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ENVIRONMENTAL MANAGEMENT AT KUNING RIVER COURSE IN MERAPI VOLCANO YOGYAKARTA SPECIAL REGION

(Pengelolaan Lingkungan Alur Kali Kuning di Gunungapi Merapi Daerah Istimewa Yogyakarta)

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Abstract

This Research aims at: (a) to study the influence of grain size and amount of sediment to the river course function and geometry, (b) analyzing the impact of the using the sediments, water and land to the river channel and (c) evaluating the current environmental management and formulating some strategies for future river management. Beside that Merapi Volcano is known as the most active volcano in the world and it is pointed as a National Park because of the amount of vegetation specieses. The methods of this research are threehold: (1) morphometrical measurement of Kuning River e.g depth and width coupled with the analysis of the sediment (e.g diameter, specific gravit, percentage of boulders); (2) physical-environmental aspect determination (vegetation, percentage of coverage) and (3) social-economic survey in order to determine the household improvements, level of income, socialization of sediment related hazards as well as the sand mining. These three analysis were conducted in the framework of ecology and spatial concept. The results obtained in this research are: 1) Merapi eruptions materials diturbed the river channel geometry to an abnormal condition following the rules of ecology, also the function of river as: gathering, storage and drainage of water and sediment, 2) utilization of river courses for water supply, agriculture and mining in particular sand, rocks and boulders can be made a spatial planning arrangement and utilization is also to improve the welfare of local society and the District, 3) evaluation management to catchment or river course is undeveloped and have not even seen, so it requires management that is based on Indonesian regulation and should also noticed the characteristics of Merapi Volcano such as lahar, nuee ardente and the dense of population in the research area.

Key words: Environmental management, Merapi volcano, River course, and Yogyakarta Special Region.

Abstrak

Penelitian ini bertujuan: (a) mempelajari pengaruh besaran sedimen terhadap fungsi alur sungai, (b) menganalisis dampak terhadap alur sungai akibat pemanfaatan sedimen, air dan lahan dan (c) evaluasi terhadap pengelolaan lingkungan alur sungai dan mencari arahan untuk meminimalisasi dampak yang terjadi. Selain Gunungapi Merapi merupakan yang teraktif di dunia, juga telah dipilih menjadi Taman Nasional karena mempunyai spesies yang cukup banyak.Metode yang digunakan dalam penelitian ini meliputi: (1) pengukuran geometri dari Kali Kuning meliputi kedalaman dan lebar lembah sungai dikaitkan dengan material sedimen yang meliputi: diameter, berat jenis dan persentase bongkah, (2) determinasi terhadap aspek lingkungan fisik (vegetasi dan persentase tutupan lahan) dan (3) survei sosial-ekonomi untuk melihat peningkatan kesejahteraan masyarakat dan penghasilan serta sosialisasi terhadap bahaya sedimen termasuk penambangannya. Ketiga analisis ini dirangkum melalui pendekatan ekologi dan spasial.Hasil yang diperoleh dalam penelitian ini: 1) material erupsi Merapi yang terus-menerus mengakibatkan perkembangan geometri alur sungai menjadi tidak normal secara ekologis, sehingga fungsinya sebagai: penyimpan, penimbun dan pengaliran air dan sedimen kurang optimal: 2) pemanfaatan alur sungai untuk air bersih, pertanian dan khususnya penambangan pasir, batu dan bongkah dapat dibuat tata ruangnya, sehingga mempermudah untuk mendapatkannya dan meningkatkan kesejahteraan masyarakat dan daerah: dan 3) arahan pengelolaan pada daerah aliran sungai maupun *pada alur sungai belum terlihat, sehingga diperlukan pengelolaan berdasarkan peraturan yang telah ada dan perlu memperhatikan karakteritik Gunungapi Merapi seperti lahar dingin, awan panas dan penduduk yang padat.*

Kata kunci: Alur sungai, Gunungapi Merapi, Pengelolaan lingkungan dan Daerah Istimewa Yogyakarta.

BACKGROUND

Environmental issues in the world that occur in Indonesia such as land degradation, pollution, natural disasters and social conflict currently happens, due to human activities in utilizing natural resources with less management system. This problem is unlikely to be solved by a sector, but must use an integrated approach. Environmental science that encompasses elements of abiotic, biotic and socio-cultural course has a real contribution in solving environmental problems in an area, so that the ecological approach is one that can be used.

Indonesia is one of a country which lies towards the Pacific rim volcanoes throughout Asia, has more than 129 volcanoes and is also a State with the largest number of volcanoes in the world (16%). The eruption with pyroclastic materials and lava flows often cause of human loss, damage to land and infrastructures. On the other hand the people prefer to remain stay in the area compared to other areas that are more secure, they knew the activities in the area will stayed their soul and threatened, but they are sure that the activities also brought the blessings namely fertility of land (Agus Sumaryono, 2002).

Sediment yield of watersheds can be determined by measurement of sediment transport on river flows, it is seen from the grain size of sediments that toward downstream size will be smaller. Therefore, when associated with utilization of sediments by surrounding communities, there will be differences of activities directly or indirectly depending on the backgrounds of the people. Sediment disaster-prone areas and its ravines which produce sediment continuously like in Merapi, mining materials of Type C is very much especially the sand and stones (Sutikno et al., 2004). The amount of sediment material from Merapi varies between 0.5 - 4.3 million m^3 and spread out towards the West, South-west, South and Southeast from Senowo River to Woro River (Ratdomopurbo et al., 2006). Supervision is nessary to balance the flow of a river disaster-prone regions included upstream to downstream. The disaster-prone area maps (2005) divided the area into Disaster-prone zones III, Disaster-prone zones II, and Disaster-prone zones I like in Figure 1, it seens that should be change after the 2010 eruptions.

Merapi volcano (2,359 masl) is an andesitic-basaltik type and is located on the border of Central Java and Yogyakarta Province. Merapi represents the continous activity of eruption. Since 1961, at least ten eruptions have been documented and produced the voluminous phyroclastic materials (Table 1). Although small compared to the tremendous belongs to others, the level of danger is quite high due to the hot-cloud called 'Nuee-Ardente' that always accompanies the eruption and in a dense population area (Ratdomopurbo, 2006).

Merapi Volcano has been selected as an area of research, among other volcanoes because the latter is an active volcano in the world and lahar through ravines recent years toward the southern part of which is a densely populated area, so that it can be said is a disaster-prone area, especially in the area surrounding rivers where there are supplies of material sediments. In addition to a disaster-prone area or the lahar reports can be utilized as the minerals to improve the welfare of the inhabitants of class C mining materials in the vicinity of the river. The locations is choosen Kuning River to limit the use of the sediments downstream.

