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## Strategy for controlling surface runoff in kemuning river basin, Indonesia

Kustamar<sup>1,\*</sup>, Togi H. Nainggolan<sup>1</sup>, Liliya Dewi Susanawati<sup>2</sup>, Agung Witjaksono<sup>1</sup>

<sup>1</sup>Faculty of Civil Engineering and Planning, National Institute of Technology (ITN) Malang, Jalan Bendungan Sigura-Gura No. 2 Malang, Indonesia

<sup>2</sup>Faculty of Agricultural Technology, Brawijaya University, Jalan M.T. Haryono, Malang, Indonesia

\*Corresponding author: kustamar@lecturer.itn.ac.id

**Abstract.** Kemuning River flood every year and inundate the city of Sampang. Flood discharge is dominated by surface runoff. The Sungai Kemuning River Basin (DAS) is mostly (77%) in the form of gardens, fields and rice fields. The control of surface runoff is done by land conservation method, with the combination of 3 methods, namely: Vegetative, Mechanical, and Constructive Method. Conservation of vegetative methods, it is advisable to plant Mango or water apple with a combination of elephant grass (*Pennisetum purpureum* cv. Mott) in the garden, polowijo and elephant grass in the fields, and Paddy and Polowijo (one of: corn, soybeans, beans) in the fields. Mango and water apple is a local plant, but it is recommended to be updated with more superior varieties to be more productive. Elephant Grass is a new variety that is suitable to be planted in the watershed area, and it is intended to increase the stock of livestock feed, both cattle and goats. Conservation of mechanical methods, in the form of: making of infiltration holes and bench terraces in the garden, improving the design of embankments in fields and fields. The height of the embankment is reminded from 30 cm to 40 cm so as to increase the depth of the puddle in the fields from 0 cm to 30 cm, and the paddy field from 15 cm to 30 cm. With a land area of 20,526,430,000 m<sup>2</sup> and a rice field of 1,183,356,100,000 m<sup>2</sup>, an increase in rainwater storage capacity of 793,296 m<sup>3</sup> is obtained. This is identical with the capacity of two large dams. Conservation of constructive methods in the form of wells in the fields and rice fields. Recess wells are made in fields and rice fields with the amount and distribution of 1 unit per 2500 m<sup>2</sup>. The well serves as a recharge well to accelerate the decrease in the height of the normal puddle in the fields and in the rice fields. The peak flood discharge rates on the seven Sub-watersheds after conservation of land, respectively from Sub-DAS 1 to 7 are: 55%; 51%; 50%; 20%; 67%; 58%; 56%.

### 1. Introduction

Kemuning River passes through Sampang City, and every year it floods. Some influential factors are: Watershed (DAS) quality, River Capacity, tidal water, and topography of urban areas. Efforts to control that have been done in the form of increasing the capacity of the river, in the form of improved river flow and floodway making [1-3]. However, floods are still routinely occurring, so another effort is needed. Flood discharge is dominated by surface runoff, thus the quality of the Watershed (DAS) deserves attention. Kemuning River Basin is dominated by garden area, fields and rice fields (77%), the rest are forests, settlements, and ponds. Thus improving the quality of the management of the Garden, the Fields and the rice Fields will have a significant impact on the efforts to reduce surface runoff [4-6].



The control of surface runoff is carried out by land conservation methods, in the hope of also improving the availability of water irrigation for agricultural cultivation. Improving the quality of the management of gardens, fields and paddy fields is done with land conservation consisting of a combination of 3 methods, namely methods: Vegetative, Mechanical, and Constructive [7-8]. Conservation sites are prioritized in highly critical, critical locations. Map of the condition of the land is produced from the process of land condition analysis with a review of the ability of land in the rain water absorb [9-10].

The determination of plant species in vegetative conservation is based on the topographic slope and environmental conditions (soil physical and chemical, water availability, topography, and climate) on the condition of growing plants. Of the various types of plants whose growth requirements are met, they are selected which have high hydrological and economic impacts. Thus, farmers will actively participate in caring for plants [11].

The selection of types of land mechanization attempts in conservation is built on the orientation of reducing topographic slope and creating temporary shelters on the land. Reduction of the slope of the land is done by making the terrace, with the type that suits the topographic slope. Temporary makeshift on the land, built by making bunds in the fields and improving the design of rice field embankments. Constructive efforts in conservation generally cost a lot, especially if it is done by making a sink in the river. Therefore, in this study developed the concept of collecting water before entering the river flow, which utilizes aquifer. To support the maximization of water infiltration into the aquifer, developed deep absorption wells [12].

