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The Effect of Water Table and Rainfall on the KBDI Drought Index in the Liang Anggang Protected Forest Area Block 1

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ABSTRACT

Peatlands in Indonesia cover an area of more than 7% of the land area, which is around 14.95 million hectares spread over the islands of Sumatra, Kalimantan, and Papua and a small part of Sulawesi. The utilization of peatlands is carried out by clearing land and constructing a drainage network. This results in peatlands being unable to absorb water, causing a decrease in the water level (TMA) as well as land fires and irreversible drying. This also occurs in a protected forest in Liang Anggang District, Landasan Ulin Utara. This study aims to determine the drought index on peatlands in the Liang Anggang Protected Forest Area, South Kalimantan, for hotspots. This study uses an analytical method by collecting rainfall data from 2000 to 2021 obtained from the Syamsudin Noor Banjarmasin Class II Meteorological Station. Then the data will be processed using analysis from the Keech Byram Drought Index (KBDI) model of modification of the physical properties of peat. The results obtained from this study are data to determine the drought index on peatlands in the Liang Anggang Protected Forest Area, South Kalimantan, for hotspots and the level of the KBDI drought index, which affects the spread of hotspots where the higher the KBDI drought index is at an extreme level, the hotspots more and more.

Keywords: *Fibric Peat, KBDI modification, Hotspot, Liang Anggang Protection Forest*

1. INTRODUCTION

Peatlands in Indonesia cover an area of more than 7% of the land area, around 14.95 million hectares spread across the islands of Sumatra, Kalimantan, Papua, and Sulawesi. This condition has resulted in the utilization of peatlands of approximately 2.2 million hectares over the last ten years. Peatland degradation is caused by agricultural activities, drainage development, plantations, illegal logging, and land fires (Novitasari et al., 2018) which results in an increase in surface runoff as well as a decrease in water seeping into the ground (Kurdi & Novitasari, 2020) so that peatland peat cannot absorb water because water flow infiltrates into the soil and some flows to lower places (Harisnor & Amalia, 2016). The lack of water infiltration causes a decrease in the water level (TMA), resulting in drought and land fires. Most fires on peatlands because of long periods of no rain and low heavy rains, so the peat, which should function as a water absorbent in the field, will lose its function (Fitriati et al., 2017) therefore, it is necessary to carry out a rain analysis in the city of Banjarbaru to determine the characteristics of the rainfall that happened (Sofia & Amalia, 2021). This also occurred in a protected forest area located in Liang Anggang District, Landasan Ulin Utara Village, which changed the land use plan that was previously used as a conservation area into a built-up area and plantations, resulting in drought (Amalia, 2011). The results obtained from this study are data to determine the drought index on peatlands in the Liang Anggang Protected Forest Area, South Kalimantan, for hotspots and the level of the KBDI drought index, which affects the spread of hotspots where the higher the KBDI drought index is at extreme temperatures, the more hotspots.

2. LITERATURE REVIEW

Keetch-Byram Drought Index **(KBDI)**

The drought index is a crucial indicator for detecting, monitoring, and evaluating drought events. One of the drought index methods that can be used is to calculate the KBDI (Keech-Byram Drought Index) value. The KBDI drought index is an index using a number that represents the net effect of evapotranspiration and precipitation in producing a cumulative moisture deficiency in thick litter or topsoil related to the flammability of organic matter in the soil.

The KBDI calculation method is quite simple because only three modifiers are needed to calculate the value of the fire hazard level, as follows.

1. Average annual rainfall from local/local weather stations
2. Daily rainfall
3. Maximum temperature

The method of calculating this method is based on the following equation.

$$KBDI_{p,t} = KBDI_{p,t-1} + DF_{p,t} - RF_{p,t} \quad (2.1)$$

withal:

$KBDI_{p,t}$: Drought index today

$KBDI_{p,t-1}$: Previous day's drought index

$DF_{p,t}$: Drought Factor

$RF_{p,t}$: Effective Rain

The value of the rainfall factor (RFt) is determined using meteorological data in the form of annual rainfall, and daily rainfall RFt of more than 5.1 mm/day is considered a reduction in the drought index and is determined using the following equation:

$$RFt = \begin{cases} (R_t - 5{,}1), R_t \geq 5{,}1 \text{ mm}/day, \text{first rainy day} \\ R_t, R_{t-1} \geq 5{,}1\ mm/day, \text{the second day and the next rainy day} \\ 0, R_t < 5{,}1 \text{ mm/day} \end{cases}$$

Where Rt is the daily rainfall at t and Rt-1 is the daily rainfall at t-1.

