Tsukuba Geoenvironmental Sciences, Vol. 10, pp. 43-50, Dec. 26, 2014

Aspects of water environmental issues in Jakarta due to its rapid urbanization

Akio YAMASHITA*

Abstract

The purpose of this paper is to discuss the causes for the serious water environmental issues in Jakarta in Indonesia currently facing due to its rapid urbanization and the measures required to deal with them. For the purpose, first, the urbanization process will be analyzed with paying attention to the bioregion, i.e. river basin, in terms of time and space. Second, the author will divide Jakarta's current water environmental issues into qualitative and quantitative aspects using examples and describe them. Two things can be pointed out as qualitative aspects of water environmental issues in the canals and ditches in Jakarta; serious non-point source pollution caused by urbanization, and rubbish dumping by residents living alongside the river. On the other hand, Jakarta is currently facing serious land subsidence and expanding areas below sea level. A problem unique to a large tropical city such as Jakarta caused by land subsidence is that there are frequent flood inundations during the wet season. Heavy storm water in a short period of time is not able to penetrate into the impermeable surface and does not flow out into the sea through river or waterway due to land subsidence.

Key words: rapid urbanization, water environmental issue, land subsidence, flooding, Jakarta

1. Introduction

The major large cities in Asia are located in low-lying areas along downstream of large rivers and have made rapid urbanization since the latter part of the 20th century. The pace and the scale of the urbanization of these cities appear to exceed the urbanization experienced by cities in Europe and America and this has led to several significant water environmental issues (Taniguchi *et al*., 2009). Yamashita (2011) created mesh maps for the land use by seven Asian cities for three different periods during the 20th century and conducted a comparative analysis on each city's development process. Subsequently, Yoshikoshi (2011) identified characteristics of water environmental issues related to the seven cities and summarized the occurrence of urbanization and water environmental issues chronologically.

The purpose of this paper is to discuss the causes for the serious water environmental issues in Jakarta in Indonesia currently facing due to its rapid urbanization and the measures required to deal with them. Jakarta is covered in the above mentioned studies and began its urban development relatively late. For the purpose, first, the urbanization process will be analyzed with paying attention to the bioregion, i.e. river basin, in terms of time and space. Second, the author will divide Jakarta's current water environmental issues into qualitative and quantitative aspects using examples and describe them.

2. Rapid urban development in Jakarta

2.1 History of Jakarta

Jakarta originally prospered as a port city of the Hindu Sunda Kingdom and was called Sunda Kelapa. This name still remains as the name of a port in central Jakarta. In 1527, the Muslim Banten Sultanate conquered the land and changed the name into Jayakarta.

In 1619, the Dutch East India Company occupied the land and changed the name to Batavia. In 1645, the construction of Batavia Fort was completed, and the fort was used as a base for the Asian colonial policy by Holland. The town center of Batavia is the current Kota area, and there are still Dutch colonial squares and architecture. In 1808, Daendels, the Governor General of the Dutch East Indies, moved the administration center to Weltevreden (called Gambir at present), the city which is more on the South and inlying. The administration center in Jakarta remains in Gambir at present, where the Indonesian Presidential Palace and Merdeka Square with the National Monument are located.

In 1942, Japan occupied the Dutch East Indies and changed the name of the city Batavia into Jakarta. After the Second World War, Indonesia declared its independence, but countries like Holland refused to accept it, which led to the Indonesian War of Independence. In 1949, Indonesia finally gained independence. Jakarta became the capital city of Indonesia. Since then, for the latter part of the 20th century, Jakarta has developed rapidly as Indonesia's capital city and seen its population significantly increased.