Problems

Based on the background, the research problems can be formulated as follows: 1).

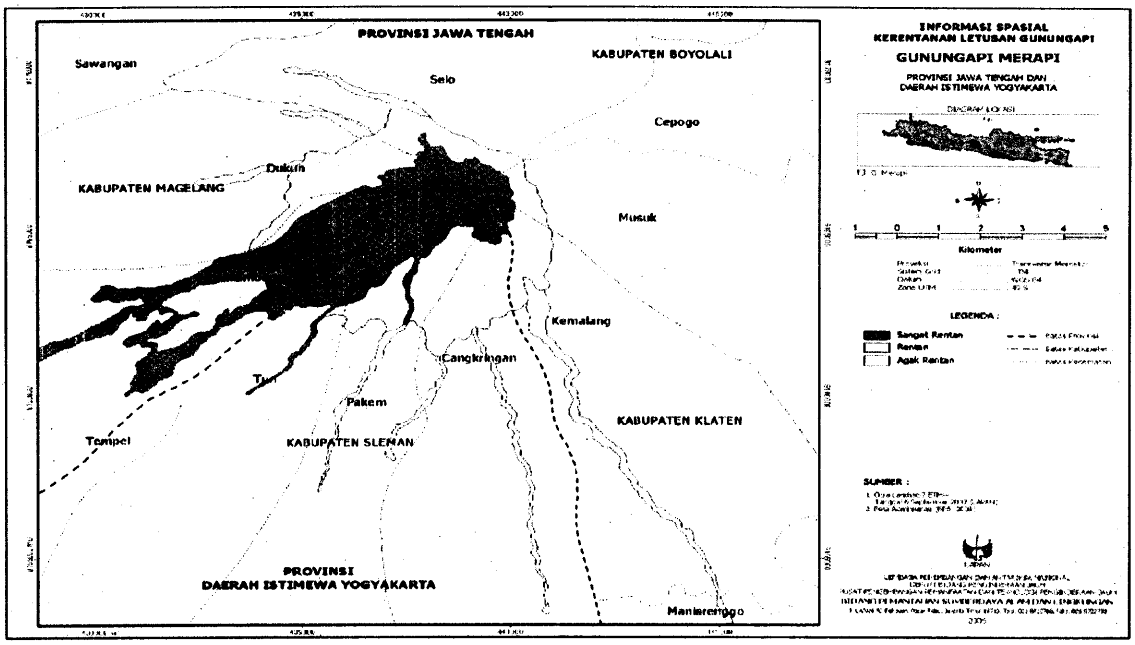

Figure 1 Merapi Volcano Disaster Prone Area (Darmanto, 2012)

Table 1 Merapi Volcano Eruption Characteritics (1961-2006)

Number	Year	The Amount of Lahar/Nuue Ardente (Million M^3)	The direction of Lahar/Nuue Ardente	the maximum distance of avalanche (km)
1	1961	42.4	South West	6.5
2	1967-1969	10.8	West – South West	7
3	1984	4.5	South West	7
4	1992	2	South West	4.5
5	1994	2.6	South West - South	1.5
6	1997	2	South West - South	6
7	1998	8.8	West – South West	6
8	2001	1	West – South West	6
9	2006	2.5	South West - South	7
10	2010	(50)	West - South	(15)

Source: Ratdomopurbo (2006)

How large is the sediment of Merapi Volcano affected the function of the river course/ravines in the south slope ?; 2). How large is the amount of sediment utilization resulting in environmental impact to the functionality of the river course/ravines ?; 3). How could environmental management needs to be done on the river course/ravines in order to minimize environmental impact ?

Authenticity and Depth of Research

As an illustration to show the authentic and depth of the research plan, it can be explained that this study examines how the management of sediment material from Merapi Volcano link between the use and handling. Camus et al (2000), shows the development of the Merapi eruption and spread of material sedimennya; Lavigne et al. (2000), describing the results in the form of Merapi eruptions since 1500 and its spread to 13 River; Aboeneh (2002), testing the hydraulics model Sabo located at Boyong River check dams in the open and closed; Kondo (2002), described the sediment disaster such as: climatic conditions, earthquakes and volcanic eruptions; Hendaryono et al., (2002), volcanic identification of sedimentary facies; Sumaryono A (2002), examines the impact of sediment disaster caused by Merapi Volcano towards water sustainability in River Progo and River Opak.

The history of Sabo in Indonesia has been initiated since the Dutch by building Sabo to prevent lahar in Woro River at 1930s due to the Merapi eruption in 1931, but it was built in the downstream river. In 1970 the Indonesia Government cooperated with the Japanese Government in efforting to cope with disasters due to sediment/debris flow, resulted from volcanic activity. Hence, the construction was carried out in the upstream with the main purpose of controlling sediment flowing to downstream area, and various Sabo facilities have been constrcted across the region in Indonesia, especially in Java (Agus Sumaryono, 2002).

Benefits

The value of this research are expected to be used to formulate a good strategy in the determination of the location to construct sediment buildings (Sabo) so technically eligible, and today by communities surrounding the river can continue without disturbing existing waterworks. The results of this research are expected to provide an idea about the characteristics of sediments on the lengthprofile of the selected river from the upperstream to downstream. In addition the results of this research are expected to be able to give an idea for handling problems of utilization of river sediments, if the material of sediment that exist in the area of research could be harmnessed to the people for their life.

Aims of Research

The aims of this research are threefold: 1). studying the influence of grain size and amount of sediment to the river course function and the geometric in Kuning River as a part of Merapi Volcano; 2). analyze the impact that occurred in ravines or river course due the use of sediment, water and land by residents; 3). evaluate the environmental management of river flow and existing environmental management directives constitute the river flow into the future.

REVIEW REFERENCES

Review References

Merapi volcano is one of the famous volcano in Indonesia upto the end of this century, the periodic eruptions resulted serious disaster. The eruption characteristics are crystalline rocks of lava, lava flows / lava followed by pyroclastic flows controlled by the gravitational force. Special type of debris has a term "Merapi-type nuee ardente" which is characterized by pyroclastic flow material derived from the glowing lava dome (Voight et al., 2000).

