the SPI drought index for 1 month, 3 months, 6 months, 9 months and 12 months. When the rainfall is high then the value of the index shows the value of wetness, and even if the low rainfall deficit, then the value of a drought index also showed extreme dry conditions and dry.
2. In the period of 1-monthly SPI, the index value indicates relatively normal conditions, but there are a few years that show moderately dry and severely dry conditions in every month. At the 3-monthly SPI, dry conditions occurred in some years such as in year 1993 and year 2013 with an index value of -1712 and -2192. At SPI 6-monthly, the index value indicates dry conditions in eight years with the worst drought index of -3254. At SPI period of 9 monthly, a drought index indicates dry conditions in nine years SPI data with the worst drought index value of -3113. In the period 12 months, dry conditions occurred in the 10 years of data SPI with the worst index value of -2922.
3. In the SPI 1-monthly, the index value for the most severe drought conditions in the Bangga watershed was in April 2015 with an index value of -3516 (Extremely dry). In the SPI value of 3-monthly period, the index value for the drought conditions are most severe in the period April to June 2015 with a score of -2815 (extremely dry). The SPI values for 6-monthly period, the index value for the drought conditions are most severe in the period from January to June 2015 with the index value -3254 (extremely dry). The value of SPI period of 9 months, the index value for the most severe drought conditions was in 2015 with a score of -2171 (extremely dry). In the 12-month SPI values, the value of the index is the worst hit in year 2015 with a score of -2922 (extremely dry).
4. From the projected drought level for Bangga Watershed in year 2020 and year 2030 in general watershed conditions are relatively normal for 1 monthly SPI. Dry conditions will occur on the 3, 6, 9 and 12 months SPI. In year 2050 general Bangga Watershed will experience extreme dry conditions with the worst drought on SPI 1-monthly in July

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