2.2 Population growth

Regarding population growth from 1950 after the Independence, the total population in Indonesia was 75,000,000 in 1950, 150,000,000 in 1980, and in 240,000,000 in 2010 (data from UN World Population Prospects). The popula-

* Faculty of Life and Environmental Sciences, University of Tsukuba

tion has increased 3.2 times from 1950 to 2010 (Fig. 1). The total population in DKI Jakarta was 1,450,000 in 1950, corresponding to 1.9% of the total Indonesian population. In 1980, the population in DKI Jakarta increased to 5,980,000, and then was 9,630,000 in 2010. The population in 2010 was 6.6 times more than that of 1950 (Fig. 1), corresponding to 4.0% of the total population in Indonesia. The population growth speed in DKI Jakarta during the past 60 years is double that of the entire Indonesian population growth. Furthermore, following the expansion of urban areas in Jakarta, the population of Jakarta and its surrounding areas (called Jabotabek) has exceeded 20,000,000, and became one of the world's largest megacities.

If you look at the population density of every 1km mesh in the basin of the Ciliwung-Cisadane River which runs through DKI Jakarta and its surrounding areas (Fig. 2), almost all the areas in DKI Jakarta, and the adjoining areas such as Bogor, Tangerang and Bekasi, have a high population density of more than 5,000 people/km^2. Bekasi, located at the east side of DKI Jakarta is connected with DKI Jakarta. Tangerang, located on the west, and Bogor, located on the south, also have a high population density and following the development of a major highway network, these cities are in the process of becoming connected with DKI Jakarta.

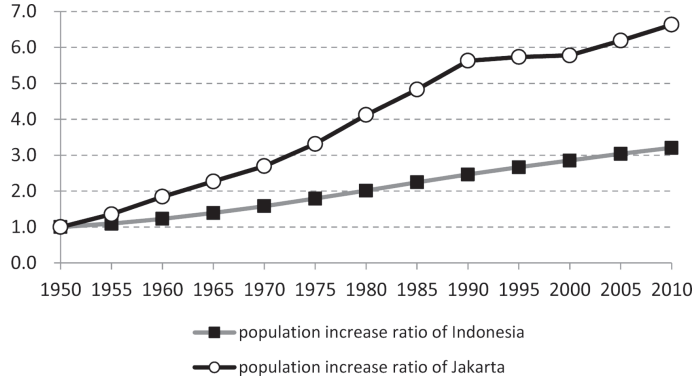

Fig. 1 Population increase ratio of Indonesia and Jakarta
Source: UN World Population Prospects

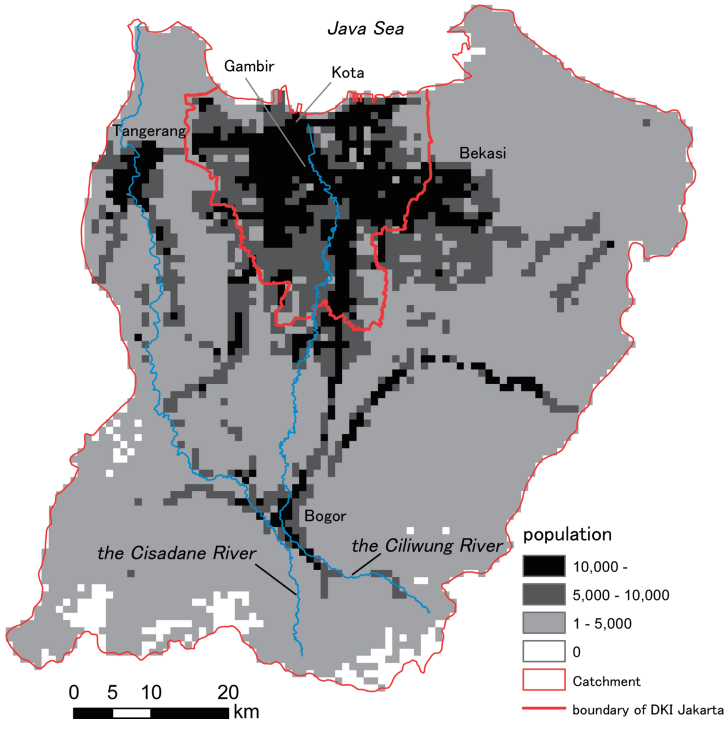

Fig. 2 Population of every 1km mesh in the Ciliwung-Cisadane River Basin (2012)
Source: Land Scan 2012

2.3 Land use change in the Ciliwung-Cisadane River Basin

In this section, to understand the urbanization process in Jakarta during the 20th century, the spatial characteristics of land use changes for two periods, namely, between the 1930s and 1960s, and between the 1960s and 2000, will be analyzed using the mesh data of the land use of the Ciliwung-Cisadane River Basin in the 1930s, 1960s and around 2000 produced by Yamashita (2011, 2013) (Figs. 3 and 4).

