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## HEALTH AND STUDY BOGOWONTO WATERSHED MANAGEMENT BASED ON HYDROLOGICAL INDICATORS

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### ABSTRACT:

The Bogowonto watershed was used as a research location because it is one of the largest watersheds with an area of 605.91 km<sup>2</sup> and has a sizeable contribution to the sustainability of water resources in Central Java Province. Watershed health assessment is intended to determine the level of health of the watershed by reviewing its watershed hydrological indicators based on the quantity of surface water. Relationship between indicators hydrology with the watershed health index described by the *power regression model*. Recommendations or directions watershed management planning priority scale from the results of an assessment of the appropriate watershed health level with PP RI No. 37 of 2012 concerning Watershed Management. The results of the analysis show that the health level of the Dodokan watershed from 2011 - 2020 is dominated by medium category. Connection watershed health index (IKD) with hydrological indicators yields which shows that the watershed health index is a function of hydrological indicators. watershed management planning recommended in the future is by: 1) the application of the technique soil and water conservation is carried out in order to maintain the continuity of the water catchment area, maintain the quality, quantity, continuity and distribution of water and 2) vegetation management is carried out in the context of conserving biodiversity, increasing land productivity, restoration ecosystem, rehabilitation and land reclamation.

**Keywords:** *Watershed Management, Water Supply, Indicators Hydrology*

### INTRODUCTION

Watershed (DAS) is a land area which is One unity with river and children

functioning river accommodate, store and drain the water that comes from it from bulk Rain to lake or sea in a manner

natural, limits on land is separator topography and maritime boundaries until with area still waters affected activity on land (Reg Republic of Indonesia Government No. 37 of 2012). Within the watershed there are various component like soil, vegetation, water, rivers, flora and fauna, buildings physical and human along mutual activity interact One each other, together compile unity ecosystem from upstream until with downstream of the watershed. it make the existence and function of the watershed becomes so important For support continuity life humans and creatures live in it.

One function main from the DAS is as water supplier with good quantity and quality especially for resident or residents in the area downstream. However from time to time, growth and development sufficient population rapidly cause enhancement need man will source water power. Fulfillment need resident will cause exploitation source Power natural in a manner superfluous which is not in accordance with ability. this tend cause over function land, more extent land critical, increasing critical watershed, illegal logging and the causes other give negative impact on watershed functions so result in occurrence decline watershed function periodically. circumstances cause watershed health to be deteriorate and make watershed function is not walk with ok. The watershed will not be healthy cause excess water (flood ) at the time

season rain and drought at times season drought.

Watershed health is tight term relation with watershed criticality or a parameter used For evaluate performance or watershed function already walk with Good or not yet. A watershed can said No Healthy or in circumstances critical if land experience degradation, system hydrology experience damage, ecosystem experience damage and welfare the watershed community is declining (Narendra et al., 2021). In other words the health of the watershed consists from a number of aspect that is aspect use land, aspect hydrology, aspect ecosystem and aspects socio-economic. (Asdak, 2007) views DAS as something ecosystem, so is monitoring and evaluation unit Because every There is input to in ecosystem the can evaluated processes that have been and are being going on with see the output of ecosystem the. The watershed area consists of from component Soil, vegetation and water play a role as processor. Producing monitoring and evaluation activities information about level the health of the watershed concerned in the system management applied Can looked at as diagnostic activity (Close, 2007).

Various monitoring indicator watershed performance that includes component biophysical, hydrological, social economy, investment building and

utilization watershed area space is effort collect and collect data and information needed For objective evaluation performance watershed management. Monitoring of indicator watershed performance done in a manner periodic in period time certain. Monitoring and evaluation watershed performance is very important For know level watershed health and beyond can used as bait come back repair planning watershed management to front.

Indonesian moment This Already own a number of guidelines related with monitoring and evaluation of the watershed in it containing stages and indicators used in identify watershed characteristics for watershed monitoring and evaluation needs. A number of guidelines the among them are 1) Directorate General of Forestry and River Basin Management Development Social No. 3 of 2013 concerning guidelines identification watershed characteristics, 2) System watershed planning and management by the Research and Development Agency Forestry, 3) Minister of Forestry No.P 61/MENHUT-II/2014 concerning monitoring and evaluation of watersheds (Jariyah, 2019), 4) PP RI No. 37 of 2012 concerning watershed management (Pambudi, 2019).

Guidelines the explain about the monitoring and evaluation of the watershed of various aspect like

biophysical, hydrological, social economy, investment building and utilization space. Although there is Lots aspect or possible indicator made size health a watershed, such as institutional parameters, regulatory parameters legislation, source parameters Power human, location parameters geographic, climatic parameters, and technological parameters, will but the water parameters are still is one of the most relevant inputs in the DAS model for know level the performance of the watershed, in particular if associated with function watershed hydrology (Directorate Forestry and Conservation Water Resources, 2010) (Chowdhury, 2010). Aspect or indicator hydrology can made diagnosis initial and alternative aspect assessment fast (rapid assessment) for evaluation condition or performance a watershed (Zawierucha et al., 2016); (Ritter & Muñoz-Carpena, 2013); (Carluer & De Marsily, 2004)

Based on a number of guidelines for watershed monitoring and evaluation (such as 1) Directorate General of Management of Watersheds and Forestry Social No. 3 of 2013 concerning guidelines identification watershed characteristics, 2) Regulation of the Ministry of Forestry of the Republic of Indonesia No. P39/2009 concerning Preparation Plan Watershed Management, 3 ) Permenhut No. P61/MENHUT-II/2014 (Nomor, n.d.) concerning Monitoring and Evaluation

watershed management ) indicators hydrology consists of the five parameters viz coefficient regime river (KRS), coefficient variation runoff (CV), index water use (IPA), index coefficient water storage (KSA), and type discharge index (IDJ) (Lestari et al., 2022).

