Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 13, No. 3, p. 48-55, 2018
http://www.innspub.net

INNSPUB
RESEARCH PAPER
OPEN ACCESS

Health evaluation of Kedangpahu watershed in relation to flood problem at Kutai Barat Regency

Suparjo[1*], Muhammad Sumaryono[2], Marjenah[2], Sigit Hardwinarto[2]

[1]*ForestryScience Doctoral Program, Forestry Faculty of Mulawarman University, Jl. Ki Hajar Dewantara, Gunung Kelua Campus, Samarinda 75123, East Kalimantan, Indonesia*

[2]*Forestry Faculty of Mulawarman University, Jl. Ki Hajar Dewantara, Gunung Kelua Campus, Samarinda 75123, East Kalimantan, Indonesia*

Article published on September 13, 2018

Key words: Health evaluation, Flood, Kedangpahu Watershed, Geographic Information System (GIS).

Abstract

Increasing occurrence of flood is one of the watershed degradation indicators. Since the causes of watershed degradation identified, restoration was one of the ways to return the balance of watershed ecosystem. Before it's held, the first step that must be done was identifying watershed characteristics and health evaluation. Kedangpahu watershed is located in Kutai Barat Regency, East Kalimantan, covering 698.952 hectares area. The problems of this watershed were the increasing of flood frequency and its duration. The aim of the research was to justify Kedangpahu watershed health status. Method of study was using Geographic Information System (GIS). The first step of the study was identifying its bio-physic elements. The study showed that 63.19 % of total area had slightly slope. Average annual precipitation is between 826.9 - 3886,6 mm/year. High precipitation occurs on December, January, April and May. The water regime index, 2.34, is classified as in moderate category, meanwhile the average annual discharge tends to increase year by year. The dissolved sediment concentration is 31.75 mg/l. Some land cover areas were converted to palm oil plantation and mining. Based on land use planning map, 53 % of total areas are located at conversion area, in Indonesia called *Areal Penggunaan Lain* (APL). It can be concluded that Kedangpahu watershed health status is in moderate category.

***Corresponding Author:** Suparjo ✉ Suparjowd@gmail.com

Introduction

Different aspect of land degradation assessments will pay attention to land degradation Indicators (Nachtergaele *et al.*, 2013). Flood, soil erosion, sedimentation, landslide are the problems of watershed in all areas in Indonesia. These are the indicators of watershed degradation. To overcome these problems, commonly restoration method is the best alternative. Restoration is the process to recover the structure, productivity and endemic biodiversity in a certain place (Setyawan *et al.*, 2004; Sudarmadji and Hartati, 2016). As an activity, restoration needs an evaluation to know its suitability with the planning or not.

The implementation of restoration in watershed is one of several cultivation system method that consider the importance of land sustainability (Supriyadi, 2014). Many things must be considered in conducting a restoration successfully such as land and site condition, indigenous people, and the involvement of local people. Before the restoration is held, the first step to take is identifying the watershed characteristics and evaluating the health. Some of watershed health indicators can be seen from its water regime index and flood intensity. Kedangpahu, one of the watersheds located in Kutai Barat Regency, East Kalimantan Province.

It covers 698,951 ha area. Kedangpahu watershed consists of seven sub watersheds namely Idan, Nyuatan, Nyahing, Lawa, Perak, Jelau and Kedangpahu sub watershed it self. There were some problems in this watershed as well as increasing of flood frequency and duration of flood, decreasing of water quality, sedimentation and migration of Pesut (*Orcaella brevirostris*) as endemic animal. Nowadays the flood occur in more than one week and rose higher than before. To solve the problems it needs evaluation of health condition, so the actions would be done suitably with the objective of restoration. Evaluation of environmental degradation and sustainability is a complex because it can not be measured directly. Several approaches have been proposed (e.g. to use indicator) to evaluate sustainability (Haileslassie, 2008). The aim of this research was to justify the health status of Kedangpahu watershed by studying its biophysics elements.

Materials and methods

Study area

The study was heldat Kedangpahu watershed in Kutai Barat Regency, East Kalimantan. The study area covered 698,952 ha. Geographically it was laid between 115°13'12" - 116°05'24"eastern and between 00°1'12" - 00°09'00"southern. Graphically, the study area could be seen at Fig. 1.