Between the 1930s and 1960s, there was little expansion

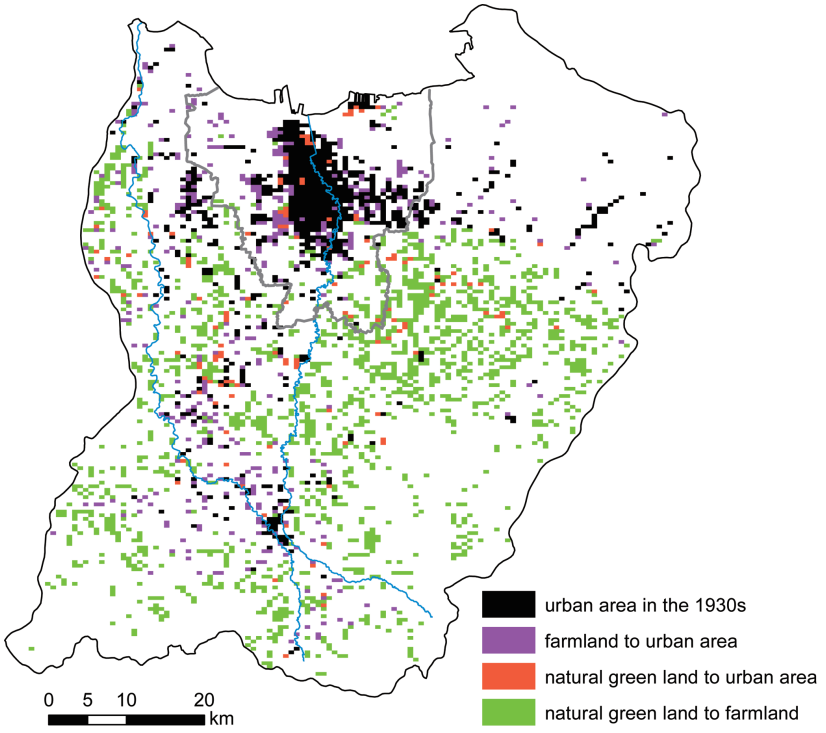

Fig. 3 Land use change in the Ciliwung-Cisadane River Basin between the 1930s and 1960s