Deteriorating watershed health Already become enough trouble serious in Indonesia. Based on data from the Ministry of Public Works and Public Housing (PUPR) in 2017 there were 22 critical watersheds scattered in 131 river basin units (SWS) throughout Indonesia and each SWS is found One or more watershed. Java Island which has many watersheds especially Central Java also do not escape from critical watershed problems in Indonesia. BPDAS Serayu Opaque Progo manage a total of 62 watersheds with working areas Central Java Province and the Special Region of Yogyakarta. one from DAS managed by BPDAS Serayu Opaque Progo namely the Bogowonto watershed. Bogowonto Watershed own enough contribution big For continuity source water resources in Central Java and the Special Region of Yogyakarta. But condition the worried will changed Because decline consequential watershed function enhancement land critical and condition hydrology in the Bogowonto watershed.

Related with description above so need done study about watershed health in the Bogowonto watershed, Central Java

– Yogyakarta Special Region. watershed health consists from a number of aspects, among others is aspect use land, aspect hydrology, aspect ecosystem and aspects social economy. In study This analysis watershed health intended For study characteristics watershed hydrology uses a number of aspect or indicator hydrology based on guidelines for watershed monitoring and evaluation in Indonesia and carried out development with add indicator hydrology in the form of a current environmental flow This start used by several developed and developing countries such as America, Australia, New Zealand, England, Cambodia, Cameroon, Zimbabwe and South Africa for Watershed Health assessment (Moore, 2004). Knowledge regarding relatively new environmental flow assessment (EFA) and new parameters need tried For implemented in Indonesia, especially at the location studies due to environmental discharge role in define and know Power support river For ecosystem around it, so suitable For made one indicator hydrology For determination watershed health. Result of calculation indicators hydrology later analyzed use method scoring For determine classification level watershed health and can made input or information in instruction planning watershed management on site research.

## RESEARCH METHODS

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One problem Bogowonto watershed environment is sedimentation. this suspected Because exists change use land to RTRW rules especially in the regions upstream that can reduce amount cover land. Condition the push happening erosion and sedimentation, will but study focused on sedimentation. Based background behind such, purpose in study This is study change use land in the Bogowonto watershed, evaluate change use land exist to the RTRW, examine impact change use land against the protected index environment and sedimentation, giving recommendation instruction function use right land For control sedimentation. The research method used covers before stage field, field, and after field. Stage before field is collect secondary data like RBI map 1990, map image Iconos 2009 year, map 2013 Landsat 8 imagery, maps and RTRW documents for districts in the watershed, and other data related to the Bogowonto watershed. Stage field form checking field use GPS devices, cameras, and equipment write write.

Retrieval technique sample on stage field use purposive sampling method. Stage after field is process data with using GIS and microsoft, then analyze based destination to be achieved. Results obtained that is change use occurring land in the 24 year period (1990-2014)

dominated change closing land that is decline wide forest protect of 618.26 ha and an increase wide moor of 1,141.97 ha. Change use land to RTRW directives consist of from category compatible 33,240.51 ha, no compatible of 20,730.32 ha, and not yet compatible of 5,726.50 ha.

Impact change use land against the protected index environment that is lower function protect area especially caused decline wide use land forest protect and upgrade wide use land moor. Change use land also impacts on sedimentation shown with exists sedimentation on yield interpretation image nor checking field. order sedimentation No Keep going continues, then recommendation instruction function use offered land is minimize incompatibility with push recovery function area protect and carry on with adjustment area cultivation. Key words : change use land, Bogowonto Watershed, Regional Spatial Plan, sedimentation, protected index environment.

## RESULTS AND DISCUSSION

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### Land use analysis of the Bogowonto watershed

The results of calculating the percentage of land cover by permanent vegetation (PPV) and changes in land use *are presented in Table 5.25 below.*

**Table 1**  
**PPV calculation results for the**  
**Bogowonto watershed**

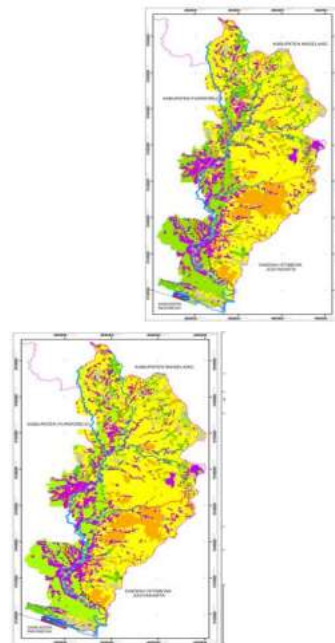
<b>Permane nt vegetati on type</b>	<b>Permane nt vegetati on area (LVP) (km2)</b>	<b>Watersh ed area (km2)</b>	<b>PPV (%)</b>
Forest	146.02	605.91	31.1 1
Shrubs	150.87	605.91	1.96
Plantatio n	58.05	605.91	66,9 4
<b>Amount</b>			<b>58,5 8</b>

