The impact of tin mining in the Pompong watershed on vegetation sustainability to maintain environmental quality

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Abstract. Over the past 10 years, the POMPONG watershed has experienced a drastic change in land use, from agricultural to gradually becoming residential and mining area. Mining activities carried out in the Pompong watershed result in changes the characteristics of the watershed and the presence of vegetation that functions as land cover. Therefore, this study aims to investigate the extent of the impact caused by tin mining activities on the survival of vegetation to maintain environmental quality. The data of vegetation type was obtained through field observation. Besides, several maps of the Pompong watersheds, such as watersheds and river networks, land use, soil types, land slopes, contour, topographic and administrative boundaries were needed. These maps were obtained from several related agencies. Data processing and analysis used ArcGis 10.1. The observation results showed there are four types of vegetation, namely secondary-dryland-forest, dryland-agriculture, dryland-agriculture-mixed-with-shrubs, then bush-and-shrub. The research results indicated there was a change in the function of the land from dryland-agriculture-mixed-with-bush to mining by 0.327%. The existence of these vegetations affect the ability of surface water absorption. Therefore, it is better to use vegetative methods in managing the conservation of land around the Pompong watersheds.

1. Introduction
Over the past 10 years, the POMPONG watershed has experienced a drastic change in land use, from agricultural to gradually becoming residential and mining area. Mining activities carried out in the Pompong watershed result in changes the characteristics of the watershed and the presence of vegetation that functions as land cover. Therefore, this study aims to investigate the extent of the impact caused by tin mining activities on the survival of vegetation to maintain environmental quality. The decline in environmental quality that occurs in the Pompong watershed is influenced by changes in land use in the watershed. This is due to the Detailed Spatial Planning (RDTR) of the Sungailiat Urban Area 2010-2030 [1] which converted the areas in the Pompong watershed for residential use, such as the areas in Sungailiat, Kuday, Karya Makmur, Air Ruai and Pemali. In addition, mining activities carried out on the other side of the Pompong watershed (Penyamun Village, Pemali District) also accelerate environmental damage. As a result, the land use change has impacts on vegetation change which affect surface flow velocity [2].
2. Research Method
This research requires secondary and primary data. Secondary data such as land use, soil types, and land slopes were obtained from BPKH Region XIII Pangkalpinang [3], while primary data like the vegetation types and the impacts due to mining activities in the Pompong watershed were obtained through direct observation in the field.

2.1. Data collection
The needed maps needed to the Pompong watershed are the maps from 2000, 2003, 2006, and from 2009 to 2018. The primary data taken in this study consisted of 2 (two) types of data, namely the type of vegetation (land cover plants) and changes in land use in the Pompong watershed. The identification of vegetation types and the impacts due to mining activities is carried out by observing the condition of the Pompong watershed for one week. The identification is done by manual recordings and taking the vegetation documentation.

2.2. Data analysis
Data processing and analysis use ArcGis 10.1. Data analysis uses descriptive methods to determine the impact of mining activities and the needed treatments for the vegetation sustainability so that the environmental quality can be maintained. Primary and secondary data processing use ArcGis 10.1 software. This software is used for determining land use change, land slope, and soil type. Furthermore, the output data from ArcGis 10.1 are analysed to discover information of the sustainability of vegetation to maintain environmental quality. From the research results obtained, recommendations could be given to the parties concerning on the environmental quality improvement in the Pompong watershed.

3. Research Results
The results of this research were grouped into three categories, namely the characteristics of the Pompong watershed, the impact of mining activities, and the types of vegetation in the Pompong watershed.

3.1. Characteristics of the Pompong watershed
The characteristics of a watershed (DAS) are influenced by factors of land use, soil type, and slope [4]. This characteristic also affects the land's ability to retain water. The first factor is land use. The land use in the Pompong watershed is shown in Figure 1.