To determine the drought factor for a, b, and c as follows:

$$DFt = (wc\text{-}KBDIt\text{-}1)\frac{(ae^{(bTm+1{,}5552)} - c)10^{-3}}{1+10{,}88e^{(-0{,}001736R0)}} \quad (2.2)$$

with:

DF_t : Drought Factor (mm)

w_c : the water field capacity available in the coating (mm)

$KBDI_{t-1}$: moisture deficiency (KBDI pada t-1)

T_m : daily maximum temperature (^oC)

t : time increase (day)

R_0 : average annual rainfall (mm)

a dan *c* : coefficient, which is influenced by the average annual rainfall (R_0)

b : coefficient affected by evapotranspiration

KBDI Index of Peat Physical Conditions

The nature of maturity/decomposition of peat organic matter is divided into 3 (three) types, namely fibric, hemic, and sapric. In the field, the degree of maturity of the peat is determined by the pressing method, which can be demonstrated by looking at the yield of the liquid and the rest of the pressed ingredients by hand. Meanwhile, determining the thickness of peat is done by measuring from the top layer to the mineral soil. Sapric peat is peat that has an advanced level of weathering (mature) in the field, where it is characterized when the soil is held, and it will pass between the fingers without any residue in the hands. Hemic peat is peat that has a moderate level of weathering (half cooked), some of the material has undergone weathering, and some is in the form of fiber in the field characterized by the fact that if you hold it in your hands, some of the soil will pass between your fingers and some will stay in your hands. Fibric peat is peat with an early (raw) level of weathering which is characterized by a high content of plant tissue materials or plant residues which, when encountered in the field, hold them all in the hands. (Suswati dkk., 2011).

Mature peat tends to have finer fibers which can be seen in the field easily between the fingers so that under normal groundwater conditions, it is more resistant to subsurface fires. The ability of mature peat to retain water is also higher than immature peat. Dry peat is characterized by a permanent wilting point condition, namely at a stress of 4.2 pF equivalent to a stress of 15 atmospheres (bar). This condition occurs when the peat does not receive rain for a particular time. The effect of physical properties on the modified dryness index is presented in Table 1.

Table 1 Effect of Physical Properties on Peat Maturity

Physical Properties	Safri		c Hemic Fibric
Absorb water (%)	Small	Currently	Large
Store/water retention (%) at 15 bar	100	84	67
Releasing water (%)	Small	Currently	Large
Volume weight (BV) (g/cm^3),	0.2	0,1 – 0,2	0,1
Total pore space (TRP) (%)	86,7	90,0	93,3

Sumber: (Andriesse, 1988)

The drought index formula developed in the 2019 study found that for conditions of fibric physical properties to determine the drought factor for physical properties conditions, and for a, b, and c with the formula as in equation 2.2 (Novitasari dkk., 2019)

Table 2 Climate Variables and Drought Factor Coefficients for Peat Physical Conditions

Parameter	Peat Physical Characteristics
T_m [ºC]	32
R_0 [mm]	2540
A	0,6547
B	0,0905
C	5,62
w_c	400

Sumber: (Novitasari dkk., 2019)

Based on the new w_c (groundwater table) condition value of peatland, the KBDI class value is modified for the condition of the physical properties. Drought index classes are classified into four levels, as presented in Table 3.

Table 3 Modified KBDI Drought Index Class for Physical Properties Conditions

Class	KBDI Index of Peat Physical Properties
Low	0-200
Currently	201-300
Tall	301-350
Extreme	>350

Sumber: (Novitasari dkk., 2019)

3. RESEARCH METHODS

Processing steps in this research

1) Preparation and study of related literature.
2) Collection of necessary data such as daily rainfall data for 2000-2021, maximum daily temperature for 2000-2021, and hotspots for 2012-2021.
3) Calculate the adequate daily rainfall (RF_t) using daily rainfall data.
4) Calculating the drought factor (DF_t) for wetland conditions is assumed to occur at a groundwater level of 400 mm.
5) Calculating today's drought index ($KBDI_t$) using the previous day's drought index data ($KBDI_{t-1}$), drought factor (DF_t), and adequate daily rainfall (RF_t).
6) Determine the drought index level with the KBDI drought index class table.

