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# The impact of urbanization on environmental degradation in Jakarta

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## ABSTRACT

**Background:** The urbanization discussed in this paper refers to the process of expansion in the proportion of the population living in urban areas. Urbanization is one of the population-growth processes that drives a region's functional transition from rural to urban activities. The case discussed in this paper is urbanization occurring in Jakarta city. This paper aims to examine the relationship between urbanization and the decline in environmental quality. **Methods:** In assessing environmental quality, the reference used follows that set by the Ministry of Environment and Forestry, namely the Environmental Quality Index (EQI), which consists of three elements, namely the Water Quality Index (WQI), Air Quality Index (AQI) and Land Cover Quality Index (LCQI). The data collection method used is secondary data collection through a literature review and official data sources from related stakeholders. The collected data is then descriptively analyzed to determine how urbanization affects each variable**. Findings:** Based on the literature review and the results of the LCQI data used, there is a negative correlation between population growth and land cover in Jakarta. This condition is marked by an increase in floods and an increase in surface temperature. Regarding air quality, this paper found a negative correlation between urbanization and AQI. However, from 2013 to 2018, a positive correlation was found between the population and AQI. **Conclusion:** This indicates that an increase in population is not always followed by a decrease in environmental quality. Meanwhile, concerning water quality, population growth from the urbanization process significantly impacts water quality in Jakarta. **Novelty/Originality of this article:** The development of a sophisticated and comprehensive correlation analysis method between population growth and environmental quality indicators provides a predictive tool that city governments can use to monitor, manage, and plan mitigation strategies, as well as support data-driven decision-making in sustainable urban planning.

**KEYWORDS**: decline; environment; influence; quality; urbanization.

## 1. Introduction

Countries worldwide have entered the period of the urban society age, as in 2008, more than half of the world's population had become urban residents (Zhao et al., 2010). This condition is an empirical depiction of the urbanization process. Urbanization is not only seen as the migration of people from rural to urban areas but also as a process of forming urban areas spatially, economically, and socially (Iaquinta and Drescher, 2000; Brenner, 2013). The urbanization process is viewed as a driver of growth in a region. This process has successfully promoted increased productivity, innovation transfer, and reduced economic costs (Adhikari, 2016). However, it is also associated with negative externalities in several development sectors.

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The rapid urbanization process has brought changes to the environment. The impacts include a decline in ecosystem service capabilities (Radford and James, 2013; Lyu et al., 2018), degradation of environmental quality such as air and water pollution (Babatunde, 2014; Xu et al., 2018; Wang et al., 2020), and increased environmental vulnerability (Qiu et al., 2015). All regions do not uniformly feel these negative impacts of urbanization. Differences in management systems, policies, and financial backgrounds will significantly influence this (Xu et al., 2019). Conditions in developed and developing countries will show different tendencies in experiencing these negative externalities from the process.

The urbanization process in developing countries tends to show more pronounced negative impacts. Urbanization in these countries often leads to various social and economic issues that concern the government (Troin, 2018). Previous research indicates that the pattern of urbanization in developing countries tends to blur the functional boundaries between urban and rural areas. The disappearance of these boundaries allows urban activities to expand more freely into rural areas. This encourages unplanned activities where environmental protection and urban sustainability are poorly predicted or managed (Babatunde, 2014). New urban activities in rural areas tend to negatively impact the environment (Lin et al., 2017). Given this situation, we selected the Jabodetabek metropolitan area as the study area to examine how the urbanization process affects environmental conditions in Jabodetabek.

The Jabodetabek metropolitan area has the highest concentration of urbanization in Indonesia, comprising several administratively distinct regions (Rustiadi et al., 2015). Jones (2002) even describes the phenomenon in Jabodetabek as an example of 'mega-urbanization. This area's development has also led to the term 'desakota,' used by some researchers (Mcgee, 1991). The extreme population growth in the Jabodetabek area significantly contributes to Indonesia's national economic growth (Rukmana, 2008). However, this growth contrasts sharply with environmental quality, where Jabodetabek tends to lag significantly (Steinberg, 2007). The region faces issues such as water supply crises, degradation of clean water quality, poor waste management, poor air quality, and numerous slum housing areas, illustrating environmental degradation in Jabodetabek. Large-scale land investments driven by the government promote expansion into rural and protected areas of Jakarta (Firman, 2000). Combined with spatial management that does not implement sustainable urban systems, this condition tends to worsen.

