Analysis of the green infrastructure implementation to the enhancement of environmental support capacity (Case study: Watershed outside University of Indonesia)

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Abstract. The several things to fulfil human needs are water resources, like household, laundry, industry and agriculture, the activities that reduce the availability of ground water and produce waste which makes the quality of river water decrease. This research was conducted in a catchment area outside University of Indonesia which is included in the Ciliwung watershed area which aims to increase the carrying capacity of water resources by carrying out a Water Governance approach by considering 3 aspects Place, People and Policy. The Place aspect or technical recommendations was an approach using the concept of WSUD (Water Sensitive Urban Drainage), the green infrastructure used are bioretention and constructed wetland by using ArcGIS, GitBola and SWMM for simulations of improving air quality and volume of runoff water reduction. The People aspect or stakeholders are conducted in-depth interviews or snowball interview with stakeholders and residents in the catchment to find out responses to green technology recommendations and stakeholder responses. The policy aspect makes appropriate policy recommendations that regulate the management of liquid and solid waste so as not to pollute water bodies, to improve the condition of catchments around University of Indonesia, making policy recommendations based on the technical aspects of green technology proposals, community or stakeholder responses and also based on existing policies or regulations from the central to the regional level.

1. Introduction
The University of Indonesia is located in the central sub-watershed area of Ciliwung and has 6 lakes of Lake Kenanga, Agatis, Mahoni, Puspa, Ulin and Salam where one of the lakes in the UI outlets is directly to the Ciliwung river, the inlet of the upstream lake in Rawa Besar and through 2 sub-districts and several kelurahan, so that all activities that occur in some special kelurahan through the inlet to Lake UI will affect Lake UI water quality and of course the Ciliwung River, this research takes place on the Mahoni inlet channel [1].

Population growth and increased activity around the UI campus greatly affect water quality and water quantity, ranging from changes in land use, increasing water demand, increasing the burden of household pollutants, industry and facilities in general, water scarcity in terms of quantity and decreasing quantity has become the main problem in Indonesia, especially the city of Depok, the vulnerability of UI catchments, in particular the mahoni inlet channel, is highlighted, the first is land use and the second
is population density in the drainage basin, based on depok in the population density calculation of 222372 people with an area of 14.30 km², the population density is 15550.5 inhabitants / km² [2].

Figure 1. Left Cijantung watershed and right UI Water Management System.

2. Methodology
Integrated Water Resources Management (PSDAT) is a process aimed at improving the development and management of water, land and related resources in a coordinated manner to achieve maximum economic and social welfare in a manner that is fair and absolutely maintains the sustainability of vital ecosystems, population, settlements and pollution, this research will be assessed the level of disaster risk to the mahoni inlet channel by using three parameters namely the level of hazard, the level of vulnerability and the level of capacity in responding to the disaster risk so that mitigation measures are obtained, mitigation measures conduct research to increase the carrying capacity of water resources by taking a water governance approach by considering 3 aspects, the first is from a technical / Place perspective, the second is the stakeholder / People and the third is a policy recommendation / Policy that can be applied.

The first parameter of risk level assessment is the level of hazard, a survey is carried out along the channel to find out the condition around the channel and is sampled at one of the MSMEs to find out how much pollutant content is produced. The second parameter is the level of vulnerability, this phase is based on the population density because it has a direct impact on disaster risk. The third parameter is the level of capacity of the area to respond, this stage is the location of the waste disposal center, because the closer the distance the higher the capacity value of the area.

Mitigation measures with a water management approach that has three important aspects, namely Place, People and Policy, place aspects, namely technical recommendations for planning green infrastructure technology with the help of ArcGis, GitBola and SWMM softwarers for simulating the technology, People / policy stakeholder recommendations are carried out in-depth interviews to the stakeholders, business actors and the community at the research site, the interview method uses the snowball theory, the question points that will be asked to stakeholders are three aspects namely capacity, information and accountability, question points for the people living in the location and play a role in quantity and quality of water, namely aspects of knowledge about water resources, aspects of management of water resources and legal aspects about water resources, in addition to interviews also provide information about recommendations technical, along with its benefits, while for the technical
recommendations that have been simulated from several recommendations where the land is privately or publicly analyzed, the response to participation in the application of green infrastructure technology can be at their own expense, willing with government assistance or not, and for location Publicly owned land can also be seen from the response of stakeholders to the availability of land for the application of green infrastructure through the interview.