The absorption well is a catchment well suitable for use in fields, rice fields that can be directly beneficial to farmers. This is so that farmers can accept, even support it. The accumulation of these three conservation efforts is expected to reduce the runoff discharge by 50% so as to reduce the burden of flood discharge. Increasing the amount of water absorbed into the soil will improve the basic flow discharge, so the water supply in the dry season will increase. Selection of the right types of plants and planting methods, and the availability of adequate irrigation water will increase the productivity of farmers. Thus, land-use programs will work well and flood mitigation efforts can be successful at a lower cost.

## **2. Methodology**

### *2.1. Infiltration Potential Analysis*

The potential for infiltration on a given land depends on rainfall, topography, and soil conditions. Rains duration, sloping topography, and land with porous soil will be more potent in absorbing water. The topography slope can be reduced by making the terrace, and the porosity of the soil can be increased by vegetative. The potential analysis of infiltration is done by combining maps: rain, slope inclination, and soil infiltration capacity.

### **Rain Data Analysis**

Rain behavior is characterized in various reviews, namely: the intensity, duration, frequency, and total of rainy days, and the amount of rain. In land conservation, with a review of rainwater absorbing capacity, the amount of rain is a major factor that receives attention. The amount of rain in a year is calculated by summing the daily rainfall in the base year of planning.

### **Topographic slope Analysis**

Topography in general in macro review forms a gradation from steep to ramps, followed by the division of watershed areas, namely: upstream watersheds, central watersheds, and downstream watersheds. In the analysis of land conditions, the slope is classified by the range of: (> 8) %; (7 to 8) %; (5 to 7) %, (5 to 7) %, (2 to 5) %, <2 %. Topographically macro classified as steep can be changed with terraces. Individual terraces are suitable for slopes of more than 30%, whereas for land with a slope of 8 to 30% more precisely made porch benches.

### **Earth Data Analysis**

Porosity is a part of the ground character that directly affects the capacity of land reclamation. The porosity of the soil is formed by the variability of grains and the behavior of microorganisms. Microorganism

activity is determined by organic content, and oxygen circulation, as well as air temperature. Behavior of the organism will be built along with the vegetative conservation.

### 2.2. Land Use Data Analysis

Types of land use and user activity give direction to the formation of land cover conditions, and land porosity. The division of watershed areas from upstream to downstream is generally followed by land use groups, is from upstream to downstream watersheds: forests, gardens, fields, settlement, rice fields, and ponds. Land use with topographic slope reduction policies and vegetative presence will have a positive impact in reducing surface runoff. In hydrological analysis with current conditions review, land use data is categorized based on land cover conditions in the field. In contrast, for future discharge predictions, land use and land cover planning data are used.

### 2.3. Identify Priority Conservation location

The location of conservation priorities is based on the land condition map, i.e., land that is critical and very critical. The land condition map is constructed with operational comparisons between maps: soil, rain, and topography, with land use maps. The operational and criteria used were chosen by the model by the Ministry of Forestry of the Republic of Indonesia [1]. In the model, the maps: soil, rain, and topography are combined into a composite map that informs the magnitude of the potential for infiltration of rainwater. The amount of natural potential is classified. For this purpose, land use maps are based on the type of land use that describes the actual capacity of the recharge. Comparison between the potential absorption maps with the actual recharge map, yields a map of land conditions, see Figure 1.

