Land use, climate parameters and water quality changes at surroundings of Code River, Indonesia

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Abstract. Regional development of an area has the potential adverse impact on land use, vegetation, or green space. The reduction of green open space is known to contribute to global warming. According to the Intergovernmental Panel on Climate Change (IPCC), global warming has become a serious and significant phenomenon in human life. It affects not only ecological environment but also social and cultural environment. Global warming is a rise in global annual temperature due to, one of which, greenhouse gases. The purpose of this research is to determine the effects of land use change on water pollution and climate parameters at Code river. The results showed that Code River is experiencing land use conversion. Rice field was the most extensively reduced land use, by 467.496 ha. Meanwhile, the other land uses, namely plantation, grass, and forest, were reduced by 111.475 ha, 31.218 ha, and 1.307 ha, respectively. The least converted land use was bushed, whose decreased 0.403 ha. The land use conversion in the study area deteriorated the water quality of river, as proven by the increasing trend of COD and BOD from 2012 to 2016. The COD from 2012 to 2016 was 14, 16.6, 18.7, 22.5, and 22.8 ppm, respectively. Meanwhile, the BOD from the same observation years was 6, 7.2, 8.9, 9.3, and 10.3 ppm, respectively.

1. Introduction
Regional development in an area has a potential adverse impact on land use, vegetation, or green space. Land use change is the conversion of one land use into another, which suits the objectives of human activities in fulfilling their needs. Therefore, the conversion includes a shift of the land’s function. Along with the expansion of housing construction, the function of green space is increasingly turned into a built-up area or, in other words, the extent of green space constantly diminishes. The availability of green space plays a major role in the arrangement of the integrated area along Code River, particularly to compensate buildings density. Land use conversion also disturbs the hydrological cycle. In the middle of this cycle, water is retained and stored (temporarily) in rivers, lakes or reservoirs and soil, providing a chance for humans and other creatures to utilize it [1].

Open green space plays a role in provide shade from the warming environment and as a medium for the people along the upper Code River to socialize and interact with nature. The actualization of green space is an initial effort to raise awareness of media that promote environmental harmonization especially regarding the decreasing availability of clean and healthy air supply due to environmental degradation along the river.
According to the Intergovernmental Panel on Climate Change [4], global warming has become a serious and significant phenomenon in human life. It affects not only ecological environment but also social and cultural environment. Global warming is a rise in global annual temperature due to, one of which, greenhouse effect. In general, the presence of green space along Code River is expected to reduce global warming and air pollution level in the Special Region of Yogyakarta. Therefore, an awareness of green space preservation and function restoration, i.e., as an absorber of global warming, becomes necessary. Such awareness can at least start from the process of ‘thinking together’ with the local people in the study area as the smallest scope. This process is expected to contribute a greater thought to the other regions around Code River to preserve and organize the open green space as part of urban open space, which plays a major role in the sustainability of the living beings around it.

Relying on the potential of green space, the concept of the spatial planning in the study area is expected to harmonize the existence of vegetation, as well as the ecological environment, with the development of regional infrastructure. The harmonization helps achieve the objectives of sustainable development and overcome the current global warming problems. The purpose of this research is to determine the effects of land use change on water pollution and climate parameters at Code river.

2. Methods

This research took place at Code Watershed in the Special Region of Yogyakarta. The secondary data was acquired from related institutions, while the primary data was obtained from interviews with the major figures in the community. The interviews aimed to dig information of the geographic condition and topography along Code River and to collect data on settlement areas. The research data includes land use map, climatological data (i.e., rainfall and air temperature) in 1976-2005 [2], and the water quality of Code River in 2012-2016 [3]. These data were analyzed using a descriptive method. The determinants of land use conversion consist of physical and biological factors, economic considerations, and institutional factors. The physical factor includes suitability to the physical properties of an area, such as geology, soil, water, climate, and population, while the biological factor consists of flora and fauna. As for the economic consideration, it represents profitability, market condition, and transportation. The institutional factor is the role of government in regulating and organizing an area.

The land use in the study area is divided into nine classes, as presented in Figure 1. Figure 1 shows that the dominant land use in 2012 and 2017 is settlements. Referring to the administrative boundaries, almost all of the land in Yogyakarta City (at the center of the Special Region of Yogyakarta) is used for settlements. The study area is located in the tropics, specifically in the south of the equator and in the western part of Indonesia. Consequently, it is strongly influenced by the east-southeast and west-northwest monsoonal climate. The rainfall in the Special Region of Yogyakarta is thereby categorized as having a tropical rain climate.