This paper aims to examine the concept of urbanization and its impact on ecological aspects in Jakarta, particularly regarding the Environmental Quality Index. This will be achieved by analysing relevant literature on population growth conditions in metropolitan areas and their general ecological aspects, with a specific focus on the Jabodetabek region.

## 2. Literature Review

### *2.1 Urbanization as a process*

Urbanization can be defined as the process of 'urbanizing.' This process is characterized by changes in a region, both structurally and functionally (Jones, 2002). Urbanization is often associated with an increase in the population of an area. However, urbanization cannot be viewed as a simple process. It is seen as a complex and dynamic process involving social, economic, and physical changes in a region (Hudalah et al., 2007; Winarso et al., 2015). The urbanization process is often marked by transforming an area from being predominantly rural to predominantly urban (van Leeuwen, 2010). This process results from long-term conditions influenced by political aspects of policymaking and regional management.

As a complex process, some previous literature even suggests that there can be no economic growth without urbanization. This tends to place urbanization as a very important process in the development cycle of a region (Sugiri & Buchori, 2016). This is because urbanization generally serves as a crucial moment in the transformation of

activities, the transfer of information and knowledge, and as part of globalization. This transformation ultimately drives increased economic transactions and changes in the social structure of society (Boyce, 2004). Consequently, modern and more developed communities emerge, simultaneously driving the broader development of their regions.

### *2.2 Externalities of urbanization*

Although the urbanization process is seen as an important aspect of regional development, it is also often viewed as a cause of several developmental issues. Previous research agrees that urbanization has also negatively impacted social, economic, and environmental aspects. However, these negative impacts result from failures in systems and policies to anticipate and manage these changes.

Urbanization tends to have a significant negative impact on the environment. Closely related to the increase in population, urbanization directly affects the environment. The increasing population greatly influences environmental aspects, particularly those related to provision and utilization (Maes et al., 2016). Several studies indicate that population growth inversely correlates with the capacity of ecosystem services (Qiu et al., 2015; Wan et al., 2015; Alvarado & Toledo, 2017). Greater consumption occurs due to the increasing population.

The environmental impact of urbanization also results from increased urban activities, such as higher energy and water consumption in industrial activities and the growth of residential areas (Peng et al., 2010). Moreover, environmental quality is also significantly affected. The growth of residential areas and activity centres leads to environmental degradation. Urbanization in suburban areas increases population movement and fuel energy consumption (Sodri & Garniwa, 2016). This directly correlates with increased emissions that pollute the air.

Over time, this not only affects the quality and quantity of the environment but also impacts the productivity of the population itself. Some literature illustrates that continuous urbanization has led to a decline in the quantity of food provision (Maes et al., 2011; Pribadi & Pauleit, 2015), especially in urban areas. This is caused by the conversion of open land into built-up areas to meet the growing needs of the population. This situation is driven by land use management and environmental planning that do not set functional and physical boundaries for urban activities (Ravetz et al., 2013). Consequently, such development continuously encroaches on areas that should serve as buffers and protective zones (Palomo et al., 2013).

## 3. Methods

### *3.1 Types of research and method of collecting data*

This research is descriptive qualitative in nature, relying on sources obtained from existing literature. The analysis method used for the literature review is descriptive analysis. The study method for urbanization and environmental degradation in the Jabodetabek area is conducted to examine the influence of changes in population size and activities on the decline in environmental quality, particularly regarding land use changes, availability of clean water, and waste management.

Data collection in this research is conducted through a literature study. According to Zed (2014), in library research, the literature review is not only an initial step in preparing the research design, but also involves utilizing library resources to obtain research data. Data collection is not limited to books; it can also include research findings, scientific journals, and other relevant data. This data collection aims to uncover relevant theories regarding urbanization issues and environmental problems in the Jabodetabek area. These theories can then be compared based on the results of various studies to determine whether they are interrelated.

### *3.2 Research variable*

The Jabodetabek region is a metropolitan area that originated from the city of Jakarta, which began to develop into a major city. Jakarta's growth eventually extended beyond administrative boundaries, merging with surrounding cities such as Bogor, Tangerang, and Bekasi, forming an urbanized area (Silitonga, 2010). This has led to a population increase in the Jabodetabek region. According to Katherina (2014), urbanization in Indonesia is driven by economic development, particularly in the industrial and service sectors, which tend to be located in large cities. This development is due to the availability of utilities such as water, electricity, ports, airports, and the concentration of skilled labour and markets.