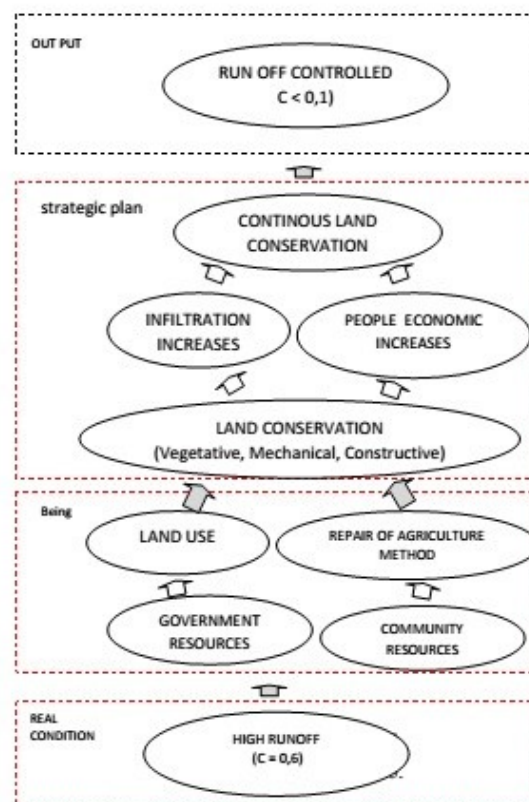


Figure 1. Strategy Map

## 3. Results and discussion

### 3.1. Watershed

In this study, watershed (DAS) Kemuning is divided into sub- watershed (sub-DAS) see Figure 2.

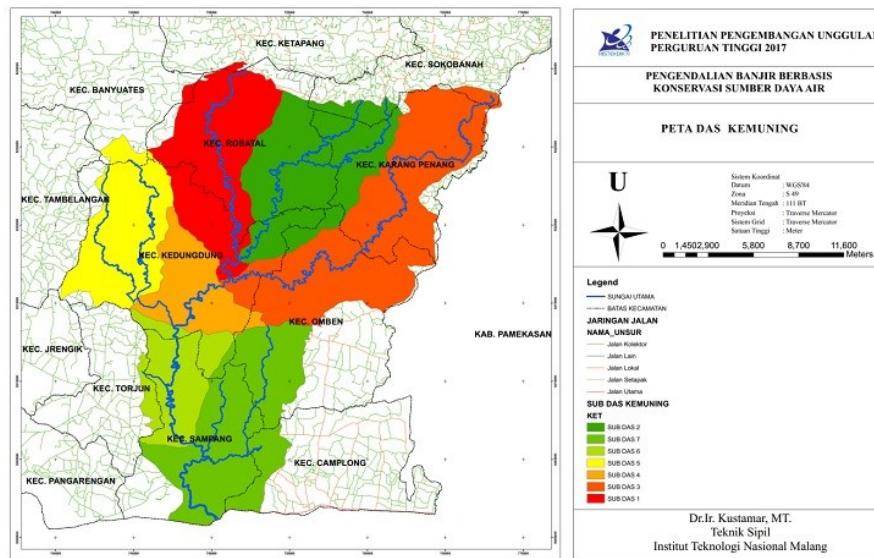


Figure 2. Kemuning Watershed

### 3.2. Conservation Strategy

The conservation strategy is structured with the orientation of reducing surface runoff water, increasing the amount of water infiltration into the land, increasing the groundwater reserves, and facilitating the injection of ground water. Conservation is selected by a combination of vegetative, mechanical, and constructive methods, and mobilizes the involvement of key actors in order to be effective and sustainable. See Table 1 and 2.

Table 1. Peak discharge before conservation ( $m^3/sec$ )

Period	Sub-DAS						
	1	2	3	4	5	6	7
Q <sub>2</sub>	104.57	111.71	114.12	95.56	56.25	79.51	82.19
Q <sub>5</sub>	124.32	133.15	173.81	153.11	71.22	109.27	115.28
Q <sub>10</sub>	137.22	144.68	213.32	191.21	81.14	128.97	140.00
Q <sub>20</sub>	150.13	153.42	251.23	227.76	90.65	123.23	167.32
Q <sub>50</sub>	164.64	162.19	300.29	275.07	102.95	172.33	200.95

Table 2. Peak discharge After Conservation ( $m^3/sec$ )

Period	Sub-DAS						
	1	2	3	4	5	6	7
Q <sub>2</sub>	47.06	55.16	57.55	76.13	18.32	33.61	36.44
Q <sub>5</sub>	55.95	65.73	87.51	121.96	23.19	46.19	51.11
Q <sub>10</sub>	61.75	71.42	107.35	152.31	26.41	54.52	62.07
Q <sub>20</sub>	67.56	75.73	126.38	181.41	29.50	52.10	74.19
Q <sub>50</sub>	74.09	80.05	151.01	219.09	33.51	72.86	89.10