3. Preliminary Results
Based on survey results along the mahoni inlet channel there are several analyzes of potential water quality hazards, as follows:
- Most of the domestic waste disposal is directly channeled into the drainage network.
- Home industries such as laundry, washing vehicles or culinary businesses, dumping waste directly into the drainage network.
- There is no water management for both domestic and industrial wastes.

Pollutant sources are Detergents, TSS, Oils and Fats. The conditions around the Mahoni channel

![Figure 2. Mahoni inlet 1.](image)

3.1. Level of disaster risk
Research conducted at Mahoni Lake calculates the burden of pollutants entering Lake UI that conditions are increasingly compliant with and according to the Standards of Quality of Domestic Domestic Water Regulations [3] the parameters studied are.

| Table 1. Sample quality testing results on Depok campus water waters. |
|---|---|---|---|---|---|
| Parameter | Units | Quality Standard | Result | Depth | Width | Discharge |
| BOD | mg/L | 2 | 14 |
| NO3, as N | mg/L | 10 | 0,04 |
| Turbidity | NTU | - | 19,9 |
| TSS | mg/L | 50 | 98 |
| Total Phospat as P | mg/L | 0,2 | 0,46 |
| pH | mg/L | 6 to 9 | 6,79 |

And research conducted in one of the community SMEs activities in the urban area of Steamers is the laundry business, the results of lab testing on water quality produced from the laundry business TSS parameters according to laboratory results of 170 mg / L, the water quality studied is Total Suspended Solid (TSS), because the conditions in the lake TSS levels exceed the quality standard, and also the impact of TSS on water quality can cause a decrease in water quality. This condition can cause
disturbance, damage and danger to all living things that depend on water resources. TSS causes turbidity and reduces the light that can enter the water, as long as the inlet channel does not have self purification, the channel which is downstream will experience the highest levels of pollutants, the more downstream the TSS concentrations get higher, so the potential for danger in the channel can be seen in the image below.

Based on the delianiation calculation from ArcGIS, the area of das mahoni is 86.68 Ha with a land cover in the form of a building of 46.06 Ha, land cover is assumed to be a residential area, by dividing into 3 sub-areas based on the elevation at that location where the highest elevation is at 87 masl and the lowest elevation is at elevation 65 masl, with an area of land cover sub-area 1 12.31 Ha with a population based on the assumption of population density the previous calculation became 1914 inhabitants, sub-area 2 an area of 10.59 Ha with a population of 1647 inhabitants and sub-area 3 an area of 23.16 Ha a population of 3602 people, The parameters of vulnerability class population based on BNPB low class below 2500 people, medium class between 2500 to 5000 people and high class above 5000 people who are exposed or affected, with these parameters the distribution of vulnerability levels is illustrated in the figure 3.

![Figure 3](image.png)

**Figure 3.** Left the level of potential danger of the mahoni inlet channel and right map of distribution of mahoni inlet populations.

Regional capacity in the implementation of disaster management is an important parameter to determine success for disaster risk reduction. Regional capacity in disaster management must refer to the National Disaster Management System contained in Law No. 24/2007 on Disaster Management and its regulations, the final disposal site in the mahoni inlet channel area does not have a lying disposal site, most of each house has a micro TPS collected by the cart operator and then taken to the nearest landfill, the Cipayung Landfill, the closest distance from the Cipayung Landfill to the mahoni inlet around + - 3 km and the farthest + - 9 km, with low level parameters below 4 km, medium level between 4-8 km and high levels above 8 km, based on this radius the capacity level in the base is explained in the figure 4.

### 3.2. Hazard

The research carried out at a community SME activity in the village of kukusan namely the laundry business obtained laboratory testing results about the quality of water produced from TSS laundry parameter business according to laboratory results of 170 mg/L.

Population growth and increased activity around the UI campus greatly affect water quality and water quantity, ranging from changes in land use, increasing water demand, increasing the burden of household pollutants, industry and facilities in general, water scarcity in terms of quantity and decreasing quantity have become the main problem in Indonesia, especially the city of Depok.

Research on the role of lake ui catchment communities on UI catchment management concludes that community behavior that pollutes water quality includes the presence of solid waste disposal into rivers [4], the majority of gray water flow directly flows into the channel without special treatment and the
existence of black water disposal directly into water bodies and suggested a more massive approach to make the research partner community to be approached by other stakeholders such as higher government heads, it is also necessary to enforce the law or regulations governing the management of liquid and solid waste so as not to polluting water bodies.