According to Harahap (2013), the negative impacts of the high rate of urbanization in Indonesia are (1) increasing scarcity of vacant land in urban areas, (2) increased pollution in urban areas, (3) causes of natural disasters, (4) social and economic pollution, (5)causes of traffic congestion, and (6) disruption of urban planning. Uncontrolled urbanization in the Jabodetabek area leads to a decline in environmental carrying capacity and quality, causing various environmental problems, such as land use changes, reduction of green open spaces, air pollution, water pollution, waste issues, water resource shortages, floods, and slum areas. In this study, the researcher limits the issues to urbanization and environmental degradation (land use changes, availability of clean water, and waste management). The research variables used in this paper refer to the environmental quality index (*IKLH*) assessment established by the Ministry of Environment and Forestry, consisting of the water quality index (*IKA*), air quality index (*IKU*), and land cover quality index (*IKTLH*).

## 4. Results and Discussion

### *4.1 Jakarta's development and environmental challenges*

The initiative by the Dutch Colonial government to establish Batavia as a centre of government and trade replaced Banten as the Dutch centre of activity in Indonesia (Rustiadi et al., 2015). The construction of Jakarta was designed similarly to Amsterdam, with the development of several canals, government centres, religious centres, and trading centres resembling the concept of Amsterdam. Thus, the term "tropical Amsterdam" emerged during the colonial period. Jakarta's growth increased further with the development of the global industry, making the canals in Jakarta more active and crowded with international trade activities. This led to population growth in Batavia (Steinberg, 2007), surpassing regional centres in Indonesia. By 1931, the population of Batavia had reached 533,000 inhabitants, which was 50% larger than Surabaya and approximately 150% of the total population of Semarang at that time (Rustiadi et al., 2015).

The population growth in Batavia at that time gradually posed environmental problems. Among the increasingly busy trading centres and canals, residential centres in the form of "kampung" from the Batavia community emerged (Steinberg, 2007). The unplanned increase in population was not accompanied by proper sanitation development. Additionally, settlements around flood-prone canals and inundation became another issue for Batavia at that time. This increased malaria cases in Batavia during its urban evolution (Steinberg, 2007). The urban development driven by urbanization in Batavia continued. Even after independence, this condition greatly impacted the environmental situation.

After Indonesia's Independence, Batavia transformed into Jakarta and was given special attention by Sukarno, the first President of Indonesia. Jakarta was planned to be a more modern and superior city compared to other cities in Indonesia, dominated by iconic national buildings (Rustiadi et al., 2015). The president directly formulated the development scenario at that time. Jakarta's special status further increased the influx of migrants to Jakarta. These migrants, often with minimal skills, generally occupied informal sectors in Jakarta (Rukmana, 2008).

### *4.2 The influence of urbanization on land cover*

The urbanization process fundamentally has wide-ranging impacts on various environmental aspects, including land cover. According to Patra et al. (2018), urbanization has temporally impacted land cover changes, continuously increasing surface temperatures and reducing water infiltration areas. Land cover change is a crucial indicator commonly assessed to observe regional urbanization, reflecting the transition of activities from rural to urban areas (Hudalah et al., 2007; Liu et al., 2012). Additionally, land cover can indicate human activities' impact on the environment, particularly concerning ecosystem values (Qiu et al., 2015). Therefore, land cover assessment is regarded as a vital variable in assessing the impact of urbanization processes on environmental quality.

Specifically, in the case of urbanization in Jakarta, land conversion to built-up areas has occurred over a long period. According to Murakami et al. (2005), almost the entire administrative area of Jakarta has been categorized as an urbanized area, indicating land use dominance by built-up areas. The pattern of land cover change in built-up areas appears to rapidly expand within 15 years (Rustiadi et al., 2013). The influence of urbanization on land cover is driven by the significant demand for residential and business activities (Rustiadi & Panuju, 2002). This condition is accelerated by policies seemingly facilitating land use change, providing legality through legal permits to convert built-up land into non-built-up land (Firman, 2000). See the Figure 1 below.