Rainfall events are recorded by rain gauges, which are installed at rain stations in predefined locations. Therefore, to identify the rainfall events in the study area, the research used a set of rainfall data obtained from various rain stations. In addition to rainfall data, this research used temperature data from a weather station owned by the Indonesian Agency for Meteorology, Climatology, and Geophysics. This station is located in Adi Sucipto International Airport at an elevation of 350 m above sea level. It records both daily rainfall and temperature. The methods for identifying land use change by analyzing land use maps. The water sampling used water sampler, by taking river water at the middle and left part of the river then mixed as a composite. Sampling is done every year for 5 years at the same point. Laboratory analysis of using spectrophotometric method, BOD analysis using Winkler method (volumetric titration), and COD analysis with potassium permanganate, with spectrophotometric method.
3. Results and discussion

3.1 Land use change in Code Watershed
The analysis of land use change not only concerns on the conversion of forest to non-forest (settlement) land use, but it also includes the analysis of each land use change. From the perspective of urban development, the rapid growth of elite settlements (public housing) and various trading sites is the main factor of land use change.

![Figure 1. The Land Utilization in Code Watershed in 2012 and 2017](image1.jpg)

![Figure 2. Land Use Change in the Study Area in the Last Five Years (2012-2017)](image2.jpg)
The extent of land use change, as presented in Figure 2, was calculated from the analysis of land use maps in 2012 and 2017. The negative (-) sign presents diminished extent for each type of land use. Settlements are the land use increased extensively in the study area, i.e., from 1,535.505 ha in 2012 to 2,127.088 ha in 2017. In these years, the settlement area has increased by 591.583 ha or 118.316 ha per year. The extensive land use conversion to settlement in 2012-2017 was caused by population growth. On the contrary, rice field continuously decreased, from 2012 to 2017 shrank by 467.496 ha or 93.4992 ha per year. Furthermore, within five years, the areas of some other land uses also became smaller, namely plantation area (decreased by 11.475 ha or 22.295 ha per year) and grass (31.218 ha or 6.2436 ha per year), forest (1.307 ha or 0.2614 ha per year). As for shrubs and bushes experienced the smallest reduction, i.e., 0.403 ha or 0.10075 ha per year. The constantly diminishing open green space leads to climate change.

3.2 Rainfall and air temperature changes

3.2.1 Rainfall. The largest source of groundwater in the world is rainwater, which makes regional precipitation the determinant of groundwater potential in an area. When a high rainfall is complemented with highly permeable aquifer and suitable land use, the groundwater resource becomes highly reliable. The data consists of monthly rainfall, i.e., from January to December, in 30 years, as presented in Figure 3.

![Figure 3. The fluctuation of rainfall in 1976-2005](image)

\[ y = 10.39x - 18716 \]
\[ R^2 = 0.04 \]

3.2.2 Air Temperature. Such conversion decreases the open green space and hence, raises the air temperature. The air temperature records in 30 years (1976-2005) are depicted in Figure 4.

![Figure 4. Air temperature rise in 1976-2005](image)

\[ y = 0.1152x - 195.65 \]
\[ R^2 = 0.871 \]
The annual air temperature rise in the study area is caused by the reduction of open green space. A temperature rise is observable from 30-year time series data. Figure 4 shows that the annual temperature increase in the study area is 0.115°C.

3.3 Water quality of Code river
The land use change from agricultural areas to settlements indicates an expansion of residential areas, or in other words the population density also increases. Population growth increases the number of household wastes disposed into the river. Consequently, the concentration of domestic waste in the river also increases, which deteriorates the water quality of Code River. The analysis results of the water quality data in the study area (Sayidan Bridge, Gondokusuman) in 2012-2016 are presented in Figure 5.

![Figure 5. Increasing pollution in Code river from 2012 to 2016](image)

Figure 5 shows an increase in the concentrations of COD, BOD, and Nitrate at Code River. The deterioration of river water quality in the study area is indicated by the annual increase of COD (i.e., 2.35 ppm), BOD (i.e., 1.07 ppm), and Nitrate (i.e., 0.78 ppm), all of which are caused by the conversion of many types of land use to settlements. The expansion of residential area is likely followed by population growth as well as the constantly increasing volume of waste disposal to the river. In this case, a larger settlement leads to the deterioration of river water quality.

Considering those changes, an environmental management dealing with global warming and climate change become necessary. The preservation of open green space and the cultural movement of tree planting significantly increase the vegetation cover in an area. Areas with critical land degradation can adopt the following management strategies: planting perennials, using natural energy source, and forbidding logging to maintain water storage and filtration (especially during continuous rain events). Bare land is also susceptible to landslides because the absence of tree roots makes the soil easily eroded and transported by water.

4. Conclusion
The land use conversion along Code River is quite extensive. In five years (2012-2017), many types of land use were converted to settlements (591.583 ha or 118.3166 ha per year). This extensive conversion is caused by the population growth. The mostly decreased land use was rice fields (467.596 ha), followed by plantation (111.475 ha), grass (31.218 ha), forest (1.307 ha), and shrubs and bushes (0.403 ha) as the least affected land use. The land use conversion in the study area reduced the
extent of open green space but widened the residential area. Consequently, it causes a greater volume of domestic wastes, air temperature rise, and the deterioration of river water quality, as indicated by an increase in the concentrations of COD (2.35 ppm per year), BOD (1.07 ppm per year), and Nitrate (0.78 ppm per year). An environmental management dealing with global warming and climate change become necessary.

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