Procedures

The procedure of the research was conducted in the following steps:

Collecting of research data, particularly thematic maps namely soil map, rainfall map, land slope class map and land cover map from forestry ministry department of Indonesia, Landsat, Shuttle Radar Topographic Mission (SRTM), the last 10 year discharge data of Kedangpahu, precipitation data.

Geo-referencing maps and remote sensing data. These activity was done to refer the data until they suited the actual condition at the field. All data used in the study must have the same references.

Building of topographic map. From SRTM data, a contour map was built using Global Mapper 11 software.

Building of 3D map. A 3D map was built from the contour map using Global Mapper 11 software.

Building of watershed border. The border of watershed tracing the hilltop or mountain was digitized based on the 3D map.

Building of land slope map. The land slop map was generated from topographic map by using Arc View 33 software.

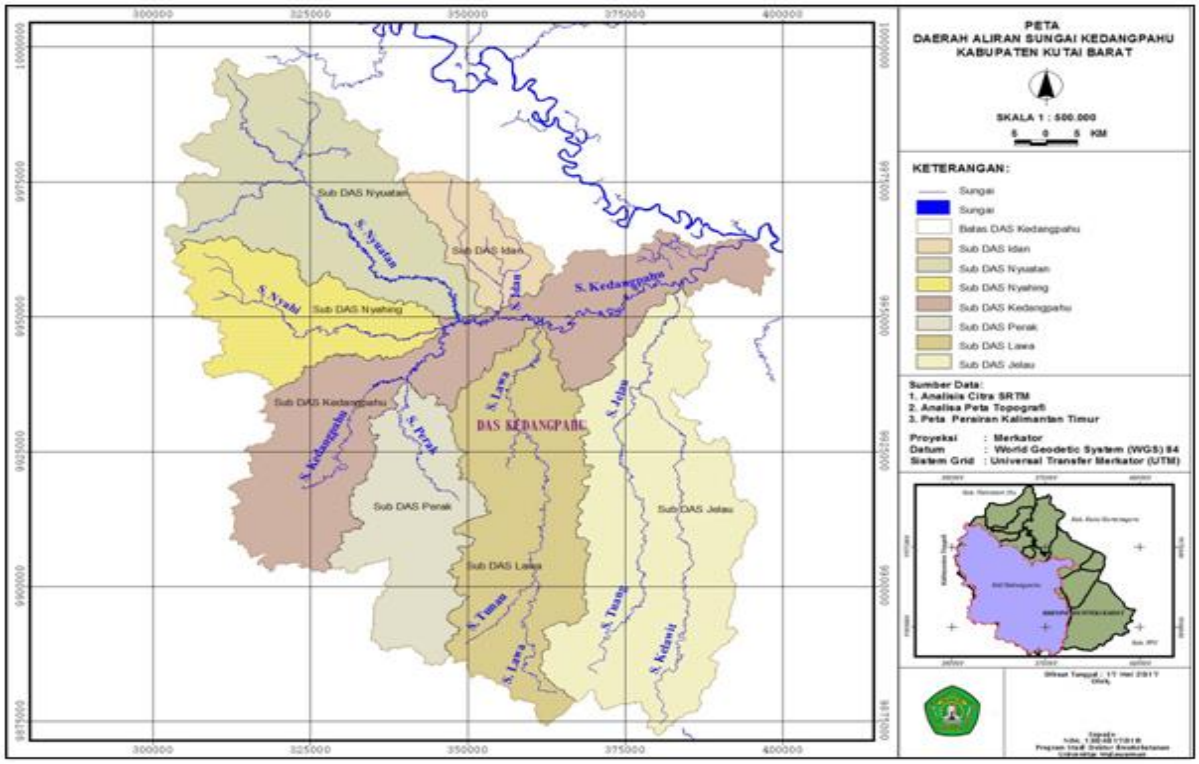


Fig. 1. Location of Kedangpahu Watershed.

Digitizing soil map, precipitation map and land used planning map. Those maps are raster format. The first step was geo-referencing all raster maps with *Rupa Bumi Indonesia* (RBI) map using Global Mapper 11. The next step was digitized using ArcView 33.

Classifying land cover of the study area based on remote sensing data. This map was verified to the field to build the actual land used map.