### 3.3. Vegetative Conservation Land

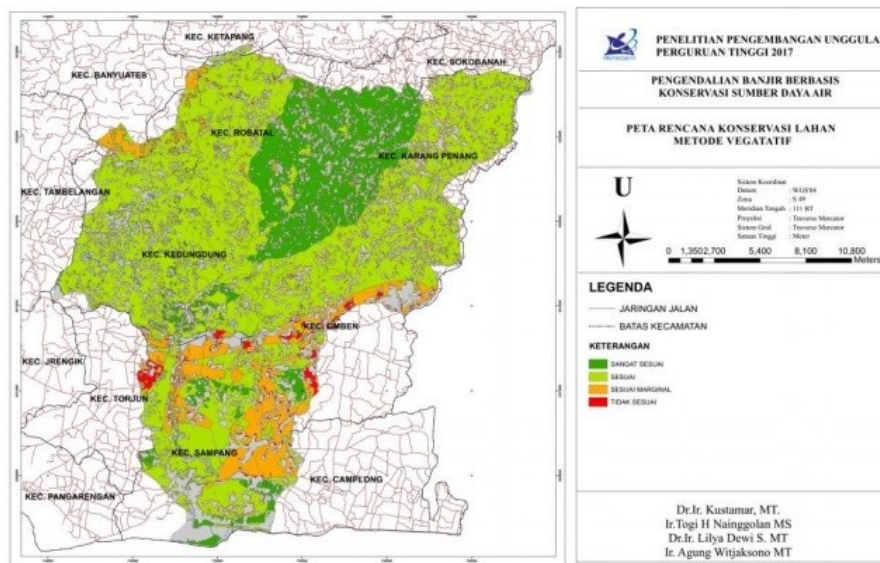
Land conservation in the Kemuning River Basin is focused on the lands of gardens, fields, and rice fields. This is in accordance with the strategy developed, since the width of these three types of land use dominates the watershed. The priority location is identified by the analysis of the condition of the land, which informs that the area of land is critical, critical, and critical start = 85%. The crop suitability analysis was conducted by comparing the growing requirements with watershed environmental

conditions. Compliance tests were performed on the crops: Mango, Guava, Tobacco, Elephant Grass, Corn and Rice.

With hydrological and economic considerations, the following plant types are selected:

1. Mango or Water apple with a combination of Elephant Grass (*Pennisetum purpureum* cv. Mott) in the garden,
2. Polowijo and Elephant Grass in the fields,
3. Rice and polowijo in the rice fields.

Mango and Water apple is a local plant, but it is recommended to be updated with more superior varieties to be more productive. Elephant Grass is a new variety that is suitable to be planted in the watershed area, and is intended to increase the stock of livestock feed, both cattle and goats. Vegetation conservation plans are shown in the Figure 3.



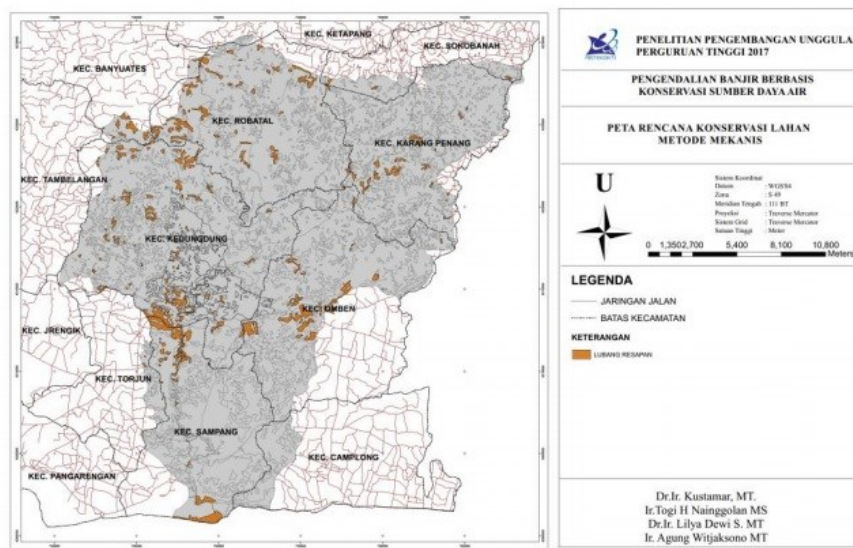
**Figure 3.** Plan of Vegetative Land Conservation

Planting location, Plant species and planting methods are important factors in vegetative conservation. The types of plants were selected based on the level of conformity between environmental factors at the planting site with the requirement of growing plants in the analysis of the condition of the land. The location of planting is selected in the priority area, that is critical area and very critical. The types of plants are selected from a hydrological, economic, and aesthetic point of view. Selection from a hydrological point of view, selecting plants with thick leaves and wide-brimmed and strong roots. In an economic point of view, the productive crop is the primary choice. However, it is better to choose the type of plants taken fruit. The selling value of the area will be built if the types of plants that are presented also form the beauty. In this case, vegetative conservation should also be formulated so that the area can serve as tourism.