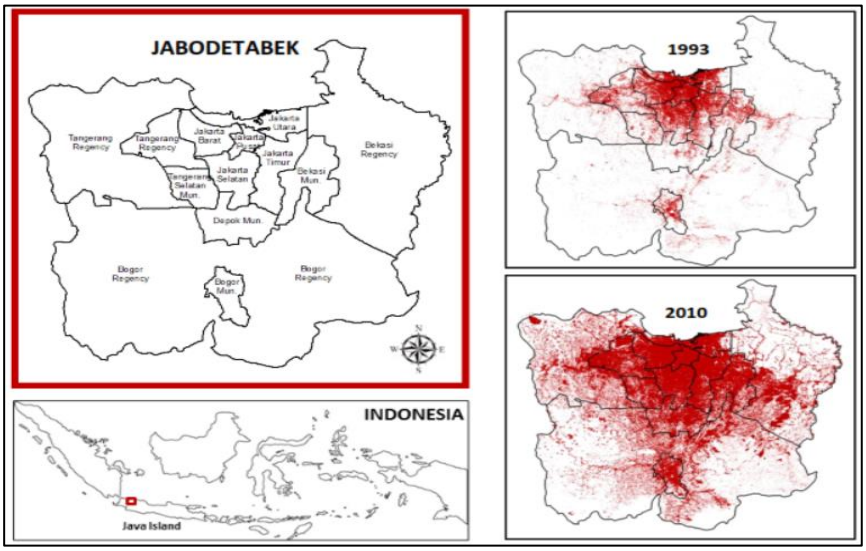


Figure 1. Increase in Jakarta, Bogor, Depok, Tangerang, dan Bekasi (JABODETABEK) urban land cover 1993—2010
(Rustiadi et al., 2013)

Changes in land cover in the Jakarta area have become one of the causes of environmental degradation, such as increased flooding and erosion (Asdak et al., 2018). Jakarta's natural factors, which already have flood potential due to being located in the estuary area of the Citarum and Cisadane rivers, are exacerbated by land use changes to built-up areas, significantly increasing the flood potential in Jakarta. Gao et al. (2018) state that land use change to built-up areas will reduce the land's ability to absorb water and increase erosion potential, thus increasing the flood potential in an area. Additionally, land use changes in Jakarta have increased the land subsidence rate. Over 20 years, significant land subsidence has occurred in Jakarta, mainly caused by groundwater consumption, construction loads, and tectonic processes (Abidin et al., 2008, 2011). Two of these factors mentioned are the results of increased built-up areas and human activities in Jakarta. See the Figure 2 below.

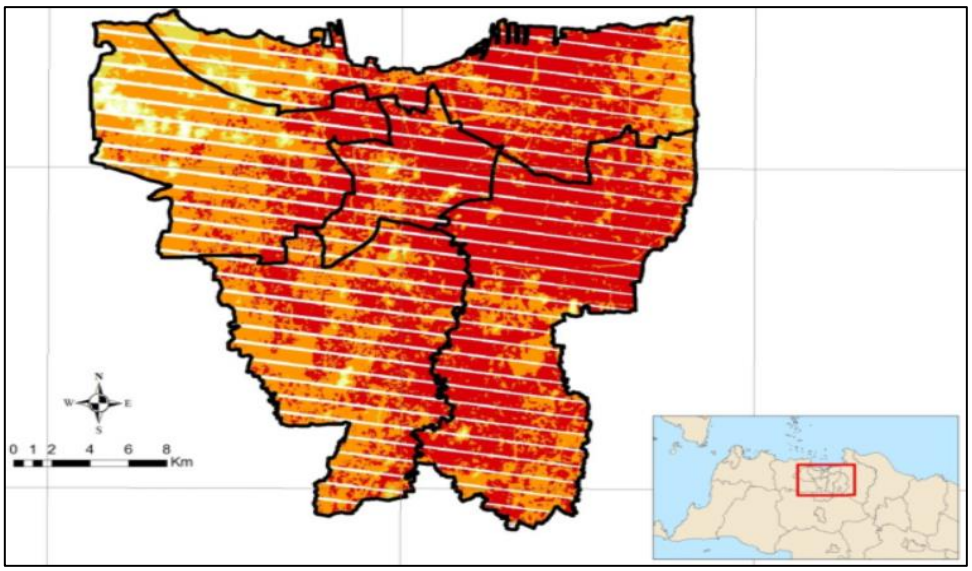


Figure 2. Surface temperature map of Jakarta
(BPBD DKI Jakarta; Rushayati et al., 2016)

Another assessment that can be observed from the impact of land cover changes is the increase in surface temperature in Jakarta. This temperature change is closely related to the increasing pressure of human activities. The paper by Rushayati et al. (2016) has provided an overview of the surface temperature patterns in Jakarta. Areas with intensive built-up land cover tend to have higher surface temperatures. This is due to higher solar radiation in areas covered by buildings and asphalt. Meanwhile, areas covered by vegetation, such as urban forests and parks, have lower temperature intensities (Zain et al., 2015). See the Table 1 below.