The data used is land use data for the Bogowonto watershed in 2016 (BBWS Serayu Opak, 2016). From the results of the analysis, it was found that the area covered by permanent vegetation in the form of forests, plantations and shrubs (Ministry of Forestry, 2013) (Wahyunto & Dariah, 2014) was 354.94 km<sup>2</sup> or 58.58% of the total watershed area. The map of land use change (*landuse*) obtained from *Google Earth* is then cropped using the *Geographic Information System (GIS) arcMAP 10.2.2* based on the watershed boundaries that have been obtained and in accordance with the research location, namely the Bogowonto watershed.

Based on the Regulation of the Director General of Watershed Management

Development and Social Forestry Number: P.3/V-Set/2013 concerning Guidelines for the Identification of Watershed Characteristics, permanent vegetation is in the form of forests, plantations and shrubs. The three land covers are used as a reference in this study to see the extent of the catchment area and see its relation to the hydrological conditions in the Bogowonto watershed.

**Figure 1**  
**Bogowonto watershed *land use* map**



Quantitative data on changes in land use in the Bogowonto watershed were obtained from the Serayu Opak River Basin Office and were only available in 2013, due to limited data available. Quantitative data on land use change is used to see changes in land cover that become water catchment areas

(permanent cover vegetation) and settlements that can affect the hydrological conditions of the Bogowonto watershed. Changes in land use in the Bogowonto watershed over a span of several years. Changes in the land use of the Bogowonto Watershed from 2008 to 2013, especially in the permanent cover vegetation which became water catchment areas respectively, namely forest decreased 3.79%, plantations 3.79% and shrubs/shrubs decreased 1.77%. Land use in the form of settlements also increased by 7.91%.

**Table 2**  
**Land Change**

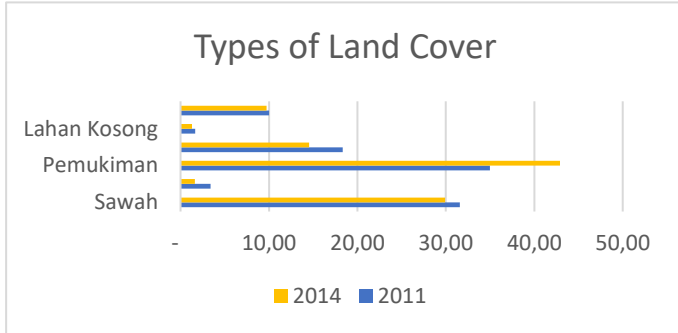
<i>Land use</i>	2011		2013		<i>Land use change</i>
	<i>Area (km<sup>2</sup>)</i>	<i>%</i>	<i>Area (km<sup>2</sup>)</i>	<i>%</i>	
Ricefield	191.47	31,6	181.29	29,92	1.68
Moor	20,60	3,3	9.88	1.63	1.77
Settlement	212.07	35	260.91	42.91	-7.91
Forests and Plantations	111.06	18.33	88,10	14.54	3.79
Empty land	10,12	1.67	7,82	1.29	0.38
Ponds and Lakes	60,59	10	58,83	9,71	0.29

<b>Total</b>	<b>605</b>	<b>10</b>	<b>605</b>	<b>10</b>
	<b>.91</b>	<b>0</b>	<b>.91</b>	<b>0</b>

**Source :** Results of BBWS Serayu Opak 2018 data analysis

According to (Asdak, 2014) and (de Mello et al., 2020) land use activities that change the landscape in a watershed can often affect water yields, especially vegetation management where forests as a regulator affect the timing and distribution of water flows. Other factors that affect runoff are soil, climate and percentage of watershed area. The greater the change in land use, the greater the runoff that occurs. Changes in land use in the Bogowonto watershed indicate a change in hydrological conditions in the Bogowonto watershed, whereby the reduced percentage of permanent cover vegetation areas and the increase in residential areas can indicate the amount of runoff that occurs as a result of rain falling on the surface and causing a large amount of discharge in the watershed. river due to surface runoff that returns to the river. This is evidenced by the KRS and IDJ values of the Bogowonto watershed which increased from 2011-2014 respectively by 88.65 to 834.6 and 0.006 to 0.010. The area of permanent vegetation land cover is expected to decrease every year in line with population growth in the Bogowonto watershed.

**Figure 2**  
**Land use changes in the Bogowonto watershed in 2011 and 2014**



provides a priority order of the weight values of each indicator based on certain considerations by going through three stages, namely pairwise comparisons which were previously preceded by an assessment for each hydrological indicator, then prioritized synthesis and finally the consistency test.