Merapi volcano is located in Central Java and Yogyakarta Special Region, densely populated that several times overcome with lava of pyroclastic deposits due to several factors: (1) millions cubic meters coming from periodic eruptions at an intervals of 2-5 years; (2) the intensity of high rainfall (40 mm average rainfall in 2 hours), and (3) the dense flow pattern. In addition the sediment transport in rivers furrows of Merapi are due to three factors: i.e. the change of slope in the river channel will affect the deposition of lahar; primary source material is the debris of lahar "Merapi type" and the flow of ash, variations of rainfall intensity and distribution of the grain affects the magnitude of sediment transport (Lavigne, 2002).

According to Hasan (2002) application of advanced technologies such as Sabo need to be considered by local conditions, both natural and socioeconomic conditions as well as traditional culture. Therefore, modifications have been developed that are tailored to the tradition, so in general the basic construction is not only perform preventive Sabo for the residents and land forms of damage, but also: 1). regulation use of natural resources, especially sands, gravels and boulders for building material, which must consider the condition of the environment; 2). sendiment mining area, including the deposition of sand in order to use it does not result in harm to the surrounding population; 3). to introduce the direct benefit of the Sabo to the local peoples, for the development of small-scale irrigation, and water resources supply as well as microhydro electricity.

According Ratdomopurbo (2006) Merapi Volcano eruptions have characteristics in comparison with other volcanoes such as: short time eruption intervals; volcanic gas temperature reached more than 600° C; eruption can be lava flow, lava eruptions and avalanches; boundary between the state of "inactive" and "active" is relatively unclear, and have a hot cloud is often known as "nuee ardente".

Theoritical foundation

Based on the research problem and literature review it could be formulated a theoretical foundation as presented in Figure 2. The geometric of river cross-sections were measured for each location includes: the width of the valley, valley form, slope of the riverbed, the thickness of sediment material and grain size, while the socio-economic conditions includes: the use of land and water in the river flow, socialization about sediment hazard and the Sabo building construction in some parts of the furrows of the river.

Over utilization of sand deposits by human activities can result a negative impacts on the environment and the mining-community, but it also can bring a positive impact, especially for the improvement of people's income and sediment control hazards. Therefore it is necessary for environmental management in the furrows of the river optimaly, so that the activities that takes place can be sustained.

Hypothesis

Based on the research objectives and the theoretical foundation the following hypothesis are developed: 1). Sediments thickness in the river, will have greater effect on the function of river as a collector, storage and drainage of water; 2). Utilization of sediment and water in the river channel will increase the income of the people surroundings the river, but could also be disaster for the community of miners if they do not follow the technical regulation of mining; 3). Environmental management of the river course that has been used are inefficient, and spatial-ecological approach is more efficient in managing river courses in the sense of the functions.

METHODOLOGY

Three approaches have been applied in this research, namely: spatial, ecological and spatial-ecological approach.

Spatial Approach

This study compares conditions of sediment deposit materials in the respective watersheds which are located at the southern flank of Merapi Volcano the Yogyakarta Special Region. How does the distribution of sediment materials in the upper, middle and lower reaches of the river flow. In addition this research was addressed to utilize the secondary data from various agencies of previous years, is expected to be more aware of processes that occur on each of the river basin.

Ecological Approach

Alfandi (2001) Environmental Geography has the same definition with the environment, i.e. the interaction and interdependence functions in a system called the eco-geography. The ecological approach would emphasize on human

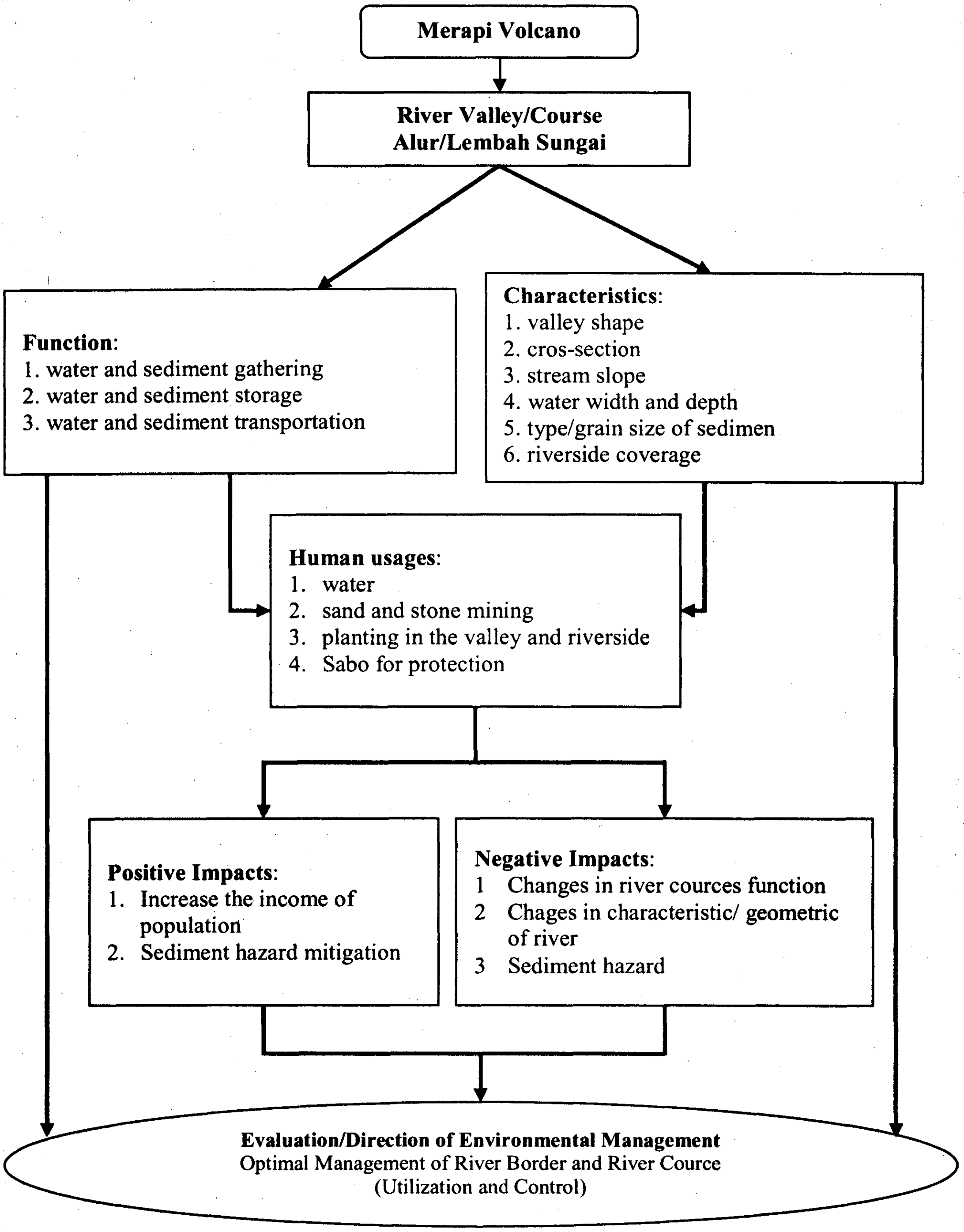

Figure 2 Theoritical Foundation (Darmanto, 2012)

activity towards material utilization of sediments, in addition to reviewing whether technology like Sabo which is sediment control technology have succeeded in accordance with what was planned.