![Figure 1. Land Use in the Pompong Watershed](image)
Land use is divided into six groups, namely: shrubs/shrubs, open land, water bodies, dry land agriculture, dry land mixed with shrubs, and mining. In 2012-2013, there was a change in land use of 0.557 km$^2$ (0.724%) from shrubs/shrubs to secondary dryland forests. In 2014-2015, there was a change in land use by 5.477 km$^2$ (7.111%) from open land to dry and mixed shrubland. This is because the open land that is neglected is overgrown by plants with the main function of producing fruit and agricultural products. Among these, the plants are still mixed with shrubs between the distances of the plants. In addition, in 2015-2016 there was a change in land use of 13.497 km$^2$ (17.525%) from dry land agriculture to residence. Furthermore, the most common land change use found was from dry land farming mixed with shrubs to mining at 0.252 km$^2$ (0.327%).

The second factor is the type of soil. Soil type is influenced by grain shape, density, and soil water. These properties greatly affect the infiltration rate so that surface runoff is obstructed. The mapping of soil types in the Pompong watershed is shown in Figure 2 below.

![SOIL TYPE MAP OF POMPONG WATERSHED](image)

**Figure 2.** Map of soil type

The soil in the Bangka Regency area has an average Ph less than 5 and contains tin ore minerals. Soil types in the Pompong watershed are divided into three groups, namely alluvial, red yellow podzolic, and brown podzolic. Soil types in the Pompong watershed are mostly dominated by red and yellow podzolic with an area of 61.992 km$^2$ (80.496%). The alluvial was 14.540 km$^2$ (18.880%) and the podzolic brown was 0.481 km$^2$ (0.624%). Red-yellow podzolic and alluvial are almost scattered throughout the area in the Pompong watershed, while brown podzolic are only scattered in a small part of the Pompong watershed area, namely in Pemali Village, Sungailiat Village, and Kuday Village.

The last factor is slope of the land. The level of slope of the land affects the amount of the flow coefficient, meaning that the steeper or the greater the percentage of the slope of the land, the greater the surface runoff. In other words, there is a linear relationship between the slope of the land and the flow coefficient. Mapping of land slope in the Pompong watershed is shown in Figure 3 below.

The Pompong watershed varies from flat (0-8%), gently sloping (> 8-15%), rather steep (> 15-25%) and very steep (> 40%). The type of land slope in the Pompong watershed is mostly dominated by the type of slope (> 8-15%) with a percentage of 63.312%. Furthermore, the slope of flat land (0-8%) with a percentage of 19.819%. The slope of the land causes flooding and inundation, especially in low-lying areas in the downstream area.
The slope of the land is rather steep (> 15-25%) and found in the Pompong watershed, amounting to 12.465%. The type of land slope is very steep (> 40%) which is the least found in the Pompong watershed of 4.404%.

![Land Slope Map of Pompong Watershed](image)

**Figure 3.** Map of land slope

### 3.2. Impact of tin mining activities

Mining activities carried out by the community in the Pompong watershed area are against the regulations issued by the local government [5]. Observations show that changes in land use in the Pompong watershed due to mining activities have an impact on local natural ecosystems. This phenomenon causes a decrease in the quality of the environment, namely natural resources such as soil and biodiversity as well as changes in the behavior of water systems (hydrological cycle) and biodiversity.

In addition, mining activities could also cause changes in the hydrological cycle. In the form of changes in surface water behavior and function, namely decreased base flow and increased surface runoff. This results in a hydrological imbalance. Changes in land use due to mining activities in the Pompong watershed amounted to 0.327% in Penyamun Village, which contributed to environmental damage due to mining by 30.001% (23.104 km²).

### 3.3. Vegetation types in the Pompong Watershed after mining activities

The results of observations show that the grouping of vegetation types is the same as the information obtained from BPKH Region XIII [3], namely: secondary-dryland-forest, dryland-agriculture, dryland-agriculture-mixed-with-shrubs, then bush-and-shrub.