As long as the inlet channel does not have self purification, the channel which is downstream will experience the highest levels of pollutants, the more downstream the TSS, BOD and COD concentrations are higher, so that the potential danger to the channel can be seen in the figure 4. In its implementation, the risk assessment uses the following general formula by RBI (Indonesia Disaster Risk):

$$R_{risk} = \frac{Hazard \times Vulnerability}{Capacity}$$  \hspace{1cm} (1)

The parameters of the low class risk level are 1, medium class 2 and high class are high, with the above hazard, vulnerability and capacity parameters the water quality risk level in the mahoni level can be calculated with the risk level explained in the table 2.

*Figure 4. Left Administrative boundary of mahoni inlet channels and Right Map of mahoni inlet capacity.*

| Subcatchment | Hazard | Vulnerability | Capacity | Risk = H x V / C |
|--------------|--------|---------------|----------|-----------------|
| 1            | 3      | 1             | 1        | 3               |
| 2            | 2      | 1             | 2        | 2               |
| 3            | 1      | 2             | 3        | 2               |

The parameters of the low class risk level are 1, medium class 2 and high class are high, with the above hazard, vulnerability and capacity parameters the water quality risk level in the mahoni level can be calculated with the risk level explained in the table below:

Can be concluded that:

- Sub-area 1 high risk level
- Sub-area 2 moderate level of risk
- Sub-area 3 low risk level

3.3. Technical recommendation

Place or technical aspect is approached with the concept of WSUD (Water Sensitive Urban Drainage). WSUD is a land planning and design engineering approach that integrates urban water cycles, including rainwater, groundwater, waste water and clean water management, into the design of an urban area to minimize environmental damage and increase aesthetic appeal and recreation, the benefits of applying the Water Sensitive Urban Design concept in the development of an area, some of which are improve water conservation, reducing the risk of flooding and realizing the concept of green infrastructure,
The green technology chosen in this study is bioretency and construction of wetlands with ArcGIS, GitBola and SWMM simulations for simulating water quality improvement and decreasing runoff volume, location selection is the mahoni lake inlet located south of the UI campus, green technology selection is Bioretensi and Wetland Construction, Performance of green infrastructure based on studies in various locations such as the following:

3.3.1. **Bioretensi.** Based of study Adoption Guidelines for Green Treatment Technologies. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities bioretensi can reduces Stormwater Pollutant removal range: TSS: 53% (-12% up to 92%) TP: 46% (-7% up to 75%) PO4: 45% (4% up to 75%) TN: 25% (-24 % up to 68%) [5].

3.3.2. **Wetland construction.** Based of study A review on the sustainability of constructed wetlands for wastewater treatment: design and operation. Wetlands built with water surface TSS, COD and BOD: 70-80% TN: 60 - 75% TP: 13-75% [6].

The delineation process uses ArcGIS and GitBola software with an accuracy of 1: 400, land cover is divided into four namely buildings, green open spaces, roads and water bodies (situ and channel), the delineation results can be used to help the GitBola process and simulations in SWMM that calculate water runoff and water quality before and after green technology.

4. **Hypothesis and discussion**
The results of this study can later produce appropriate recommendations and can be applied based on previous research sources and simulation data sources. It is expected that the policy recommendation parameters for this research are divided into several choices which are certainly based on applicable regulations, choices of policy recommendations namely:

- From the technical recommendations suggested whether / it has been regulated in the policies and regulations;
- From the stakeholder's recommendations if the community is willing to play a role in the application of technical recommendations whether they have been supported in policies and regulations;
- From the stakeholder's recommendations if the community is not willing to play a role in the application of technical recommendations whether the government has policies and regulations that govern the alternatives.
- Policy recommendations based on existing regulations there needs to be a law regarding the rules of green infrastructure technology ranging from the terms of use, technical guidelines, the definition of green infrastructure to the responsibility for managing green infrastructure to whom, but all there needs to be a relationship between stakeholders and the community with deep interview.

Based on the recommended parameters of the policy which includes increasing capacity, allocating water resources efficiently, improving administration, functional and hydrological.

5. **Conclusions**
Because the results of this thesis have not yet been completed, this paper wants to show the methodology being carried out in the research and fill hypotheses about the analysis of the application of green infrastructure in the community environment and appropriate policy recommendations for its application. In the future, the community's response to green infrastructure and this method is expected to be a tool for implementation in various locations.

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