Scoring of all thematic maps. All elements of thematic maps were scored referring to BAPPLAN (Badan Planologi). Overlaying and scoring thematic maps to gain the critical stage hazard map.

Data analysis

Data of the research were analyzed by Geographic Information System (GIS) using ArcView 33.

The application of GIS also conducted by Hajam *et al.* (2013), to assess the goe-hydrological characteristics of Vishav drainage basin and identify the ground water potential zones through geo-morphometric specs. Field verification was conducted to match real information such as land cover/land used type, speed of water flow, water acidity, water temperature and total dissolve sediment. Based on the result of GIS analysis and field verification, the discussion was done and presented in the following section.

Results

Kedangpahu Watershed

Based on the delineation of SRTM data, it was known the total area of Kedangpahu watershed is 698,952 ha as indicated in Table 1.

It can be said that Kedangpahu watershed is the big watershed in East Kalimantan. If the rainfall is high in all over area of Kedangpahu the flood must occur in this area. It consists of seven sub watershed in succession; they are Idan 29,666.72 ha, Nyuatan 120,181.9 ha, Nyahing 64,083.09 ha, Kedangpahu 140,506.4 ha, Perak 70,540.69 ha, Lawa 113,654.42 ha, and Jelau 160,318.02 ha, graphically as shown in Figure 1. Jelau is the largest sub watershed among of them.

Table 1. Slope classes at the study area.

Slope class	Slope	Explanation	Area (ha)	Percentage %
1	0-2 %	Flat	38,554.4	5.52
2	2-8 %	Slope Slightly	441,686.6	63.19
3	8-15 %	Aslant Slightly	168,385.0	24.09
4	15-25 %	Aslant	42,743.8	6.12
5	25-40 %	Steep	6,545.6	0.94
6	>40 %	Very Steep	1,035.7	0.14
	Totals:		698,951.2	100,00

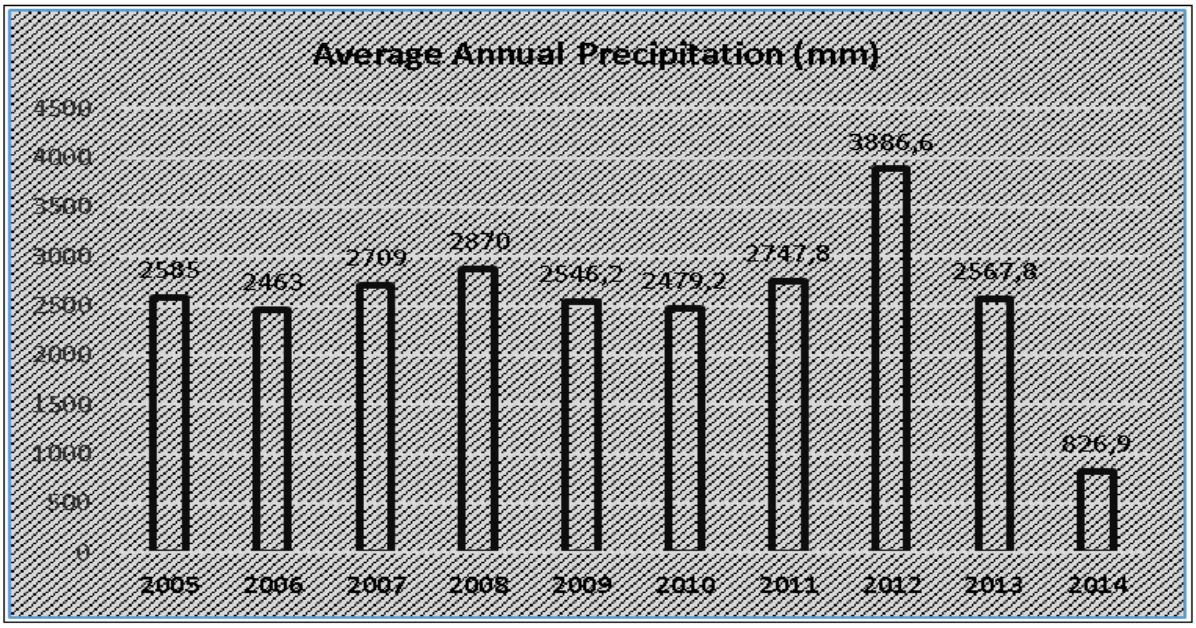
Source : Result of srtm analysis year of 2016.