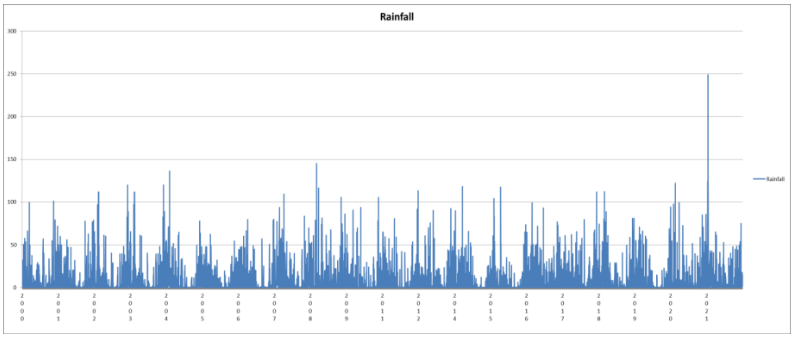
4. RESULTS AND ANALYSIS

Results of Data Analysis of Rainfall and Hotspots

Daily rainfall data every year from 2000 to 2021, as shown in Table 4.

Table 4 Monthly Cumulative Value of Daily Rainfall 2012 to 2021

Monthly Cumulative Value of Daily Rainfall from 2000 to 2021																						
Month	Year																					
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2011	2012	2014	2015	2016	2017	2018	2019	2020	2021	Total Rain
January	393	357	264	264	626	269	547	371	253	318	517	221	279	339	383	385	280	293	458	898	7714
February	293	209	551	551	375	272	373	539	319	160	249	156	300	503	350	264	474	326	532	418	7211
March	426	262	133	133	303	333	348	480	421	139	296	264	295	80	329	173	553	328	265	166	5725
April	122	133	212	212	127	130	182	473	275	255	181	403	214	274	333	237	212	309	59	214	4556
May	126	133	50	50	228	230	185	147	85	186	263	126	211	158	292	266	44	84	175	200	3241
June	187	76	98	98	80	50	202	205	196	56	72	162	194	107	213	209	152	172	127	222	2878
July	156	21	47	18	90	19	12	159	268	66	79	145	75	45	129	139	56	9	79	64	1676
August	142	17	142	42	0	49	58	66	99	26	46	27	20	45	81	99	64	27	115	162	1326
September	75	105	110	110	33	36	39	20	88	21	44	32	15	0	155	116	16	3	110	122	1248
October	185	163	171	171	55	177	0	103	213	103	160	166	0	29	201	103	113	58	173	145	2485
November	347	347	265	265	290	203	120	331	441	400	195	338	52	84	449	377	218	91	352	284	5446
December	411	363	656	656	413	284	347	355	438	227	639	463	300	474	328	391	609	325	501	328	8507
Annual Amount	2861	2184	2698	2569	2620	2051	2413	3249	3096	1955	2741	2502	1956	2137	3243	2757	2791	2024	2945	3221	52013



Picture 1 Monthly Cumulative Value of Daily Rainfall from 2000 to 2022

It can be seen in Picture 1 that in 2004 there was an extreme rain of 136.1 mm on 3 February 2004; in 2008, there was an excessive rain of 145 mm on 4 March 2008; in 2014, there was an extreme rain of 118.2 mm on 21 March 2014, in 2015 there was a heavy rain of 117.5 mm on 13 April 2015, in 2020 there was an extreme rain of 122.1 mm on 18 February 2020. In 2021 there was an extreme rain of 249 mm on 14 January 2021.

Results of the Calculation of the Drought Index of Peat Physical Conditions

The results of calculating the average drought index every month for 20 years from 2000 to 2001 for the physical properties of peat can be seen in Table 5.