Table 1. IKTL calculation results for Jakarta 2013—2018 compared with the total population

| Year | *IKLH* | *IKA* (water quality index) | *IKU* (air quality index) | *IKTL* (land cover quality index) | Total population (data *IKLH*) |
|---|---|---|---|---|---|
| 2013 | 31.97 | 34.71 | 34.71 | 22.75 | 9,607,787 |
| 2014 | 36.88 | 34.00 | 46.28 | 31.99 | 9,969,900 |
| 2015 | 43.79 | 22.35 | 78.78 | 33.62 | 10,177,924 |
| 2016 | 38.69 | 24.62 | 56.40 | 35.97 | 10,177,924 |
| 2017 | 35.78 | 21.33 | 53.50 | 33.32 | 10,277,600 |
| 2018 | 39.02 | 31.43 | 66.57 | 24.04 | 10,277,628 |

(Ministry of Environment and Forestry, 2013—2018)

In addition, the assessment of land cover quality is one of the variables used by the Ministry of Environment and Forestry to assess the environmental quality index (*IKLH*). The land cover indicator is a representation of the forest cover index, forest performance index, forest cover condition index, water body conservation index, and habitat condition index. Based on the assessment of the land cover index (*IKTL*) published by the Ministry of Environment and Forestry, the *IKTL* value of Jakarta is among the lowest in Indonesia. From 2013 to 2018, the *IKTL* value of Jakarta Province has consistently been the lowest compared to other regions. Although experiencing fluctuating *IKTL* trends with an average score of 30.1, this figure has always remained below the national average value. Considering the indicators used by the Ministry of Environment and Forestry to measure the *IKTL* value, the current condition of Jakarta seems challenging to improve the *IKTL* value. This is due to the high saturation of built-up land use in Jakarta, while the availability of green open spaces is very low. Moreover, with the ongoing increase in Jakarta's population, especially due to incoming migration, the demand for built-up land will remain high.

### *4.3 The effect of urbanization on air quality*

Cohen (2006), as cited in Parrish & Stockwell (2015), states that since the early days of the Industrial Revolution, people have been increasingly congregating in urban areas, so much so that by 2005, more than half of the human population lived in cities. There are around 28 major cities inhabited by populations exceeding 10 million. Based on projections, most future population growth worldwide will occur in urban areas. Urbanization indirectly affects air quality.

Table 2. Data on road length, number of vehicles, and number of industries in Jakarta in 1970 – 1989

| Year | Road length (km) | Number of vehicles (units) | Number of industries | | |
|---|---|---|---|---|---|
| | | | Large and medium industries (units) | Small industry and household (units) | Number of units |
| 1970 | 1,011 | 222,082 | Not available | Not available | Not available |
| 1971 | 1,046 | 252,374 | Not available | Not available | Not available |
| 1972 | 1,317 | 288,048 | Not available | Not available | Not available |
| 1973 | 1,845 | 341,296 | Not available | Not available | Not available |
| 1974 | - | 414,719 | Not available | Not available | Not available |
| 1975 | - | 488,719 | Not available | Not available | Not available |
| 1976 | 2,093 | 543,229 | Not available | Not available | Not available |
| 1977 | 2,325 | 583,716 | Not available | Not available | Not available |
| 1978 | 2,494 | 635,575 | Not available | Not available | Not available |
| 1979 | 2,710 | 692,817 | Not available | Not available | Not available |
| 1980 | 2,828 | 754,546 | Not available | Not available | Not available |
| 1981 | 2,954 | 876,714 | Not available | Not available | Not available |
| 1982 | 3,086 | 1,008,432 | 1,515 | 48,036 | 49,187 |
| 1983 | 3,168 | 1,116,952 | 1,332 | 42,847 | 44,179 |
| 1984 | 3,431 | 1,213,352 | 1,340 | 37,850 | 39,190 |
| 1985 | 3,510 | 1,286,608 | 1,668 | 33,785 | 35,453 |
| 1986 | 3,540 | 1,334,896 | 1,695 | 27,072 | 28,767 |
| 1987 | 3,583 | 1,380,015 | 1,746 | 27,901 | 29,647 |
| 1988 | 4,420 | 1,435,731 | 2,038 | 28,734 | 30,772 |
| 1989 | 4,435 | 1,515,299 | 2,100 | 28,734 | 30,834 |