Climate

Air temperature laid between 28,63ºC to 27,24ºC. The highest average relative humidity is 86.17% and the lowest 79.10%. Average precipitation is 2,568.2 mm/year with maximum 3,886.6 mm/year and minimum 826.9 mm/year as seen in Fig. 2. Base on this figure the highest one occur on the year of 2012. While monthly average precipitation could be seen in Fig. 3. Base on this figure the highest precipitation occur on December.

Based on the ratio of average dry month and average wet month, Q (Quotient) value was 31.15 %. This indicates that the area under study belongs to B type of climate.

This type of climate is corresponding to the statement of Koesnandar and Hardwinarto (2014).



Source of Data: River Area Bureau of Kalimantan III Year of 2015.

Fig. 2. Average annual precipitation.

Topography

Based on the result of topography analysis, the study area consists of vary slope classes from flat to very steep. The slope classes condition can be seen in Table 1.

Based on the Table 1, it can be seen that majority topographic condition at the study area is slope

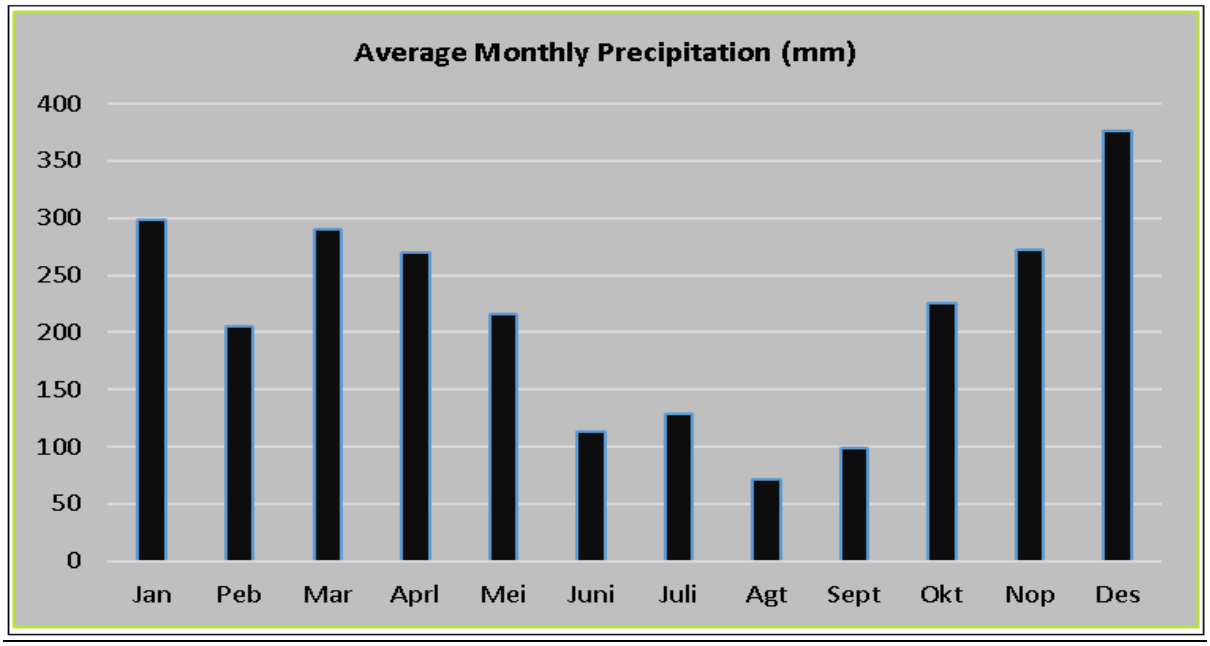
slightly. It's 63.19 % of total area or 441,686.6 ha. Asdak (2007) stated that generally the upper side of watershed has steep and very steep slope. But in fact majority of Kedangpahu watershed has slightly slope. This condition caused the flood occur in the study are run in long period because of the slow of stream flow.