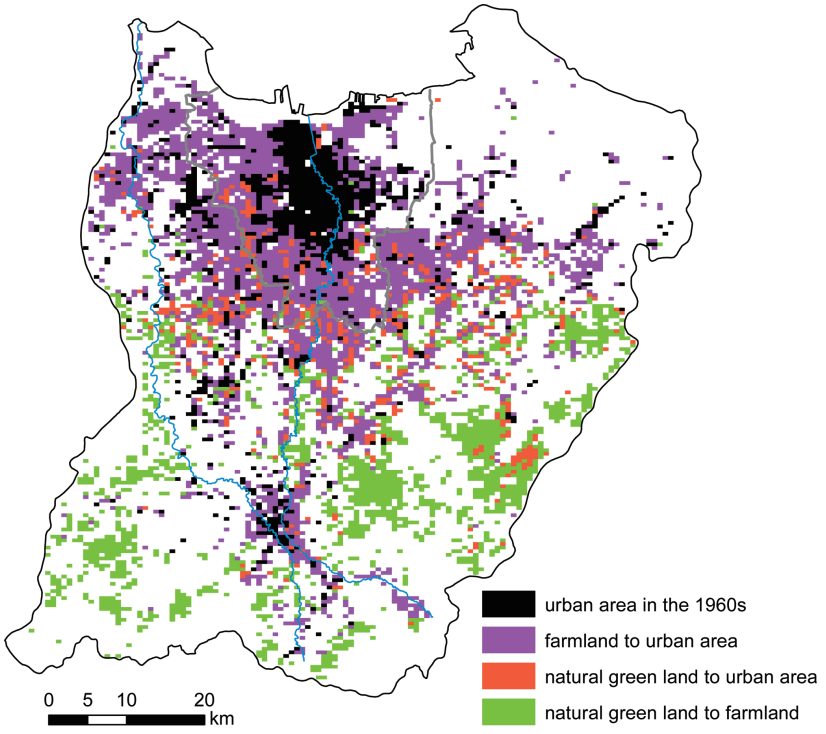

Fig. 4 Land use change in the Ciliwung-Cisadane River Basin between the 1960s and 2000

of the urban areas, and the only farmlands adjoining the existent urban areas were built up. In large outside areas of DKI Jakarta, natural green lands became farmlands, the majority of them were paddy fields.

During the latter half of the 20th century, between the 1960s and 2000, urbanization progressed rapidly in Jakarta and the surrounding urban areas expanded. A large part of DKI Jakarta and also its surrounding areas were developed into urban areas. Urban areas were especially expanded in Bekasi on the east side, and in Tangerang on the west side. Urbanization was spread further into the South side and the upper reaches of the rivers into the surrounding areas of Bogor. Some of these urban areas were developed from natural green lands such as forests and grass lands, but the majority of them were developed from farmlands such as rice paddy fields. On the other hand, in the upper reaches of the rivers, natural green lands reasonably continued to be developed into farmlands.

Next, the relationship between the change of the land use and topographic conditions such as elevation and slope will be analyzed (Figs. 5 and 6) (Yamashita, 2013). In these figures, if the specialization coefficient is over 1.0, the land use change is specialized in the elevation or slope zone.

There is little correlation between the change from natural green lands into urban areas and topographic conditions. The change from farmlands into urban areas was mainly observed in the areas within 30 meters above sea level and 100 to 280 meters above sea level between the 1930s and 1960s. This reflects urban areas have expanded from existing villages in the wide basin in pinpoint style. With regard to the period between the 1960s and 2000, the change in the areas from 10 to 100 meters above sea level was mainly observed. This reflects dramatic changes in the urban areas of lower reaches of the rivers during this period. Regarding the degree of slope, during both periods, the change was observed only in very moderate slope areas, and where there was a steep slope, urbanization did not progress as much.

Looking at the change in the land use from natural green lands into farmlands, between the 1930s and 1960s, the

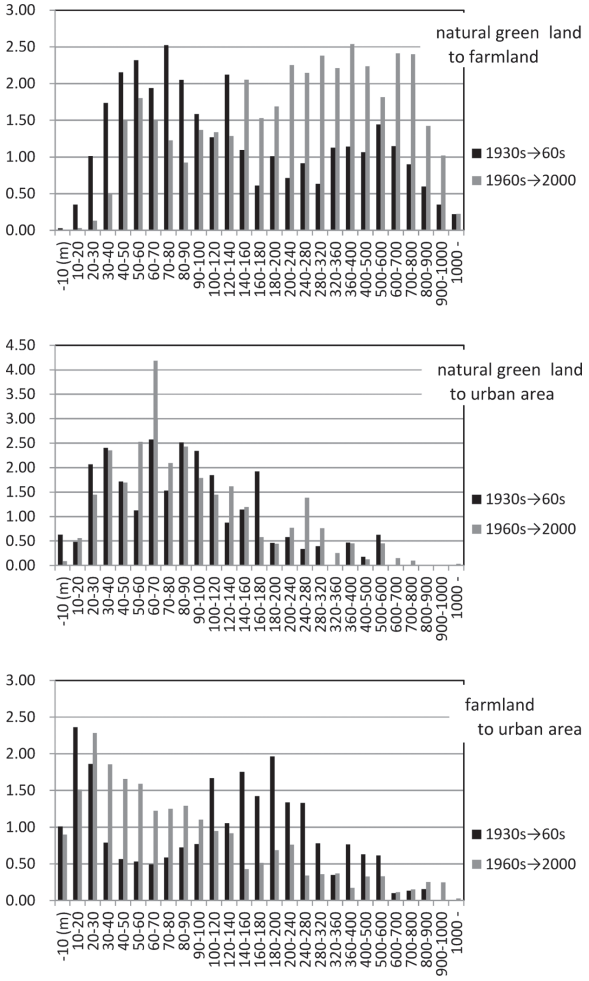

Fig. 5 Specialization coefficient of land use change by elevation zone in the Ciliwung-Cisadane River Basin