#### 3.4. Mechanical Conservation Land

The concept of mechanical conservation is built with the orientation of land slope reduction and creates the effect of a catch above fields and fields. The slopes of the watershed topography are mostly less than 30%, so in reducing the slope the porch is applied (Figure 4).





**Figure 4.** Plan of Mechanical Land Conservation

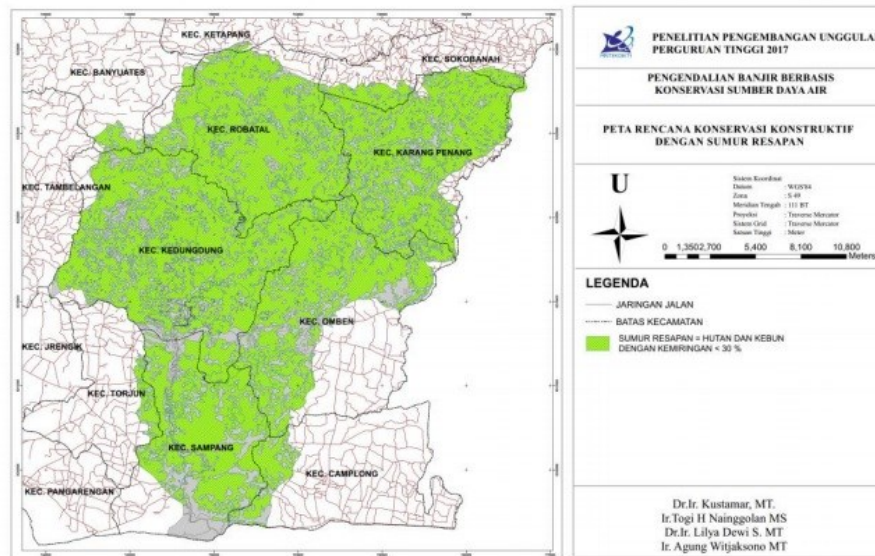
In the current field there is no bund, therefore it needs to be made bunds to form a "reservoir" on the land. While in the rice field area, the design of the embankment needs to be repaired so that the "reservoir" formed on top of the rice field is maximal. However, the height and duration of standing water must be controlled so as not to decrease agricultural productivity. The rainfall data used in this research is the daily rainfall data for the last ten years. For the analysis of land suitability and the potential for soil absorption, rain data is used in the base year of planning. As for the surface runoff discharge analysis, the rain is used with various re-rails. Limitations of debit and rain data in this study, in the hydrograph analysis of surface runoff discharges used synthetic unit hydrograph. From several existing models, based on the physical condition of the watershed is selected hydrograph model Synthetic Unit Nakayasu. Hydrograph surface runoff discharge at each sub-catchment is calculated based on hourly rain data with various unit hydrographs.

### 3.5. Constructive Conservation Land

Constructive Conservation Land in the form of wells in the fields and rice fields. Recess wells are made in fields and Rice fields with the amount and distribution of 1 unit per 2500 m<sup>2</sup> (Figure 5 and Table 3). The well serves as a recharge well to accelerate the decrease in the height of the normal puddle in the fields and in the rice fields.

**Table 3.** Decrease Peak Discharge (%)

Sub-DAS	1	2	3	4	5	6	7
DQ	55	51	50	20	67	58	56



#### 4. Conclusion

The control strategy of surface runoff discharge in DAS dominated by garden area, lading, and rice field with soil conservation method is effective enough to decrease the peak of debit up to 67%. Groundwater conservation of mechanical methods by making temporary water reservoir above plot fields and rice fields, able to accommodate water with a large enough volume. The use of absorbing wells to control the surface height of the fields and fields is very good, especially if the upper layers of the land are clay that is naturally difficult to take rain water. The combination of these three methods of soil conservation can decrease the surface runoff coefficient from 0.6 to 0.1.

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