Spatial-Ecological Approach

This approach is a combination of spatial and ecological approach to describe how the environmental state of the abiotic constraints (river courses and sediment materials), biotics (vegetation cover) and social-culture (problems of demography) in each watershed start in the upper-middle-lower reaches of the river as well as between watersheds. This approach is expected to be determined a model of sustainable environmental management, for tackling the sediment hazards.

The research method is survey method that emphasys on primary and secondary data of sediment which is from the Merapi Volcano that went into the valley of the river in the southern part of Yogyakarta Special Region. The study conducted at Kuning River that hopely data will be available.

Population and Sampling

In this study population is called Opak Watershed up to meeting with Oyo River, while the sample area are Boyong/Code River, Kuning River and Gendol/Opak River. Because this study is related to the environment, the research variables includes physical, biotic, and socio-economic components. However, in this analysis that most variables are of the physical components, some components of the socio-economic variables and biological component only the percentage of vegetation cover on the valley and border of the river and the types of crops grown in the valley of the river.

Research Variables

The variables for each physical, biotic and socio-economics components are as follows: 1). Variable physical components: include valley shape; slope of the river; elevation of river channel cross-section sample locations; diameter of the grain material; color; specific gravity; wide cross-section width of water in rivers and river basins; 2). The value of biological components: the type of plant that is in the river channel including the demarcation of the river and the percentage of land cover; 3). Socio-economic variables: main-job; family involve; income; distribution of sediment; sex; education; warnings and regulation setting or not.

Materials

The main materials used in the study: 1). Topographic maps or Digital RBI Scale 1: 25000, BAKOSURTANAL Sheet: Kaliurang (2008), Pakem (2008), Yogyakarta (2001), and Timoho (1999); 2). Disaster Prone Areas map of Merapi Volcano in Central Java and Yogyakarta Special Region Scale 1: 50000 in 2002, the Directorate of Volcanology and Geological Hazard Mitigation, to know the disaster-prone areas.

Equipments and Instruments for Compiling Data

Devices for the field and analysis: 1). Equipment for field measurements: Laser Distance Meter "Leica Disto "Switzerland" and "Elst Chausset" Israel (cross-section, slope of river), ribbon meters (distance), Geology Compass "Brunton" USA, Garmin GPS "Maps 60 CSx" Taiwan and the Garmin "eTrex", the sample bottles and jalons; 2). Hardware (CPU, monitor, printer, scanner) is used for typing, calculation and printing of the final of the dissertation; 3). The software for mapping " ArcView 3.2".

Collecting and Compiling Data

1. The preparation phase: a). Secondary data collection and litterature studies; b). Geometric data collection of River; c). Collection of maps of Merapi Volcano; d). The orientation of the field to determine the points of measurement, observation location of the interviews and sampling sites; e). Preparation equipment, work maps 1:25000 scale maps RBI, determination point of measurement and sampling and research permits.
2. Field survey phase: a). Cross-section measurements; b). Sediment samplings; c). Interviews with residents, miners and community leaders on problems related to the utilization of sediment materials and

the socialization of Merapi Volcano sediment hazards.

3. Analysis and data processing phase: a). Laboratory analysis; b). Analysis of the map; c). Proving the hypothesis by comparing the measurement results and analysis of terrestrial laboratory results and the results of interviews in each section in the upstream, midstream and downstream with the standards or regulations.

Collecting and Analyzing Data

Flowchart is a sequence of steps performed from data collection of both primary and secondary and getting research results which consistent with the research foundation of theory. In addition, in determining the upper-middle-downstream river gradients can be distinguished from a row of 5 m / km, 1.67 m / km and 1 m / km (Gabler et al, 2007).

Data Collecting

Data collection includes the direct measurements of parameters and secondary data through instansional surveys. Primary data are: cross section of the river, the width and slope of the riverbed measured using the Laser Distance Meter, the cross sections and sampling locations is chosen by using a Topographic Map of 1:25000 scale and GPS, and camera images to get a picture of the field activities. In addition, interviews conducted surrounding the mining areas, to the miners, Mining Company and Government Agencies who carry out the supervisions.

Secondary data include thematic maps related to research such as 1:25000 scale maps of topography (RBI), Prone Hazard Areas Map, and research results from several agencies such as the "Sabo Technical Center" Yogyakarta, GMU Center for Disaster Studies , Project Merapi Yogyakarta, Yogyakarta Directorate of Volcanology and both government and private agencies associated with this research.

Evaluation Data

Sediment materials samples were analyzed in the laboratory: sediments were analyzed granulated with a sieve method to obtain the size of its diameter, color of the sediment using a standard book of color and also determination the specific gravity of each sample.

Vegetation data consist of crop-types and percentage of land-cover in the border of rivers and river valleys. Results of interviews data are conducted and tabulated to be prepared for further analysis, the parameters used for the analysis is selected related to the purpose of this study.

Data of field measurements were inventoried, made into tabulations and then calcula-tions required for data analysis and if possible can be illustrated in the form of thematic maps. For each measurement location cross-sectional profile is measured, and than in each watershed is made longitudinal cross section.

Result Analysis

There are two approaches to be used as the basis of analysis in this study, ecological approach which examines the relationship between environmental components that exist in this study between abiotic-biotic and socio-economic-cultural (the width of valley and types of vegetation is influence by people) and as well as the spatial approach that will describe the environmental management in each Sub-basin of the research conducted as described in the background of this research.

Proving the first hypothesis using descriptive and comparative analysis of data from field measurements, conducted at each site section at the upper-middle-downstream in the watershed and among watersheds, which are equipped with photographic images.