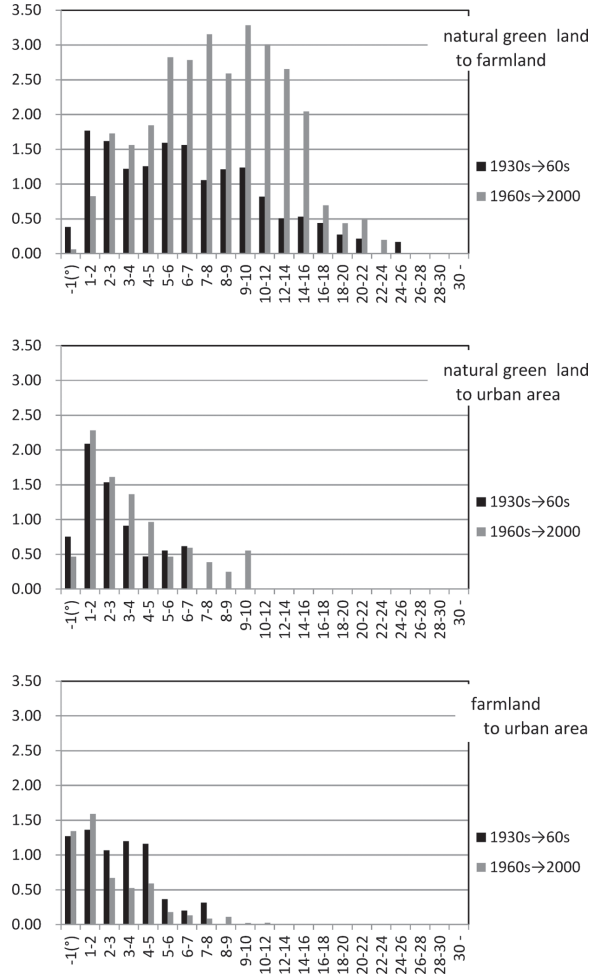

Fig. 6 Specialization coefficient of land use change by slope zone in the Ciliwung-Cisadane River Basin

change was mainly observed for areas of 30-140 meters above sea level. However, between the period of the 1960s and 2000, the change was observed in more elevated areas, such as 140-900 meters above sea level. Regarding the degree of slope; while between the 1930s and 1960s, the change was mainly observed in the areas where slope was 1-3 degrees or 5-7 degrees. However, between 1960s and 2000, the change was observed in the areas where slope was 5-16 degrees. Therefore, it can be said that more steeply sloped areas were developed into farmlands in more recent years.

Findings of this section can be summarized as follows; in the 1930s, urban areas were limited to the lower reaches of the rivers in DKI Jakarta, and farmlands and natural green lands accounted for the majority of the river basin. In the 1960s, farmlands were gradually expanded into relatively moderately elevated and moderately sloped areas in the middle and lower reaches of the rivers. By 2000, farmlands were expanded further into highly elevated areas with steep slopes. Due to the dramatic urban development in the latter half of the 20th century, many farmlands in the lower reaches of the rivers were developed into urban areas. In short, low-lying areas at the lower reaches of the rivers experienced two-step changes for the land use, from natural green lands to farmlands during the first half of the 20th century, and then from farmlands to urban areas during the latter half of the 20th century. On the other hand, in the upper reaches of the rivers, natural green lands were developed into farmlands during the latter half of the 20th century. Although very few cases of direct change from natural green lands into urban areas were observed, by 2000, natural green lands remained only at highly elevated steeply sloped mountain areas in the most upper reaches of the rivers.