(Sukana & Naseh, 1993)

According to Li et al. (2019), changes in meteorological conditions due to urbanization can influence the concentration of air pollutants, including nitrogen oxides (NOx), ozone ($O_3$), and fine particulate matter (PM2.5). According to Lippmann (1989), pollution from NOx and $O_3$ is a major public health issue in megapolitan areas. Meanwhile, according to research conducted in Jakarta by Sukana & Naseh (1993), the number of industries, road length, and the number of vehicles influence the high concentrations of $SO_2$ and NOx. The article presents data on road length, the number of vehicles from 1970 to 1989, and the number of industries from 1982 to 1989 (Table 2).

The air quality data, especially NOx and $SO_2$ in residential locations between 1982 – 1990 can be seen in the following Table 3. It is clear from the data in Table 1 that in 1982, the length of roads increased approximately threefold compared to 1970, while the number of vehicles increased by about 4.5 times. Furthermore, the number of vehicles continued to increase almost sevenfold by 1989.

The data on the number of industries from 1982 to 1989 indicates a tendency for a shift in the scale of industries from small and household industries to medium and large industries. This data suggests the presence of urbanization in Jakarta, both due to the increasing population, which is associated with the increase in the number of vehicles, and the change in the scale of industrial activities.

Table 3. Average concentrations of NOx and $SO_2$ (ppm) in Jakarta in 1982—1990

| Year | Average pollutant concentration (ppm) in residential locations | |
|---|---|---|
| | NOx | $SO_2$ |
| 1982 | 0.01 | 0.00 |
| 1983 | 0.02 | 0.00 |
| 1984 | 0.01 | 0.00 |
| 1985 | 1.87 | 0.68 |
| 1986 | 1.51 | 0.18 |
| 1987 | 2.92 | 2.97 |
| 1988 | 0.01 | 0.01 |
| 1989 | 1.63 | 1.00 |
| 1990 | 2.44 | 1.02 |

The impact of urbanization on air quality can be observed from the average pollutant concentration values (NOx and $SO_2$). Table 2 shows a trend of increasing concentrations of both pollutants from 1982 to 1987, followed by a slight decrease in 1988 and a subsequent increase in 1989—1990. Next, we will present a recapitulation of the number of days categorized as good/moderate/unhealthy/very unhealthy/hazardous, along with critical parameters from air quality monitoring results averaged per day in the form of the air pollution standard index (*ISPU*) from 2015 to 2018 in Jakarta based on data from the Jakarta Provincial Environmental Agency. To monitor air quality, the Jakarta Provincial Government has 5 air quality monitoring stations (*SPKU*) located in DKI1 (Bunderan HI, Central Jakarta), DKI2 (Kelapa Gading, North Jakarta), DKI3 (Jagakarsa, South Jakarta), DKI4 (Lubang Buaya, East Jakarta), and DKI5 (Kebon Jeruk, West Jakarta). Next, see the Table 4 below.

Table 4. Recapitulation of number of days based on *ISPU* category and critical parameters in Jakarta 2013—2018

| Year | Number of days with ISPU category | | | | | Number of days with critical parameters | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Good | Moderate | Unhealthy | Very Unhealthy | Hazardous | PM 10 | $SO_2$ | CO | $O_3$ | $NO_2$ |
| 2013 | 4 | 153 | 181 | 27 | 0 | 51 | 0 | 2 | 312 | 0 |
| 2014 | 12 | 255 | 90 | 8 | 0 | 86 | 0 | 3 | 276 | 0 |
| 2015 | 43 | 258 | 64 | 0 | 0 | 166 | 0 | 10 | 188 | 1 |
| 2016 | 26 | 245 | 93 | 1 | 0 | 90 | 0 | 9 | 266 | 0 |
| 2017 | 43 | 212 | 110 | 0 | 0 | 44 | 28 | 2 | 291 | 0 |
| 2018 | 11 | 139 | 188 | 27 | 0 | 14 | 11 | 4 | 336 | 0 |