The second hypothesis proved through descriptive and comparative analysis of data from field interviews and analysis of existing thematic maps and map the results of field observations, which were then compared between each location of the upstream-middle-downstream section in the watershed and among watersheds, supplemented with photographs of the field.

The third hypothesis was verified by evaluating the river channel management that can minimize the environmental impacts optimally. The rules of technical and scientific standards that already exist has to be considered as a standard of technical building Sabo and river flows.

Definitions of Research

The flow of a river or stream (river) is a stream of water flowing in the plot big and small, in general, the calculation is linked between the velocity of water flow in a river cross section is often referred to as discharge (discharge) (Morisawa, 1968).

Watershed (DAS) is a region or area of the stream or river channel systems that are interconnected to each other atu the river will flow out through one exit (Linsley, 1949). Meanwhile, according to the Seyhan (1977) **watershed** is an area bounded by the separator topography, which can accommodate, store and drain rainwater that falls in the region through the river system and will exit through the "outlet".

Sediments can be defined as fragmental material carried in suspension or deposited by water or wind power (Linsley, 1949).

Border of river is defined as the right and left side of the river floodplain, riverbank erosion, floodplain ecology, as well as the banks of the security (Agus Maryono, 2005)

RESULTS AND DISCUSSION

An overview of the three watersheds who became the object of research derived from the Topography Map scale of 1: 25,000 Sheet 1408 Yogyakarta Edition I 2003. Kuning River has a length of 30 km up to the conjunction with Opak River and an area of 42 km2 and then will be measured several cross section along the river longitudinal track.

Environmental River Course Conditions of Kuning Watershed

Results of measurements of the River course environmental conditions of each watershed consists of: width, shape, slope and depth of the valley, water depth, grain-size, specific-density of material, the percentage of bolders, the percentage landcover on the boundary and the river valley as well as the socio-economic conditions of the interview taken at the upper-middle-lower reaches is shown in Table 2 environmental conditions in Kuning River.

Discussions

The discussion is divided into two parts, the environmental condition in Kuning River and in the Kuning Watershed.

Watershed Analysis for Physical and Biotic Components

The parameters of physical condition of the River reviewed in the research include: elevation; width, depth and shape of the Valley; the depth of water; the width of the Groove that is watery; grain size of the material; the percentage of bongkah; heavy type material and the biotic conditions for parameters is the percentage of vegetation cover. Based on the Table 2 or previous discussions of watershed components of physical condition and biotic conditions, then the spatial explaination is as follows:

a. physical condition parameters that are: elevation, width of the valley, depth of valley, slopes, streams, water depth, and wide river on the river water showed that in each of the watershed following the ecological approaches. Calculation of intermediates and based on their results of the average number does not indicate significant difference, so it can be said that physical condition of the geometry distribution following the spatial-ecological approach. Elevation is decreasing toward downstream; the valley width toward downstream is narrowing due to the use by residents; depth of valley is lowering towards downstream; further downstream slope

Tabel 2 Environment Conditions in Kuning River

Parameters:	KU-1	KU-2	KU-3	KU-4	KU-5	KU-6	KU-7
Village	Pangukrejo	Grogol	Pokoh	Yapah	Sambirejo	Bakungan	Tegalsari
Elevation (m)	875	650	398	265	205	120	75
Letitude **07**	35' 53"	37' 05"	40' 08"	42' 17"	43' 36"	47' 02"	49' 39"
Longitude **110**	26' 20"	25' 42"	25' 50"	26' 20"	26' 26"	26' 22"	26' 12"
Physical Conditions							
Valley Form **U / V**	V	U	U	U	U	U	U
Valley width (m)	42	106	63.3	49.16	28	37.3	24
Valley depth (m)	49.41	22.42	8.53	6.21	9.1	5.4	4.72
Distance between location (km)	0.25	2.55	6.25	4.3	2.25	7.25	5.65
Stream slope	0.2500	0.0882	0.0403	0.0309	0.0267	0.0117	0.0080
Water storage	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Water depth (m)	0.5-1.0	0.15	0.15	0.15-0.30	dry	0.3-0.8	0.5-0.6
Width of water (m)	1.0-2.0	1.0-2.0	1.0-2.0	3.0-5.0	3.0-5.0	4.0-5.0	7.0-10.0
Max. grainsize (mm)	< 45	< 32	< 32	> 64	< 64	< 64	< 32
Persentage of boulders	5	0	0	0	0	0	0
Specific gravity gr/cc	2.55	2.41	2.71	2.5	2.44	2.58	2.61
Color	Black	Black	Black	Black	Dark grey	Black	Black
Mining Materials	No	Yes	No	No	No	No	No
Biotic Condition							
Vegetation cover (%)	20-25	25-30	25-30	25-30	25-30	25-30	25-30
Social Conditions							
Main Job/miner/othe		23 / 7				15 / 3 / 12	22 / 8
Monthly income (thousand)		300-3600				200-3500	440-3000
Education		NS-UN				NS-HS	NS-HS
Family involve (0/1/2/3/4)		8/15/2/2/1/2				17/12///1	15/10/3/2
Status(M / F)		27 / 3				25 / 5	27 / 3
Farest distribution		In province				In province	In province
Emergency sign (yes/no)		15/15				15/3/12	6/24-
Agree regulation (yes/no)		19/11				3/15/.12	13/17

Source: primary data

flattened; water level is deeper towards downstream, and the width of water in the valley is grater towards downstream.

b. Physical parameters: the grain size material, the percentage of boulders, material density, and colors indicate the following. Material grain size and percentage of boulders follow the rules of getting into the downstream ecological granules and the percentage decreases, this occurs because the material of smaller grain size can be taken over by the flow of water further downstream. For the density of the material varies between 1.95-2.71 of its material and color variations ranging from dark gray-black.
c. Biotic parameters as indicated by the percentage of vegetation cover seems to have the same percentages that is between 25-30.%, only Pangukrejo (KU-1) is 20-25%.

Watershed Analysis for Social Economy Components

Socio-economic conditions of each watershed based on interviews with residents surrounding the river on the upstream-middle-downstream for each river, interviews some of the parameters associated with sand mining activities can be seen in Table 2. Based on Table 2 socioeconomic conditions are as follows:

a. The number of household in the middle part of Kuning River is lesser than the others due to the high diversity of livelihood of local people. This area is also classified as suburb therefore the people have another job (teacher, government official and private sectors).
b. Utilization for the active and intensive mining of sand and boulder is in the upstream of Kuning River (KU-2) is controlled by the abundance of volcanic materials and the high accessibility.