3. Water environmental issues in Jakarta

Rapid urbanization in the late 20th century in Jakarta mentioned in the previous chapter caused some serious water environmental problems. In this chapter, the author will divide Jakarta's current water environmental issues into qualitative and quantitative aspects using examples and describe them.

3.1 Water pollution

Similar to Bangkok, Jakarta is built on low-lying marshlands and has an extensive waterway network (Fig. 7). However, while the waterway in Bangkok functions mainly for boat transport, the waterway network in Jakarta seems to have been used to flow out rainwater and wastewater into the sea. Two things can be pointed out as quali-

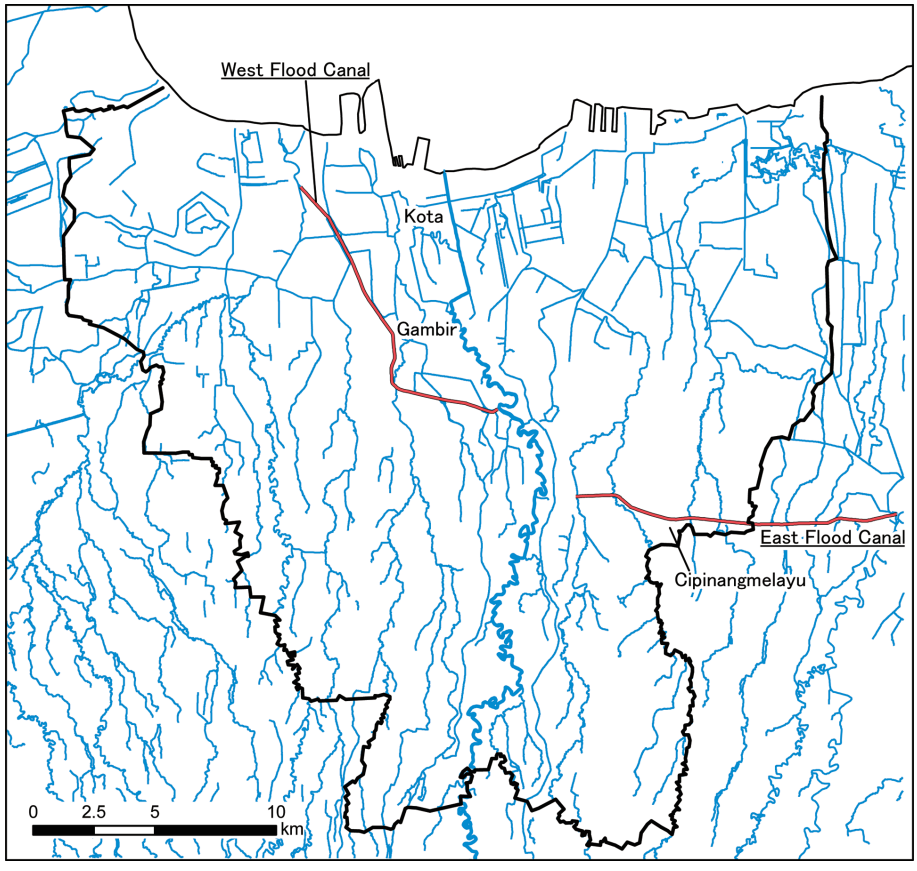

Fig. 7 Waterway network in Jakarta (around 2000)

tative aspects of water environmental issues in the canals and ditches in Jakarta; serious non-point source pollution caused by urbanization, and rubbish dumping by residents living alongside the river.

Change of the land use from natural green lands or farmlands to urban areas means change in land cover, from permeable surfaces such as soil and grass to impermeable surfaces such as concrete and asphalt. When urbanization progresses, rainwater which used to penetrated soil now runs on the surface and flows directly into canals and ditches. A large amount of dust and rubbish which exists on the surface of the urban land also flows into canals and ditches with rainwater. In fact, some canals and ditches in central Jakarta turned grey with dust, and there are odors along many parts of the canals and ditches (Fig. 8).

In addition, inadequate public services such as sewage systems and rubbish collection services following rapid population growth have led to significant water environmental issues. People tend to drain household wastewater directly into the waterway and dump rubbish (Fig. 9). Furthermore, similar to other capital cities in developing countries in Asia, in Jakarta, poor people tend to live around the river and waterways. In such areas, as rubbish collection levy becomes a burden for the residents, people are more likely to dump rubbish in the waterway (Fig. 10).