The description regarding to the vegetation group is (a) Secondary Dryland Forest. Land cover in the form of forest that is still natural or free from human intervention is categorized as secondary dryland forest [2]. This forest is located in Bukit Betung, Karya Makmur Village.
(b) Dry Land Agriculture. Dry land farming [2] is located in the vicinity of the Pompong River and is scattered in Sungailiat Village, Kuday Village, Karya Makmur Village, Air Ruai Village, Pemali Village, Penyamun Village, and Air Duren Village. The land cover is in the form of cassava, serial trees and coconut trees which are categorized as dry land agriculture around the Pompong river, namely in the Air Segambir Bridge, Sungailiat Village.
(c) Dry land mixed with shrubs. The land cover in the form of dry land mixed with shrubs [2] is around the Pompong river, namely in Air Ruai Village in the form of oil palms, serial trees,
and fern leaves mixed with shrubs in the distance between the plants. (d) Shrubs and Scrubs. Land cover in the form of shrubs and shrubs [2] that grow in very close (dense) distances found in the downstream area of the Pompong River, namely Kampung Pasir, Kelurahan Sungailiat

4. Discussion

From the results obtained, there are four things that need to be discussed regarding to the impact of tin mining in the Pompong watershed on the sustainability of vegetation to improve environmental quality, as described below.

4.1. The impact of tin mining activities on the sustainability of vegetation in the Pompong watershed

Human activity is very influential on vegetation cover change [6], [7]. Therefore, regulations related to mining activities need to be reviewed in relation to the pollution and urban vegetation and ecosystem services [8]. Another impact that has been generated is a decrease in environmental quality (environmental degradation) in the Pompong watershed, so that land restoration measures to rebalance land functions need to be carried out. Other impacts resulting from mining activities include the disruption of the sustainability of the hydrology and vegetation of the Pompong watershed so that water flow cannot be maintained [9]. Furthermore, disturbed vegetation as a result of mining can lead to reduced rainfall [10] and water drainage [11].

4.2. The relation of vegetation to soil quality

Soil type and land slope determine the type of vegetation that can grow [12], [13] in the Pompong watershed, including natural vegetation. Natural vegetation is a plant that grows without human aid and is not disturbed by human activities for the long term. Vegetation growth could be in the form of short plants or tall plants, where grass and shrubs are included in the short plant category. In addition, soil water also affects vegetation characteristics [14]. Furthermore, the type of vegetation affects the availability of mineral phosphorus (P) in the soil system [15], where tree species can have an impact on the amount of P availability in the Pompong watershed.

4.3. Countermeasures to maintain the sustainability of vegetation in the Pompong watershed

Countermeasures need to be done to reduce the impact of mining activities in the Pompong watershed: (a) Vegetation restoration. This method has been successfully applied in Wuqi, China, especially in the south-eastern part [16]. The factors that influence this method include natural factors. Vegetation restoration has a very positive impact on environmental improvement [17], [18]. However, the type of soil and its water conservation should be noted. Inaccurate determination of plant types could result in high-risk soil erosion in watershed. Therefore, plant maintenance management needs special attention.

(b) Program for integrating natural vegetation potentials into ecosystem compatibility. This program is to maintain the balance of the ecosystem [19] by taking into account climate change. Natural vegetation is very important to maintain the ecosystem [20] in the watershed, but in this case stakeholders play an important role on the planning, implementation, monitoring, and assessment stages [21] to protect vegetation in the Pompong watershed area. Evaluation of the RDTR [1] also needs to be done to avoid conflicts between policies in different institutions. Furthermore, (c) the Stabilization of acid soils due to waste from tin mining should be undertaken. This stabilization aims to reduce the acidity of the soil using the biochar (BC) and plantation of palmarosa Cymbopogon martini (Roxb.) Wats method [22]. This method is specifically used for highly acidic mine waste to restore the quality of the watershed environment.

5. Conclusion

The research results indicated there was a change in the function of the land from dryland-agriculture-mixed-with-bush to mining by 0.327%. The existence of these vegetations will affect the ability of surface water absorption. Therefore, it is better to use vegetative methods in managing the conservation of land around the Pompong watersheds.
Resources conservation and sustainable development are essential for the maintenance of ecosystems and the achievement of long-term environmental sustainability. This section provides a comprehensive review of the literature on sustainable practices, emphasizing their importance in managing natural resources.

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