River Course as Reservoir and Supplier Flow of Sediment and Water

Kuning River groove is divided into seven segments ranging from KU-1to KU-7 as listed in Table 2. The width and depth of the valley of each segment were measured, as well as the distance of each segment. As well as the characteristic measurement is the measurement made for a moment, so it is recording a moment or regarding the dynamics of the changes that will occur. On the basis of this consideration, the function of the river as a sediment maximum reservoir can be calculated as follows.

The results of calculation (distance of cross-sections multiply by depth and width of valley) in Table 2 is 13,939,959 m^3, and if divided by 7 then the result is 1,991,422 m3 which is the maximum capacity. The movement of sediment on the river flow is influenced by water discharge, is also influenced by the gradient of the river, size and amount of sediment. In general, the gradient flow of Kining River is 875 m / 28.5 km or 30.70 m / km and equal to 0.031 when calculated on a segment by segment of the river then there is a variation of a river then there is a variation of a gradient ranging from 0.250 to 0.0080. The river gradient variations affect the capacity to channel sediments, although not taking into account the characteristics of sediment, both the grain size and volume of sediment.

The results of measurements in laboratory sediments show the variation of sediment grain size, the lowest <32 mm and the largest> 64 mm. Among all segments, 4 of them are classified as <45 mm. If the slope is mostly associated with a greater than 0.0242, based on the theory of grain size <45 mm needs to have a carrier with a speed of 10-100 cm / sec (Morisawa, 1968). Eventhough the river is considered as perennial system, the discharge during the dry season is extremely low therefore the sediment load is also low. During the rainy season, the river discharge trends to increase, consequently the stream potensial is also high. Therefore the greater grain size are transported.

The tendency of the relationship between the gradient of the river with sediment grain size measurements in the laboratory, does not apply to sediment-sized (boulders). The percentage of boulders is not more than 5% in KU-1 found in river channel with a slope of > 0.0242. The results showed that the distribution of sediment in the river channel is not normal, in terms of sediment grain size gradations is not good in Kuning River. Towards downstream sediment grain size should decrease, but it varies significantly. Utilization of the river depends on the presence of sediment material, in addition to Kuning River it is not to much material so the use for agricultural activities that many noticeable.

Analysis in the watershed

This section discussed the condition of the physical components, biotic components, and socioeconomic components in Kuning Watershed which is an area between the two watersheds that are the path of the lahar, Boyong Watershed that represent before the 2006 eruption and Gendol Watershed as a representative after the eruption of 2006 until just before the eruption in 2010.

Longitudinal and cross-section of the river planned starting from the upstream-middle-downstream cross-section made interval of 100 meters and reaching elevation 100 amsl the interval changed to 25 meters, as consideration for Kuning River must reach or meeting with Opak River.

Shape, width, and depth of valley: almost all valleys show a U-shaped because

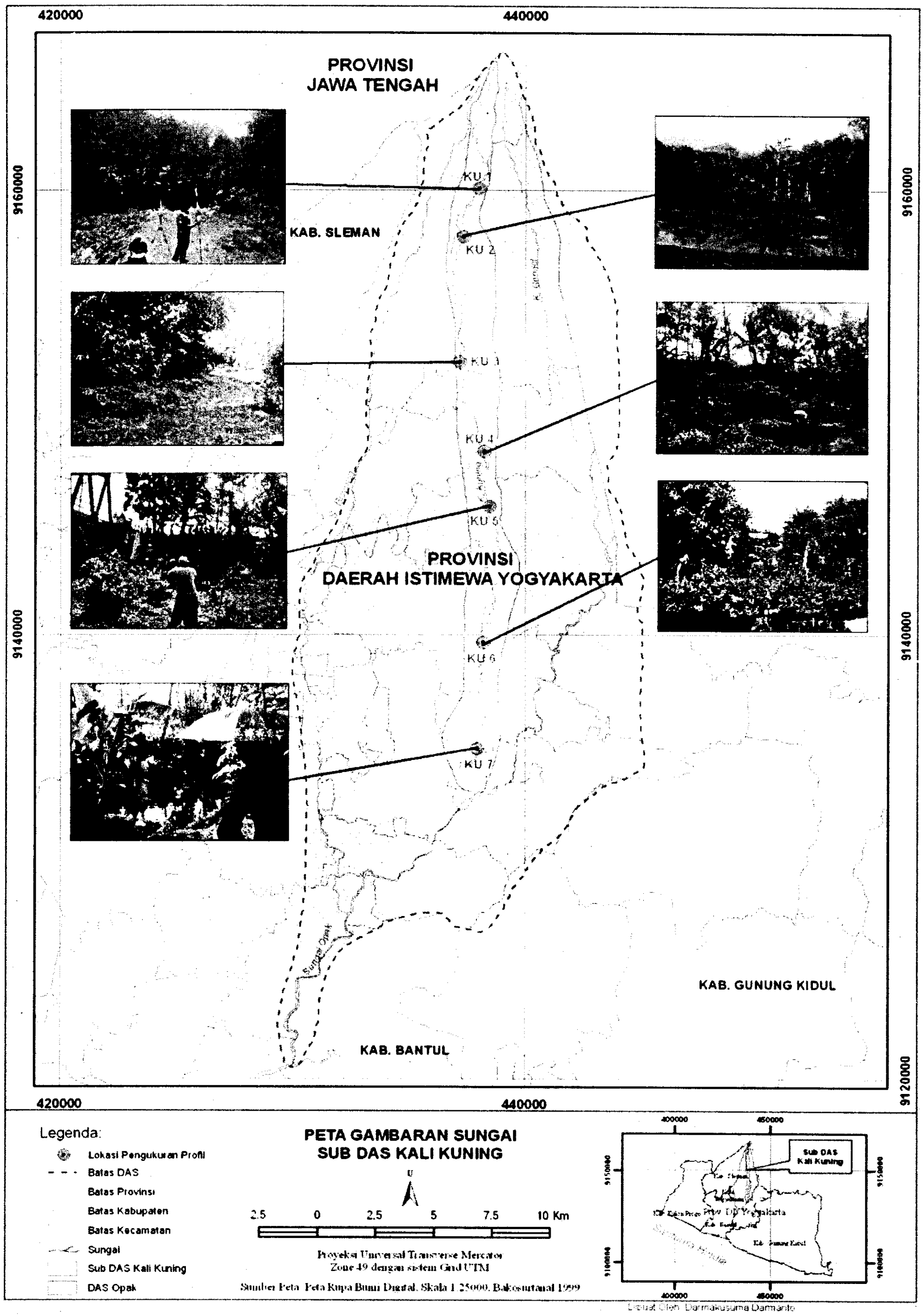

Figure 3 Cross-section of Kuning Watershed (Darmanto, 2012)

of the depth is smaller than the width, except one in Kuning River (KU-1) because the depth of the valley 49.41 meters longer than the width of the valley 42 meters so it is expressed as V-shaped valley; the upperstream is wider, and becoming shorter towards the middle upto downstream.