Table 5 Monthly Average Drought Index

Monthly Average Drought Index														
T/B	January	February	March	April	May	June	July	August	September	October	November	December	Average	Rate
2000	34.8	91.8	110.5	216.7	324.3	298.5	332.4	278.6	363.6	349.3	209.0	139.8	229.1	currently
2001	108.4	134.6	219.3	269.1	324.9	334.5	372.8	382.3	389.2	331.1	279.7	219.3	280.4	currently
2002	144.3	77.2	219.3	259.7	324.2	363.2	344.0	382.3	360.8	336.1	280.3	64.3	263.0	currently
2003	138.9	77.2	221.8	260.7	324.4	363.8	354.7	385.4	361.4	335.5	279.3	63.7	263.9	currently
2004	47.9	107.2	141.0	260.7	257.7	324.8	385.4	392.4	390.0	252.9	252.9	61.6	239.5	currently
2005	114.2	159.2	203.2	198.2	257.7	328.9	376.4	386.8	390.7	355.6	268.1	212.5	270.9	currently
2006	104.6	126.2	114.8	174.8	297.1	274.6	331.4	380.3	369.5	393.0	365.8	273.8	267.2	currently
2007	219.3	62.1	86.6	83.3	236.3	260.6	277.7	321.1	365.9	344.9	265.0	212.8	228.0	currently
2008	219.3	253.3	93.6	206.0	263.9	296.4	284.8	300.9	325.6	318.3	108.8	81.2	229.3	currently
2009	99.9	233.9	248.9	283.4	312.2	342.7	364.7	363.8	381.4	351.6	273.4	173.8	285.8	currently
2011	122.8	104.9	194.1	223.1	265.8	329.0	347.6	370.1	380.3	371.1	280.7	178.5	264.0	currently
2012	135.8	253.4	278.5	250.8	280.6	294.8	325.7	360.5	384.8	363.2	293.1	202.5	285.3	currently
2014	146.9	221.3	219.8	258.2	289.1	298.1	336.6	380.5	395.4	397.2	396.1	331.9	305.9	Tall
2015	261.3	82.9	252.1	281.9	305.1	342.9	371.3	381.6	393.3	398.3	389.0	261.5	310.1	Tall
2016	186.9	233.4	224.5	237.3	263.9	280.6	311.6	349.1	343.4	318.2	238.0	217.4	267.0	currently
2017	234.6	211.8	247.3	280.3	296.4	293.8	297.1	330.0	367.6	349.1	287.2	191.5	282.2	currently
2018	199.3	190.0	96.1	201.5	338.9	364.7	346.3	381.0	381.6	370.7	329.6	176.2	281.3	currently
2019	173.1	219.4	201.3	257.4	318.6	317.9	368.0	388.3	396.4	390.6	377.5	327.8	311.4	Tall
2020	194.4	111.5	240.0	316.5	329.3	340.4	355.8	351.1	361.6	350.1	282.2	179.6	284.4	currently
2021	89.7	138.7	237.3	267.9	319.4	318.5	328.3	355.9	328.8	337.8	288.5	233.8	270.4	currently
Average	148.8	154.5	192.5	239.4	296.5	318.4	340.6	361.1	371.6	350.7	287.2	190.2		
Rate	Low	Low	Low	currently	currently	Tall	Tall	Ekstrem	Ekstrem	Ekstrem	currently	Low		

Berdasarkan untuk rekapitulasi indeks kekeringan KBDI kondisi ekstrim per bulan selama 20 tahun dari tahun 2000 s/d 2021 didapatkan hasil bahwa indeks kekeringan KBDI kondisi ekstrim hanya terjadi pada bulan Mei s/d bulan September , dengan jumlah ekstrim tertinggi terjadi pada bulan September sebesar 472 mm. Indeks kekeringan KBDI menurun pada bulan Oktober s/d bulan Desember. Sedangkan pada bulan Januari s/d bulan Maret memiliki indeks kekeringan KBDI kondisi ekstrim 0.

Tabel 1 Tingkat Ekstrim Indeks Kekeringan Tiap Bulan

Tingkat Ekstrim Indeks Kekeringan Tiap Bulan													
T/B	Januari	Februari	Maret	April	Mei	Juni	Juli	Agustus	September	Oktober	November	Desember	Jumlah Perbulan
2000	0	0	0	0	2	0	11	0	25	19	0	0	57
2001	0	0	0	0	0	3	30	31	28	1	0	0	93
2002	0	0	0	0	8	22	12	31	17	8	0	0	98
2003	0	0	0	0	8	22	18	31	17	8	0	0	104
2004	0	0	0	0	0	5	23	31	30	31	3	0	123
2005	0	0	0	0	0	6	31	31	30	17	0	0	115
2006	0	0	0	0	0	0	11	28	30	31	22	11	133
2007	0	0	0	0	0	0	0	0	23	13	0	0	36
2008	0	0	0	0	0	0	0	0	2	3	0	0	5
2009	0	0	0	0	0	13	25	28	30	16	15	0	127
2011	0	0	0	0	0	7	16	31	30	27	0	0	111
2012	0	0	0	0	0	0	0	24	30	19	0	0	73
2014	0	0	0	0	0	0	9	31	30	31	30	4	135
2015	0	0	0	0	0	6	31	31	30	31	30	3	162
2016	0	0	0	0	0	0	0	17	8	0	0	0	25
2017	0	0	0	0	0	0	0	8	28	18	0	0	54
2018	0	0	0	0	14	25	13	31	30	26	9	0	148
2019	0	0	0	0	3	0	26	31	30	31	30	13	164
2020	0	0	0	6	4	3	26	19	24	22	0	0	104
2021	0	0	0	0	0	5	6	23	0	10	0	0	44
Jumlah Pertahun	0	0	0	6	39	117	288	457	472	362	139	31	

5. CONCLUSIONS AND SUGGESTIONS

The conclusion obtained from the analysis of the KBDI drought index modification of the physical properties of peat is that the drought level of an area, along with the distribution of hotspots in a site, can be determined using the KBDI drought index analysis. Acknowledgment this for FT ULM hydraulics laboratory and SINLITABMAS 2022.

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