**Weighting analysis with the *Analytical Hierarchy Process method***

The weighting analysis of each hydrological indicator uses the *analytical hierarchy process* (AHP) method. The AHP

**Table 3**

Comparison matrix for each indicator

Factor	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq	EF
KSA	1.00	3.00	4.00	4.00	4.00	3.00	2.00	3.00	3.00
IPA	0.33	1.00	3.00	4.00	3.00	3.00	3.00	3.00	4.00
KRS	0.25	0.33	1.00	4.00	3.00	3.00	2.00	3.00	3.00
PPV	0.25	0.25	0.25	1.00	4.00	3.00	3.00	3.00	3.00
KAT	0.25	0.33	0.33	0.25	1.00	2.00	2.00	2.00	2.00
CV	0.33	0.33	0.33	0.33	0.50	1.00	2.00	2.00	2.00
IDJ	0.50	0.33	0.50	0.33	0.50	0.50	1.00	1.00	1.00
freq	0.33	0.33	0.33	0.33	0.50	0.50	1.00	1.00	1.00
EF	0.33	0.25	0.33	0.33	0.50	0.50	1.00	1.00	1.00
Total	3.58	6,17	10.08	14.58	17.00	16.50	17.00	19.00	20.00

Comparisons are made based on the policy of the decision maker by assessing the level of importance of each indicator to one another. The process of starting a pairwise comparison of each indicator is from the highest hierarchical level to select indicators, then the elements are compared.

In this study the assessment of the scale of importance was based on the results of previous research from (Sheikh et al., 2006) by producing KSA, IPA, KRS and PPV indicators that have a close relationship and are used as indicators that can be used as hydrological indicators

for early diagnosis of watershed health in the main rivers in Java Island. Therefore the KSA, IPA KRS, and PPV indicators are given a number scale of 4 which is larger than the other indicator number scales. One indicator compared to itself is given a value of 1. If indicator x compared to indicator y produces a certain value, then if indicator y is compared to indicator x it is the opposite value. The next stage is to make the normalization decision matrix that is presented.

**Table 4**

**Normalization decision matrix**

<b>Factor</b>	<b>KSA</b>	<b>IPA</b>	<b>KRS</b>	<b>PPV</b>	<b>KAT</b>	<b>CV</b>	<b>IDJ</b>	<b>freq</b>	<b>EF</b>
KSA	0.28	0.49	0.40	0.27	0.24	0.18	0.12	0.16	0.15
IPA	0.09	0.16	0.30	0.27	0.18	0.18	0.18	0.16	0.20
KRS	0.07	0.05	0.10	0.27	0.18	0.18	0.12	0.16	0.15
PPV	0.07	0.04	0.02	0.07	0.24	0.18	0.18	0.16	0.15
KAT	0.07	0.05	0.03	0.02	0.06	0.12	0.12	0.11	0.10
CV	0.09	0.05	0.03	0.02	0.03	0.06	0.12	0.11	0.10
IDJ	0.14	0.05	0.05	0.02	0.03	0.03	0.06	0.05	0.05
freq	0.09	0.05	0.03	0.02	0.03	0.03	0.06	0.05	0.05
EF	0.09	0.04	0.03	0.02	0.03	0.03	0.06	0.05	0.05
<b>Total</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>

The normalization matrix is obtained by dividing the number scale of each indicator

by the total number scale of the indicators vertically (each column). The next stage is weighting with the AHP method.

**Table 5**  
**Weighting with AHP method**

Factor	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq	EF	Total	EV*
	1	2	3	4	5	6	7	8	9	10 = 1+ to 9	$\frac{11 = 10}{9}$
KSA	0.28	0.49	0.40	0.27	0.24	0.18	0.12	0.16	0.15	2,28	0.25
IPA	0.09	0.16	0.30	0.27	0.18	0.18	0.18	0.16	0.20	1.72	0.19
KRS	0.07	0.05	0.10	0.27	0.18	0.18	0.12	0.16	0.15	1.28	0.14
PPV	0.07	0.04	0.02	0.07	0.24	0.18	0.18	0.16	0.15	1.11	0.12
KAT	0.07	0.05	0.03	0.02	0.06	0.12	0.12	0.11	0.10	0.68	0.08
CV	0.09	0.05	0.03	0.02	0.03	0.06	0.12	0.11	0.10	0.62	0.07
IDJ	0.14	0.05	0.05	0.02	0.03	0.03	0.06	0.05	0.05	0.49	0.05
freq	0.09	0.05	0.03	0.02	0.03	0.03	0.06	0.05	0.05	0.42	0.05
EF	0.09	0.04	0.03	0.02	0.03	0.03	0.06	0.05	0.05	0.41	0.05
<b>Total</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>1.00</b>	<b>9.00</b>	<b>1.00</b>

The total value is obtained from the sum of the number scales horizontally (each row). Then the total value of the indicators for each row is added up so that the sum is used as the denominator. The result of the total number scale for each indicator is divided by the total result of the sum of the total number scale results for each indicator. The result of this division is called *the Egen Vector (EV)* which will later become the weight of

each hydrological indicator. The weight of each indicator is multiplied by 100% so that the weight value is expressed in percentage form (**Table 5.30**). After that, a consistency test was carried out with the condition that  $CR < 0.1$  (Figure 20).