(DKI Jakarta Provincial Environmental Service)

The data from Tables 3 and 4 show that air quality in Jakarta fluctuated within the range of 2013 to 2018 but did not exhibit significantly noticeable differences. The best average air quality was observed in 2015. As for the critical parameters, ozone (O3) and PM10 were frequently prominent. This aligns with the findings of Li et al. (2019) and Lippmann (1989), suggesting that urbanization indirectly affects air quality, particularly regarding O3 and PM2.5. PM2.5 is not currently categorized within the *ISPU* parameters, so it is analogized with PM10. Suppose a score is given for the categories good = 4, moderate = 3, unhealthy = 2, very unhealthy = 1, and dangerous = 0. In that case, the air quality monitoring results score can be calculated, as shown in Table 5.

The *IKU* constitutes one element in calculating the *IKLH*, with a weight of 30%. According to the Ministry of Environment and Forestry (2016), the air quality index is generally calculated based on five main pollutants: surface oxidants/ozone, particulate matter, carbon monoxide (CO), sulfur dioxide (SO2), and nitrogen dioxide (NO2). However, the current calculation of the air quality index utilizes only two parameters: NO2 and SO2. NO2 represents emissions from gasoline-powered motor vehicles, while SO2 represents

emissions from industries and diesel-powered vehicles using solar fuel and other sulfur-containing fuels.

Table 5. Air quality scoring results in Jakarta in 2013—2018

| Year | Number of days with *ISPU* category | | | | | Score |
|---|---|---|---|---|---|---|
| | Good | Moderate | Unhealthy | Very unhealthy | Hazardous | |
| 2013 | 4 | 153 | 181 | 27 | 0 | 864 |
| 2014 | 12 | 255 | 90 | 8 | 0 | 1001 |
| 2015 | 43 | 258 | 64 | 0 | 0 | 1074 |
| 2016 | 26 | 245 | 93 | 1 | 0 | 1026 |
| 2017 | 43 | 212 | 110 | 0 | 0 | 1028 |
| 2018 | 11 | 139 | 188 | 27 | 0 | 864 |

The NO2 and SO2 parameters are measured at four locations in each district/city using the passive sampler method. These locations represent transportation areas, industries, residential areas, and commercial or office/trade areas. In 2015, measurements were conducted in October and November at each location for fourteen days.

The index is calculated by comparing the annual average values to the standards of the European Union (EU) Directives. If the index value is > 1, the air quality exceeds the EU standard. Conversely, if the index value is ≤ 1, the air quality meets the EU standard. Subsequently, the EU air quality index is converted into the *IKU* using the following Equation 1.

$$IKU = 100 - \left(\frac{50}{0.9} \times (I_{EU} - 0.1)\right) \quad \text{(Eq. 1)}$$

The formula is utilized under the assumption that the measured air quality data represents pollutant concentration data. Therefore, it must be converted into air quality concentration by subtracting from 100 percent. According to the Jakarta Capital City Provincial Environmental Agency (2019), air quality index data in DKI Jakarta Province is obtained through monitoring results in the five administrative cities and the Thousand Islands Regency. The parameters monitored in the Air Quality Index calculation are NO2 and SO2 concentrations. The air quality index calculation results from 2013 to 2018 are presented in Table 6 and Figure 3.

Table 6. KPI calculation results for Jakarta 2013—2018 compared to total population

| Year | *IKU* | Total population |
|---|---|---|
| 2013 | 34.71 | 9,969,948 |
| 2014 | 46.28 | 10,075,310 |
| 2015 | 78.78 | 10,196,173 |
| 2016 | 56.40 | 10,309,310 |
| 2017 | 53.50 | 10,348,570 |
| 2018 | 66.57 | 10,846,145 |

(KLHK, 2013—2018)

Table 6 and Figure 3 show a positive correlation trend between the *IKU* and the population. However, in 2015, an extreme condition was evident: the *IKU* value sharply increased but then returned to the trend mentioned above. From this overview, it can be inferred that population size is not the sole variable influencing the *IKU*. In theory, population growth and urbanization activities can degrade air quality. However, the opposite trend is observed during the specified period (2013—2018). Instead, the *IKU* shows a positive correlation with population growth. This could be influenced by policies implemented by the Jakarta Provincial Government, such as prohibiting significant industries within Jakarta and increasing the number of green open spaces. With the relocation of major industries outside Jakarta, a process of deurbanization occurs, leading to improved air quality in Jakarta.