Soil type

Based on soil map of Bogor soil research center, soil type at the study area consists of peat, heap, structural and volcanic. In succession they were peat: 4,806.26 ha, heap: 21,520.02 ha, structural: 568,314.11 ha and volcanic: 104,310.81 ha. The characteristic of those soils are erodible. Soil mass transported to the stream caused the shallow of the stream.

Consideration of Land Used Planning

Based on the consideration of land used planning the study area consists of forest conservation 20,822.4 ha, limited production forest 109,224.65 ha, production forest 159,917.98 ha, conversion production forest 9,062.35 ha, another using area 370,176.91 ha, natural conservation area 1,677.93 ha, water body 337.78 ha and other 27,731.16 ha.



Source of Data: River Area Bureau of Kalimantan III Year of 2015.

Fig. 3. Average monthly precipitation.

Rate Flow of Kedangpahu River

Discharge of Kedangpahu river for ten years later lays from 355.5 m^3 to 610.6 m^3. Water regime index reaches 2.34 for 10 years later.

In general the condition of discharge can be seen at Figure 4. According to Figure 4 the discharge of Kedangpahu river tend to increase from year by year from 2004 to the year of 2014. While from Figure 3 could be seen the highest precipitation occurred at December. It means that the flood possibility occurred in December too.

Flood Intervals

The information from local community shows that the interval of flood hazard becomes shorter and shorter. At the year of 1980th flood hazard occur once in 7 to 8 years, at 2000th occur in about every 5 years. But recently flood hazard takes place every year. Beside that, duration of flood occurs in longer time, more than one week.

Water physic measurement indicates that total dissolve sediment (TDS) isaround 22-44 mg/l, temperature around 26 - 27.8 ^{o}C, while water chemise measurement indicates acidity around 5.5 - 6.5 and dissolve oxygen 1.25-2.5 mg/l.

Discussion

According to the results presented above, it can be said that Kedangpahu watershed covers a very large area of 698,952 ha which results in high quality of this river discharge. Geographically, the position is near the equator which means that precipitation at the study area is high with the average precipitation reaches 2,568.2 mm/year with maximum number of 3,886.6 mm/year. The highest precipitation occurred on December, it means that the flood possibility occurred in December is high. During the days with precipitation reaches the highest point, flooding will occur. Year of 2012 precipitation data indicated the highest one. While monthly precipitation indicated that December was the highest pointreaching 376.72 mm and occur until January. Discharge of Kedangpahu river in 2012 laid from 355.5 m^3 to 610.6 m^3. Figure 4 indicated the trend of discharge which shows an increasing year by year.

Source of Data: River Area Bureau of Kalimantan III Year of 2015

Fig. 4. Average discharge of lately ten years.

It is linear with land cover degradation condition. Uncontrolled deforestation in sub watersheds increases discharge of Kedangpahu river. Average of water regime index of the last 10 years reached 2.34 point. It means that in arid season the water discharge lower than in rainy season. Al-Bakri *et al.* (2013) stated that problems of water scarcity and food insecurity would be exacerbated by climate change and increased population growth. His study held in Jordan in relation to water and food security.

Based on the consideration of land used planning, it can be seen that forest production covers278,204.98 ha area or equivalent to 39.8 % of total study area. While another using of area is 370,176.91 ha which is equivalent to 53 % of the whole total land used.

This means that changeability toward worse condition is high for the future if there is no reforestation action. Reforestation or forest restoration is

reasonable activity to control flood. In some parts of the study area the topography is 2-8 % or slightly slope. Water flows in this area run slowly. When the precipitation high in the upper area, flood hazard will take place. If the water level of Mahakam river as orifice of Kedangpahu river is high, this condition increases potency of flood hazard. Even the flood becomes worse when tide occurs at the same time and the flood occur in longer period. Land cover condition also increases the frequency of flood hazard nowadays.

The physical and chemicalwater data indicate an under health condition. The intervals of flood is shorter from year to year. It was once 7 to 8 years in 1980th to become every 5 year in the year of 2000th and nowadays flood occurs annually.

From the discussion above it can be concluded: Kedangpahu watershed is 698,952 ha, a big watershed. Average precipitation is 2,568.2 mm/year with maximum 3,886.6 mm/year and minimum 826.9 mm/year. Topographic condition is dominated by slightly slope, it's 63.19 % of total area. Water regime index reaches 2.34 for the last 10 year. Flood frequency increased annually. In general the health status of Kedangpahu watershed is in moderate health. Base on the fact Kedangpahu watershed requires reforestation in the upper zone of Kedangpahu watershed and reducing deforestation in any areas to control water flow.