**Table 6**  
**The results of the weighting of each indicator**

Indicator	EV	Weight
KSA	0.25	25%
IPA	0.19	19%
KRS	0.14	14%
PPV	0.12	12%
KAT	0.08	8%
CV	0.07	7%
IDJ	0.05	5%
freq	0.05	5%
EF	0.05	5%

From the multiplication of the number scale for each indicator with the weight, the  $\lambda$  *max value* is 10.44, so using Equation (3.18) and Equation (3.19) we get a CI value of 0.18 and a CR value of 0.12. That means the value of each hydrological indicator weight is said to be consistent because  $CR < 0.1$ .

*range* of the health level of the Bogowonto watershed can be known after the results obtained from the weighting

analysis using the AHP method. The calculation of the class *range* for the health level of the Bogowonto watershed is based on previous research from Nugroho (2010) who tried to carry out a simulation by multiplying the categorization values namely bad (1), moderate (2), and healthy (3) with the weight of each indicator so as to produce IKD from three categories with category determination is based on the assumption that the resulting scores are normally distributed. The normal curve consists of 6 standard deviations (Setyowati & Qomariyah, 2022). Furthermore, the upper and lower limits of the watershed health class *range* are determined from the simulation calculation results in the following way (Atrizka et al., 2022).

Low (Poor)	$X < M - 1SD$
Currently	$M - 1SD \leq X \leq M + 1SD$
High (Good)	$X \geq M + 1SD$

Description: 1) M: *mean* ; 2) SD: standard deviation

**Table 7**  
**Calculation of the range of watershed health level classes**

(Indicator value x weight) /total weight *100	Hydrological indicator										Water shed Health h	Water shed health level class range	Watershed health level
	KS A	IPA	KRS	PP V	KAT	CV	IDJ	fre q	EF				
	25 %	19 %	14 %	12 %	8%	7%	5%	5%	5%				
Bad	1	25, 32	19, 11	14, 23	12, 28	7,5 2	6,8 4	5,4 1	4,7 1	4,56	100	IKD<150	Bad
Currently	2	50, 65	38, 21	28, 47	24, 56	15, 04	13, 69	10, 83	9,4 3	9,13	200	150≤IKD<250	Currently
Good	3	75, 97	57, 32	42, 70	36, 84	22, 57	20, 53	16, 24	14, 14	13,6 9	300	IKD≥250	Good

The soundness class of the Bogowonto watershed is presented in Table 5.32 below. The Bogowonto watershed health class is used as a reference to determine the health level of the watershed according to the results of the scoring analysis.

**Table 8**  
**Bogowonto watershed health level class**

Watershed health level class range	Watershed health level
IKD<150	Bad
150≤IKD<250	Currently

IKD≥250	Good
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**Scoring analysis for watershed soundness classification**

The scoring analysis was carried out based on an assessment of the health level of the Bogowonto watershed which was divided into two, namely an annual analysis of the health of the watershed to see changes in the health of the watershed from year to year and as a whole using the average value of each hydrological indicator calculation result from 2011 to 2020. Values and categories use good/healthy (3), moderate (2), and bad/unhealthy (1).

The results of the annual scoring analysis show that the health condition of the Bogowonto watershed tends to change. However, the level of health is dominated by the moderate category. The results of the overall scoring analysis for the Bogowonto watershed produced a score watershed health level (IKD) of 188.14. This shows that level the health of the Bogowonto watershed is in the moderate category. The soundness level of the Bogowonto watershed is in the moderate

category indicating that from a hydrological perspective the conditions are The Bogowonto watershed still needs further watershed management planning to restore the condition of the watershed so that later it is hoped that it can change the condition of the Bogowonto watershed from moderate to good. Health Diagnostics regularly can be done within a span of 10 years.

**Table 9**  
**The results of the analysis of each indicator every year**

Year	The results of the analysis of each indicator									EF
	KSA	IPA	KRS	PPV	KAT	CV	IDJ	Frequency		
								Flood	Drought	
2011	0.002419	1.36	88.65	58,58	0.054	20.99	0.006	2 times	Never	0.08
2012	0.000921	0.50	546,69	58,58	0.054	46.55	0.007	Never	Never	0.09
2013	0.001969	0.05	403.78	58,58	0.055	35.79	0.009	3 times	Never	0.09
2014	0.000953	0.41	834.6	58,58	0.051	36.96	0.010	5 times	Never	0.09
2015	0	0.39	0	58,58	0.051	47,31	0.010	8 times	Never	0.10
2016	0.00103	0.29	386.30	58,58	0.047	21.40	0.010	2 times	Never	0.10
2017	0.002613	0.57	140,44	58,58	0.064	29,51	0.010	Never	Never	0.11
2018	0.001104	0.05	306.06	58,58	0.059	26,19	0.011	Never	Never	0.11
2019	0.002881	0.60	110.25	58,58	0.059	41.88	0.011	23 times	Never	0.12
2020	0.002901	0.39	0	58,58	0.060	42,17	0.011	Never	Never	0.12

**Table 10**  
**The results of the evaluation of the categorization of each indicator**

Year	Categorization of each indicator									
	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq		EF
								Flood	Drought	
2011	1	1	1	2	3	2	3	3	3	1
2012	1	2	1	2	3	1	3	3	3	1
2013	1	3	1	2	3	1	3	2	3	1
2014	1	2	1	2	3	1	3	2	3	1
2015	1	2	3	2	3	1	3	2	3	1
2016	1	2	1	2	3	2	3	2	3	1
2017	1	2	1	2	3	2	3	3	3	1
2018	1	3	1	2	3	2	3	3	3	1
2019	1	2	1	2	3	1	3	1	3	1
2020	1	2	3	2	3	1	3	3	3	1