Conditions of water depth and water width at river courses Kuning River the first cross-sectional profile shows the water, because the water is a spring which called Umbul Wadon at 875 meters amsl. Overview for the water depth at each cross section of the river from upstream to downstream in each watershed depth is not more than two meters. The width of water running over the valley gives an overview of similarities between watersheds the width is greater towards downstream.

Retrieval / Minings material: the locations in Kuning River is mainly in KU-2, because the Kuning River does not track the flow of lava. As an illustration of mining activities on the river after the eruption of Merapi Volcano in October 2010, the utilization of mining of sand and stone will start from the easiest access at the bridge or sabo which covered by sediment.

Vegetation / land cover in the river can be seen through the percentage area of each cross section surrounding the location of measurement, Kuning Watershed and Gendol/Opak Watershed looks to have a pattern similar percentage compare to the percentage of vegetation cover patterns in Boyong / Code Watershed.

The results of statistical tests with Student 't in the research area for the physical and biotic factors in the three watersheds show the similarities or differences of the population, the same parameters are: the slope of the river, the maximum grain size and density of material, while the different parameters: elevation and width of the valley. Details of the analysis of statistical tests of physical and biotic parameters can be seen in Table 3, the explanation of acceptable means that parameters from one river to the other river have in common, whereas if the rejection means there are significant differences between the two.

Social Economy Conditions in Table 2 seems that several social-economic parameters which related with sand and boulder minings surrounding the river course that by interview has shown in methods. Parameters include: name, location, age, gender, marital status, education, dependents, household expenditures, years of work, employment status, family involvement, marketing, vehicle, income, risk to the environment, regulations and rules.

Using analysis of variance (ANOVA) can be stated that the sample of respondents from a population of miners whether yes or not, so the hypothesis is declared or made: H0: Respondents miners homogeneous (samples come from the same population) H1: Respondents miners are not homogeneous (the sample does not come from the same population).

Value of the variance (F) at the 5% significance is 1.24 while the F critical value (FCR) of the table was 19.33, for F <FCR we conclude that H0 is accepted that the respondent sample is homogeneous or derived from the same population, meaning that all respondents were statistically the miners.

Analysis of Data from the Associated Institutions.

In addition to discussion of the data field is also carried out the analysis of secondary data obtained from several agencies associated with this research. According to Research and Development Center of Water Resources (2006) that the principle of natural disaster caused by the mass movement of debris is the controlling mass movement debris so as not to damage or harm. Therefore, Sabo technology which is a combination of vegetation and the work of civil engineering can be considered as a viable synthetic technology in place to cope with natural disasters by the mass movement of debris.

The mining activity during the period of 2002-2006 was greater than the governmental rule, that reach 12 to 17 tons. The price of mining in the area is between

Table 3 Statistical Result using Student't Test in Research Area

Parameters	Boyong/ Code River Kuning River	Boyong/ Code River Gendol/ Opak River	Kuning River Gendol/ Opak River
Elevation (m)	rejected	rejected	rejected
Valley width (m)	rejected	rejected	rejected
Valley depth (m)	rejected	rejected	accepted
Stream slope	accepted	accepted	accepted
Max. Grain size (mm)	accepted	accepted	accepted
Specific gravity (gr/cc)	accepted	accepted	accepted
Vegetation cover (%)	accepted	rejected	rejected

Source: Table 2

Table 4 Statistics Analysis of Variance '*One-way analisys*' Mining Respondent in Research Area

Location	Watershed			Total	Average
	Boyong/Code	Kuning	Gendol/Opak		
Upperstream	31	30	32	93	31
Middle	2	30	30	62	20.7
Downstream	31	30	30	91	30.3
Total	64	90	92		
Average	21.3	30	30.7	Xave = 27.3	

Source: Table 2

Rp 150,000,- to Rp 160,000,- for each truck.

The existence of this mining activity causes a negative impact on water quality conditions in rivers. Hence the river monitoring of water quality conditions is needed on rivers that have mining activity.

The results of water quality measurements for the three rivers that become the object of research from the Office of Environmental Impact (KPDL) Sleman District from 2003 to 2009 include the following elements: BOD, COD, SO_4, Cl, NO_3 and Fe results showed the same dominance for the three river studied, the element of COD and SO_4 outstanding value ranges on average between 25-45 mg / L.

Environmental Management at The River Courses

River channel is one manifestation of the environment, on which there is a component of abiotic, biotic and cultural. Abiotic components consist of the river basin with morfometry variations, bed material, sediment and water; biotic components of plants and animals; is reflected in the cultural component of human activities that include social activities, economic and cultural. Environmental component of the river should be managed properly to support the implementation of sustainable development which is the principle of national development. Environmental management such as the above description is a complex activity and requires the integration that includes planning, utilization, control, maintenance, monitoring and enforcement (UUPLH, 2009).

Coverage of environmental management is so vast, not only government that has the ability to execute it, and not individual persons may be able to do it. The ability of a person is limited in environmental management, provide feedback, criticism or suggestions follow the activities of the government ever done in one system environment or in one ecosystem. Associated with the research for this disertation component of the environmental management of rivers that were evaluated are limited to the utilization and control. Utilization and control of selected elements in this study, because these elements can be judged by anyone (individual persons) and had nothing to do directly with the authority of the bureaucracy. Here is described the use and control of the river for water supply, mining of sand and boulders, as well as for agricultural activities in Kuning River.

Utilization and Control Kuning River Courses

Substance use and control the flow of Kuning River following the utilization targets related to environmental management that has been described in the Boyong / Code River. Natural resources found in the river channel sediments (sand and stone), water, plants and animals, and social environment. Utilization of natural resources should be based on the carrying capacity, with attention to the sustainability of processes and functions of the environment, sustainable productivity, as well as safety, quality of life and welfare of the community.

Control in this study is limited to damage of the physical environment of the river. Activities in the control are of prevention, mitigation and recovery. In the present study is limited control on the idea or ideas in prevention, mitigation and recovery, not an action activities. Signs of natural resource utilization and environmental control are applied broadly in line at Kuning River.