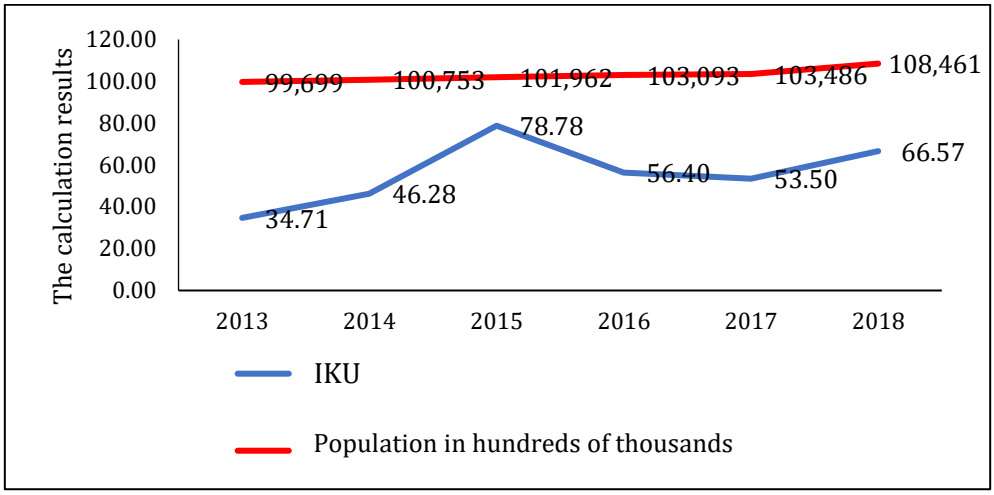


Figure 3. Results of KPI calculations for Jakarta for 2013—2018 compared to total population

*4.4 The influence of urbanization on water quality*

According to Harahap (2013), unchecked urbanization is considered to disrupt urban development plans and strain urban facilities beyond the control of city governments. Another negative impact is "over-urbanization," where much of the urban population does not correspond to the country's economic development. Additionally, "under-ruralization" can occur where the rural population is too small for the available level and manner of production. This poses a problem in the Jabodetabek area. If the population continues to increase continuously, there will be an increase in the demand for clean water.

There are three factors causing a water resource crisis: firstly, the degradation of water resources, mainly due to ecosystem and water source damage. Secondly, water resource pollution. Thirdly, water utilization itself. In this case, a crisis can occur if there is an imbalance between the population and the availability of water resources. For example, Bogor is a water resource area, with the Salak and Gede Pangrango mountains' ecosystems serving as groundwater sources for the Bogor and Jakarta areas. If the forest ecosystem in Bogor is not preserved, it will lead to a water crisis for both Bogor and Jakarta.

The poor water quality in the Jabodetabek Metropolitan Area is generally caused by several factors, including pollution from domestic waste, industrial waste, hospital waste, and solid waste still being disposed of into rivers (DESDM in Silitonga, 2010). The Jabodetabek area is an urban area with very high economic activities. The demand for clean water from both the community and industries is also increasing. The impact of water pollution is the shift from groundwater use to piped water.

## 5. Conclusions

The urbanization process in Jakarta has been lengthy, spanning from the colonial era to the present day. This condition is generally characterized by increased population and changes in population characteristics. The urbanization process in Jakarta has also negatively impacted the environment following its population growth. Assessments of land cover, air quality, and water quality are indicators that can be used to evaluate the negative environmental impacts of urbanization. The significant increase in population due to urbanization has influenced land cover. This is evidenced by specific land use changes leading to rising surface temperature, increased flood potential, and decreased *IKTL* value.

Furthermore, urbanization has also had negative impacts on air quality in Jakarta. This is demonstrated by increased SO2 and NOx concentrations from 1982 to 1989. From 2013 to 2018, an improvement in air quality is observed in Jakarta despite an increase in population. The increase in population does not directly affect the deterioration of air

quality. Besides air quality, the population increase also negatively affects Jakarta's water quality.

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The authors declare no conflict of interest.



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