Description: good/healthy (3), moderate (2), and bad/sick (1)

**Table 11**  
**Results of scoring the health level of the Bogowonto watershed**

Year	Score each indicator										IKD score	Watershed health level
	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq		EF		
								Flood	Drought			
2011	25.35	19,11	14,23	24.56	22.57	13.69	16,24	14,14	14,14	4.56	168.59	Currently
2012	25.35	38,21	14,23	24.56	22.57	6,84	16,24	14,14	14,14	4.56	180.84	Currently

2013	25.35	57,32	14,23	24.56	22.57	6,84	16,24	9,43	14,14	4.56	195,24	Currentl y
2014	25.35	38,21	14,23	24.56	22.57	6,84	16,24	9,43	14,14	4.56	176,13	Currentl y
2015	25.35	38,21	42.70	24.56	22.57	6,84	16,24	9,43	14,14	4.56	204,6	Currentl y
2016	25.35	38,21	14,23	24.56	22.57	13.69	16,24	9,43	14,14	4.56	182.98	Currentl y
2017	25.35	38,21	14,23	24.56	22.57	13.69	16,24	14,14	14,14	4.56	187,69	Currentl y
2018	25.35	57,32	14,23	24.56	22.57	6,84	16,24	14,14	14,14	4.56	199.95	Currentl y
2019	25.35	38,21	14,23	24.56	22.57	6,84	16,24	4.71	14,14	4.56	176,13	Currentl y
2020	25.35	38,21	42.70	24.56	22.57	6,84	16,24	14,14	14,14	4.56	209,31	Currentl y

**Table 12**  
**Results of analysis of each indicator for the whole year (2011 – 2020)**

watershed	The results of the analysis of each indicator									
	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq. Flood	freq. Drought	EF
Bogowonto	0.001	0.461	281.67	58,58	0.055	34,87	0.009	More than 2 times	Never	0.1

**Table 13**

The results of the evaluation of the categorization of each indicator

watershed	Categorization of each indicator									
	KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq. Flood	freq. Drought	EF
Bogowonto	1	2	1	2	3	1	3	2	3	1

**Table 14**

The weight of each indicator

KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq. Flood	freq. Drought	EF	Amount
25%	19%	14%	12%	8%	7%	5%	2.5%	2.5%	5%	100%

**Table 15**

The results of the scoring analysis of the health level of the Bogowonto watershed

Scoring Each Indicator										Score	Watershed
KSA	IPA	KRS	PPV	KAT	CV	IDJ	freq. Flood	freq. Drought	EF	(IKD)	health level
25.35	40,12	19,92	24.56	22.57	8.89	16,24	11.78	14,14	4.56	188,14	Currently

**Analysis of the relationship between hydrological indicators and the watershed health score or index**

Analysis of the relationship between hydrological indicators and the watershed health index is carried out every year to determine the effect or interest of hydrological indicators on the level of watershed health. In addition, this

analysis also provides information about indicators that can be ignored or not used in assessing watershed health and indicators that are sensitive or in other words have a high level of importance in influencing watershed health conditions. Related information can be used to determine the physical condition of the watershed and physical treatment that

can be carried out to address problems related to the hydrological characteristics of the watershed. These indicators can be

used as a *rapid assessment* or quick fingerprint in a watershed health assessment.

**Correlations**

			IKD
Spearman's rho	KSA	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10
IPA	IPA	Correlation Coefficient	.541
		Sig. (2-tailed)	.106
		N	10
KRS	KRS	Correlation Coefficient	.698*
		Sig. (2-tailed)	.025
		N	10
PPV	PPV	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10
KAT	KAT	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10
CV	CV	Correlation Coefficient	-.343
		Sig. (2-tailed)	.332
		N	10
IDJ	IDJ	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10
Banjir	Banjir	Correlation Coefficient	.105
		Sig. (2-tailed)	.773
		N	10
Kekeringan	Kekeringan	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10
EF	EF	Correlation Coefficient	.
		Sig. (2-tailed)	.
		N	10

\*. Correlation is significant at the 0.05 level (2-tailed).

**Table 16**  
**Correlation results using the SPSS method**

Variable	Mean ± SD	Median (min – max)	p.s
Indicator hydrology			
KSA	25.35	25.35	–
IPA	40.12 ± 10.85	38.21 (19.11 – 57.32)	0.004
KRS	19.92 ± 12.00	14.23 (14.23 – 42.70)	0.000
PPV	24.56	24.56	–
KAT	22.57	22.57	–
CV	8.90 ± 3.31	6.84 (6.84 – 13.69)	0.000
IDJ	16,24	16,24	–
Flood	11.79 ± 2.48	11.79 (9.43 – 14.14)	0.000
Drought	14,14	14,14	
EF	4.56	4.56	
IKD	188.15 ± 13.58	185.34 (168.59 – 209.31)	0.715*

Description : \* Normal ( $p > 0.05$ )  
 From the normality test results distributed data not normal, so For then test the relationship indicator hydrology

to level watershed health using a correlation test spearman's.