Utilization of Material Resources

Resource material (sand and stone) on Kuning River is not available like in Boyong/Code and Gendol/Opak River, but only a few at the upstream segment of the mining activity in KU-1 and KU-2 . At location KU-1 just a few mining activities, because access to the valley is difficult and its a tourism area. In KU-2 is the dominant mining sites along the Kuning River, a relatively new building of sabo (2007) and mining have entered sabo upstream to 200 meters. Toward the middle to lower part of the river during the study did not indicate any mining activity. Moreover, because the presence of the Pelawangan Hill upper the Kuning River so that awake from Merapi lava, so not much material in sediments along the river it can be seen on the conditions at each cross section.

Utilization of Water Resources

Water resources in river basins are located on the slopes of strato volcanoes are generally abundant, but their spatial distribution varies according to the position and slope. Fairly good water conditions ranging from KU-1 to the KU-7, this is because the location of KU-1 is a spring called Umbul Wadon and is the main source of water for the district of Sleman and the city of Yogyakarta. Consistency of the water in the Kuning River can not be done, because there are no data records on the river discharge/flow as well as in Boyong River existing data flow of the river at several locations.

Utilization of water for agriculture is generally associated with the weir and sluice there. Along the Kuning River there are six buildings Sabo (SDA Libang Center, 2006) which is used for security or for irrigation sediments. Availability of water in the Kuning River is insufficient for irrigation water in rice fields which include the Kuning Watershed evident in the dry season many of fallow rice fields, which need to be supported from the source water from other river basins. For example, water from Progo River through Mataram Ditch used to irrigate rice fields downstream Boyong, Kuning and Opak River.

Utilization of Land Resources and Environmental

As noted earlier that Kuning River utilization especially in the valley and the border rivers, including the location of mining sand and stones in KU-1 and KU-2, KU-1 mine in the local-local only in being a KU-2 starts from building near the upstream sabo then leads to the time of research has gone up to 200 meters upstream; utilization for agriculture includes various types of plants such as elephant grass, banana, coconut, bamboo, clereside from KU-3 to KU-7. Sectional profile of the valley up to the clear border on KU-1 and KU-2, is generally more downstream even less clear as it is covered by agricultural use. River water came from the KU-1 to the KU-7 in accordance with the utilization of agricultural and fish pond, the width of one meter watery initially increases until it reaches 10 meters wide with water depths varying between 0.15-1.0 meter.

Evaluation/Referral of Proposed Environmental Management from the research base that emphasizes some of the principles of environmental management thats utilization and protection as follow.

Evaluation/Referral management of river basins of lava

Need to consider the condition of the crater and the material at the peak of Merapi lava is likely to be in the river valleys, this is to determine the position of the location and type of the Sabo that need to be agreed by the government and local communities to avoid conflict. If there is good coordination between governments and communities around the river, the construction of Sabo will be supported by the community and society in the mining process will follow the rules or requirements for their safety and the Sabo.

Evaluation/Referral management of river basins of hot clouds (Nuee Ardente)

Material which is spread through the wind direction should be disseminated on a regular basis, whereas for the carrying through the valley of the river should lookout the depth the valley and the concentration distribution of population in order to be effective and efficient. Management the Merapi Volcanic hot-cloud must consider the opening of the crater which is the main street of the slide, and then allowed to follow the river valleys naturally.

If the planned needs building structures, must be selected at locations that is safe from the settlement, so it is likely that at Merapi Volcano eruption events of 2010 if in Gendol River is no Sabo, the glide distance will reached more than 18 kilometers in the District of Cangkringan (Atyanto, 2010) . Need for research on the speed of the hot clouds glide on a river valley, so that their distance can be estimated, but because the river is not straight possibility of additional distance that occurred not too far away.

Evaluation/Referral socialization to residents

Detail needs to be done regularly and continuously about: early warning, evacuation routes, shelter locations either permanently or temporarily. Location of the shelter both people and pets should be located in a safe zone or region of the Merapi eruption hazards. The existence of the people should live in accordance with the zoning that has been determined, given that the interval of Volcano Merapi activity is relatively short.

Evaluation Before and After the 2010 eruption of Merapi Volcano

Evaluation related to the eruptions that occurred in October and November 2010 is needed to compared with the eruption that usually happens with this devastating eruption, so it can be estimated how the best management to do. Evaluation conducted before and after the eruption of Merapi Volcano will base upon the field conditions at each location of the river in the watershed on existing cross-section by showing field photographs.

Kuning Watershed

Wadon Spring is the main source of water for the people of Yogyakarta, especially Sleman and Yogyakarta City were damaged by lava from Merapi. As a result of this incident the northern parts of Sleman are not getting clean water, so for some time in turns they get supply of clean water through the submission of water through water tankers. Effect of lava flood in the Kuning River is as in Boyong / Code River and further to the south of South Ring Road. Differences between segments of the KU-2 cross-section when making measurements in this study (October 2009) under the section after the eruption of Merapi Volcano month of October to November of 2010. Photos taken after the eruption is conducted in January of 2011, because the time is still off limits to the public prior to coming to the area.

CONCLUSIONS

Based on the results and discussion in this study and according to the research objectives to be achieved, then it can be concluded as follows:

Due to the sliding material of Volcano Merapi problems occur in the river flow as a function of the storage, accumulation, and river discharge in Kuning River.

Utilization of the river by the public in the location and of local government enterprises caused the smooth functioning of the river water delivery from upstream to downstream, thus hampering and narrowing the areas. Mining activity of Merapi Volcano sediment material in the form of sand, gravel and boulders as well as the utilization of the river valley for farming are the two things that give rise to both negative effects that inhibit the drainage of water from upstream to downstream rivers and the positive impact that increased the income for the Districts and for the welfare of the community around the location of activities.

Environmental management directives for a sediment disaster-prone areas are: a). socialization to the community and local government on early warning systems and emergency response in particular associated with the activity of Merapi Volcano should be schedule routinely and the availability of Disaster Prone Area Map that follow the latest development of Merapi should be ready and easy to be find; b). Sabo technological development which will be built by the government should be compromise with the population surrounding the Sabo to get the best deal; c) need to be communicated that Sabo's technology consists of a vegetative nature and of civil engineering, as well as necessary to determine that sediment material around the Sabo can be taken or used for development and welfare of the people; d) handling nuee ardente to be studied more about the characteristics that can be simulated by eliminating the natural structures including Sabo, if necessary then search the sabo in safe location of the dense residential occupants.

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