Acknowledgements

The research was funded by the Directorate General of Research and Development, The Ministry of Research, Technology and Higher Education Republic of Indonesia through the scheme of doctoral dissertation grand year of 2018. The authors extend their gratitude to Samarinda State Polytechnic of Agriculture for all facilities to support this study.

References

Al-Bakri JT, Salahat M, Suleiman A, Suifan M, Hamdan MR, Khresat S, Kandakji T.2013. Impact of Climate and Land Use Changes On Water and Food Security in Jordan: Implications for Transcending The Tragedy of The Commons. Journal of Sustainability **2013,** 724-748. http://dx.doi.org/10.3390/su5020724.

Asdak C.2007. Hydrology and Management of Watershed (4thed). GadjahMada University Press. Yogyakarta.

DanoedoroP.1996. Digital Image Processing Theory and Application Remote Sensing. Geography Faculty of Gadjahmada University, Yogyakarta.

Haileslassie A, HagosFitsum, Awulachew, SeleshiBekele, Peden D, Gebreselassie S, Negash F.2008. Indicators of environmental degradation in the Blue Nile Basin: exploring prospects for payment for environmental services. Paper presented at the Second Nile Development Forum, Khartoum, Sudan, 17-19 November 2008. 37p.

Hajam RA, Hamid A, Bhat S.2013. Application of Morphometrics Analysis for Geo-Hydrological Studies Using Geo-Spatial Technology- A Case Study of Vishav Drainage Basin. Journal of Hydrology Current Research **4,**57. http://dx.doi.org/10:4172/2157-7587.1000157.

Hardwinarto S.2008. Analysis and Zoning of Flood Hazard Level In 3 Sub Watershed of Mahakam River. Unpublished Research Report. Kutai Barat.

Herawati T.2010. Spatial Analysis of Erosion Danger Level At Cisadane Watershed Area Bogor District. Journal of Forest Research and Natural Conservation**7(4),**413-4224, 20010. Bogor.

Koesnandar R, Hardwinarto S.2014. Study On Land and Water Degradation of Sengata Watershed, East Kalimantan. Journal of Rimba Kalimantan Forestry Faculty of Mulawarman University **12(1).**

Nachtergaele FO.2013. Land Degradation Assessment Indicators and the LADA Project. Journal Soil Conservation And Protection for Europe, 1-13.

Sarminingsih A. 2007. Evaluation of Land Critical of Watershed and Urgently Water Conservation Action. JurnalPresipitasi**2(1),** ISSN. 1907-187X.

Setyawan AD, Winarno K, Purnama PC.2004. Mangrove Ecosystem in Java: 2. Restoration. Journal of Biodiversitas**5(2),**105-118. ISSN: 1412-033X. July, 2004.
http://dx.doi.org/10.13057/Biodiv/d050212

SeyhanE.1997. Fundamental of Hydrology (Indonesian Edition). Yogyakarta: Gadjah Mada University Press, Yogyakarta.

Sudarmadji T, Hartati W. 2016. The Process of Rehabilitation of Mined Forest Lands Toward Degraded Forest Ecosystem Recovery in Kalimantan, Indonesia. Journal of Biodiversitas**17(1),** April 2016. Page 185-191.
http://dx.doi.org/10.13057/biodiv/d170127.

Supriyadi, 2014. Impact of Watershed Restoration Base Agroforestry On Soil Quality in The Sub-Watershed Keduang, Wonogiri, Indonesia. Journal of Sustainable Development**7(6),**2014. ISSN. 1913-9063 E-ISSN 9013-9071.

Suryanto, 2007. The Carrying Capacity of Beringin Watershed Development. Unpublished student thesis, Postgraduate School of Diponegoro University.

Triatmodjo B. 2014. Applied Hydrology. Yogyakarta: Beta Offset.

Tufaila, Karim, Alam, 2012. Spatial Analysis of Erosion in Moramo Watershed Using Geographic Information System (GIS). Agroteknos Journal, 2012. **2(3),**134-142. ISSN.2087-7706.