Table of results of Spearman's correlation test of hydrological indicators on the level of watershed health

Indicator Hydrology	Watershed Health Level		Information
	p.s	r	
KSA	–	–	–

IPA	0.106	0.541	Not significant
KRS	0.025	0.698	Significant, positive, strong
PPV	–	–	–
KAT	–	–	–
CV	0.332	-0.343	Not significant
IDJ	–	–	–
Flood	0.773	0.105	Not significant
Drought	–	–	–
EF	–	–	–

From the results of testing the relationship between hydrological indicators on the soundness of the watershed using the Spearman's correlation test on the KRS indicator, it was obtained that the value of  $p = 0.025$  and the value of  $r = 0.698$ , so that it can be concluded that the KRS indicator on the level of soundness of the watershed has a significant relationship with the direction and strength of a strong positive relationship.

**Directions for the priority scale of watershed management planning**

Watershed health assessment analysis is one way to identify problems in the Bogowonto watershed. Paimin *et al* (2002) explained that the steps taken to identify problems are by understanding the characteristics of the watershed, in

this case the characteristics of the watershed are focused on the hydrological characteristics of the watershed and by knowing the potential vulnerability of the watershed. From a hydrological perspective, the identification of problems related to watershed health in the Bogowonto watershed is regarding the quantity and continuity of surface runoff. The problems found from the results of the Bogowonto watershed health assessment analysis are as follows.

- a. There is no continuity of water flow and the ability of the land to store rainwater and release water is low;
- b. The minimum debit or minimum *storage* of rivers in the Bogowonto watershed during the dry season is

relatively high so there is minimal drought;

- c. The condition of the Bogowonto watershed is less stable, this is caused by changes in land use and/or water use patterns in the Bogowonto watershed.
- d. The highest flood events occurred in 2019 which occurred in Purwodadi District, Purworejo Regency. This is due to several factors such as land cover by permanent vegetation which decreases every year, floods sent during the rainy season from the upstream Bogowonto watershed to the downstream of the Bogowonto watershed so that it often causes water overflow in the Bogowonto watershed.

From the description of the results of problem identification that occurred in the Bogowonto watershed above, the results of the relationship between hydrological indicators and the watershed health index (IKD) can be used to guide priority scales for handling these problems by planning watershed management. In accordance with the description above with reference to PP RI No. 37 of 2012 concerning watershed management, physically there are several directions for watershed management which are formulated as below.

- a. Optimization of land use according to the function and carrying capacity of the region

- b. The application of soil and water conservation techniques is carried out in the context of maintaining the continuity of the water catchment area, maintaining the quality, quantity, continuity and distribution of water.
- c. Vegetation management is carried out in the context of conserving biodiversity, increasing land productivity, ecosystem restoration, rehabilitation and land reclamation.
- d. Increased awareness and participation of related agencies in watershed management, and/or

Development of watershed management institutions to improve coordination, integration, synchronization and synergy across sectors and administrative areas.

The recommended planning directions for the management of the Bogowonto watershed in accordance with the problems that occur are points b and c, including:

1. The application of soil and water conservation techniques is carried out in the context of controlling floods and carrying out several methods such as: 1) soil conservation: selection of vegetation for land cover, erosion prevention, salt content regulation, acidity control, increasing the preservation of beneficial soil organisms, contour tillage, crop rotation, use of natural fertilizers, while for 2) water conservation can be done

in ways such as increasing the preservation and protection of water resources, water-saving programs, making water reservoirs, determining water usage rates, forming water resources management institutions, protecting forest ecosystems, making biopores and making infiltration wells (Reij et al., 2013).

## **CONCLUSION**

From the results of the analysis of watershed health assessment based on hydrological indicators in the Bogowonto watershed, it can be concluded that the health level of the Bogowonto watershed from 2011 – 2020 is dominated by the moderate category. Watershed health indicators only apply under normal conditions, but if there are external factors that exceed the carrying capacity of the watershed then the interpretation or results of the indicators on watershed health are invalid or invalid. The health condition of the Bogowonto watershed can change if there are certain external factors or additional loads that interfere with the resilience of the watershed's carrying capacity.

The recommended planning directions are carried out in several ways, namely: 1. Application of soil and water conservation techniques is carried out in order to maintain the continuity of the water catchment area, maintain the quality, quantity, continuity and

Vegetation management is carried out in the context of conserving biodiversity, increasing land productivity, ecosystem restoration, land rehabilitation and reclamation. Vegetation management can be done by managing forests and terrestrial (surface) vegetation types such as trees which have the function of production and protection of soil and water (Calder, 2012)

distribution of water by carrying out flood control by constructing ponds, controlling dams floods, and construction of infiltration wells and in several ways such as: a) soil conservation can be done by selecting land cover vegetation, preventing erosion, regulating salinity, controlling acidity, increasing the preservation of beneficial soil organisms, cultivating contoured soil, crop rotation, using natural fertilizer. Whereas for b) water conservation can be carried out in ways such as increasing the preservation and protection of water resources, saving water programs, making water reservoirs, determining water usage rates, forming water resources management institutions, protecting forest ecosystems, making biopores and making absorption wells and 2. Vegetation management is carried out in the framework of conserving biodiversity, increasing land productivity, ecosystem restoration, land rehabilitation and reclamation.

## BIBLIOGRAPHY

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- Asdak, C. (2007). *Hydrology and watershed management* (Yogyakarta. Gajah Mada University Press.
- Asdak, C. (2014). *Hydrology and Watershed Management (in Bahasa)*. Gadjah Mada University Press. Yogyakarta.
- Atrizka, D., Tanoto, S., Steven, S., Fransisca, V., & Vania, V. (2022). Work Motivation Reviewed From Job Satisfaction and Psychological Contracts in Employees. *Budapest International Research and Critics Institute-Journal (BIRCI-Journal)*, 5(1), 1669–1677.
- Calder, I. (2012). *Blue revolution: Integrated land and water resources management*. Routledge.
- Carluer, N., & De Marsily, G. (2004). Assessment and modelling of the influence of man-made networks on the hydrology of a small watershed: implications for fast flow components, water quality and landscape management. *Journal of Hydrology*, 285(1–4), 76–95.
- Chowdhury, N. T. (2010). Water management in Bangladesh: an analytical review. *Water Policy*, 12(1), 32–51.
- Close, E. B. (2007). *Forest productivity in naturally saline landscapes of Alberta's boreal forest*.
- de Mello, K., Taniwaki, R. H., de Paula, F. R., Valente, R. A., Randhir, T. O., Macedo, D. R., Leal, C. G., Rodrigues, C. B., & Hughes, R. M. (2020). Multiscale land use impacts on water quality: Assessment, planning, and future perspectives in Brazil. *Journal of Environmental Management*, 270, 110879.
- Jariyah, N. A. (2019). EVALUATION OF SOCIO ECONOMIC PERFORMANCE OF THE BRANTAS WATERSHED BASED ON APLICATION OF P 61/MENHUT-II/2014. *Jurnal Penelitian Sosial Dan Ekonomi Kehutanan*, 16(2), 95–114.
- Lestari, R., Nugroho, R., Juwandi, J., & Afandi, S. A. (2022). Stakeholder Analysis Dalam Perumusan Kebijakan Pengelolaan Daerah Aliran Sungai Di Provinsi Riau. *Academia Praja: Jurnal Ilmu Politik, Pemerintahan, Dan Administrasi Publik*, 5(2), 250–261.
- Moore, M. (2004). *Perceptions and interpretations of" environmental flows" and implications for future water resource management: A survey study*.
- Narendra, B. H., Siregar, C. A., Dharmawan, I. W. S., Sukmana, A., Pratiwi, Pramono, I. B., Basuki, T. M., Nugroho, H. Y. S. H., Supangat, A. B., & Purwanto. (2021). A review on sustainability of watershed management in Indonesia. *Sustainability*, 13(19), 11125.
- Nomor, P. M. K. R. I. (n.d.). *P. 61/Menhut-II/2014 Tentang Monitoring dan Evaluasi Pengelolaan Daerah Aliran Sungai*. Jakarta.
- Pambudi, A. S. (2019). Watershed management in Indonesia: A regulation, institution, and policy review. *Jurnal Perencanaan Pembangunan: The Indonesian Journal of Development Planning*, Asian Journal of Engineering, Social and Health

- 3(2), 185–202.
- Reij, C., Scoones, I., & Toulmin, C. (2013). *Sustaining the soil: indigenous soil and water conservation in Africa*. Routledge.
- Ritter, A., & Muñoz-Carpena, R. (2013). Performance evaluation of hydrological models: Statistical significance for reducing subjectivity in goodness-of-fit assessments. *Journal of Hydrology*, 480, 33–45.
- Setyowati, E., & Qomariyah, D. N. (2022). The Effect of Religiosity on Forgiveness of Married Individuals. *International Research Journal of Advanced Engineering and Science*, 7(2), 109–115.
- Sheikh, H. R., Sabir, M. F., & Bovik, A. C. (2006). A statistical evaluation of recent full reference image quality assessment algorithms. *IEEE Transactions on Image Processing*, 15(11), 3440–3451.
- Wahyunto, W., & Dariah, A. (2014). *Degradasi lahan di Indonesia: Kondisi existing, karakteristik, dan penyeragaman definisi mendukung gerakan menuju satu peta*.
- Zawierucha, I., Kozłowski, C., & Malina, G. (2016). Immobilized materials for removal of toxic metal ions from surface/groundwaters and aqueous waste streams. *Environmental Science: Processes & Impacts*, 18(4), 429–444.
- Arsyad, S. 1989. *Soil and Water Conservation*. Bogor: Bogor Agricultural Institute
- Asdak, C. 1995. *Hydrology and Watershed Management*. Yogyakarta: Gadjah Mada University Press.
- Asdak, C. 2014. *Hydrology and Watershed Management*. Gadjah Mada University Press, Yogyakarta.
- Azwar, S. 2012. *Preparation of the 2nd edition of the Psychological Scale*. Yogyakarta: Student Libraries
- North Maluku River Region Office. 2017. *Final Report on the Preparation of North Halmahera WS Water Balance Scale 1: 50,000*. North Maluku: North Maluku River Basin Office Work Unit

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