Residents do not have a high awareness of the environment and some residents believe that dumping rubbish is not a major problem as heavy rain during the wet season would wash the rubbish away.

3.2 Land subsidence and flooding

Change from permeable surface to impermeable surface is not only significant from a qualitative perspective but a quantitative perspective of water environmental issues. Rainwater that runs off the surface instead of penetrating into the soil suggests a decrease of the amount of groundwater recharge. However, rapid urbanization and population growth rapidly increases the requirement for the pumping of groundwater. This results in land subsidence. Jakarta is currently facing serious land subsidence and expanding areas below sea level (called “zero meter areas”) especially in the central and northwestern districts (Fig. 11) (Delinom *et al*., 2009). Such areas are also seen in large coastal cities in Japan. However, a problem unique to a large tropical city such as Jakarta caused by land subsidence is that there are frequent flood inundations during the wet season. Heavy storm water in a short period of time is not able to penetrate into the impermeable surface and does not flow out into the sea through river or waterway due to land subsidence. As a result, whenever there is a rain downfall, roads become flooded (Fig. 12).

Construction of discharge channels to ease flooding was seen during the Dutch Colonial Era. The most famous one is the West Flood Canal which was built in the 1920s in order to protect city centers such as Kota and Gambir from flooding (Fig. 7). The West Flood Canal branches out from the Ciliwung River in the upper reaches of Gambir and

Fig. 8 A canal turned grey with dust in central Jakarta (taken by author in Nov. 2010)

Fig. 9 A canal dumped rubbish in central Jakarta (taken by author in Mar. 2010)

Fig. 10 Poor residences around the Ciliwung River (taken by author in Nov. 2010)

runs through the West, then through the North West where it meets the Angke River and flows into the Java Sea. At the time of construction, the canal ran through rice paddy fields and undeveloped wetlands. More recently, the areas along the canal have been developed into residential lands and by this canal itself floods, it creates new flood damage.

East Flood Canal, a large-scale canal, has been under construction since 2002 (Fig. 7). This canal is being built crossing the existing small rivers. However, the water gates located at the crossing points have not been managed well, thus frequent flooding in the upper reaches of the existing small rivers have been reported. From field survey conducted in Cipinangmelayu which is one of the areas affected by floods (Fig. 7), it was found that the frequency of flooding increased since the construction of the water gate. For instance, in October 2010, there were 13 days of flooding when buildings were inundated, and sometimes it occurred twice a day. Therefore, measures are taken to deal with frequent flooding. The floors in the houses are raised (Fig. 13), and rooms are tiled, the bases of furniture are also raised, and measures are taken to ensure that nothing is placed directly on the floor (Fig. 14).

4. Discussion and conclusion

In this paper, the author has analyzed Jakarta's urban development paying attention to river basin in terms of time and space. Subsequently, Jakarta's water environmental issues have been divided into the qualitative aspects and the quantitative aspects and have been mentioned the details using examples. As a conclusion, the possible causes of water environmental issues and the measures required to deal with them will be discussed.

With regard to measures to deal with pollution such as worsening non-point source pollution and rubbish dumping, it is of course important to improve infrastructure, such as the sewage, the sewage treatment plants, rubbish collection and rubbish treatment facilities. In addition, it is more important to educate people living in the crowded urban areas, the poor people in particular, so that they become aware of their environment and to work towards improving the standard of living. Infrastructure improvement

Fig. 11 An area below sea level in central Jakarta
(taken by author in Aug. 2008)

Fig. 12 A flooded road during heavy rain in central Jakarta
(taken by author in Nov. 2010)

Fig. 13 A house that the floor is raised in Cipinangmelayu
(taken by author in Nov. 2010)

Fig. 14 A room that the floor is tiled in Cipinangmelayu
(taken by author in Nov. 2010)

is a “reactive” measure to deal with already created contaminants. On the other hand, letting people have the economic resources enough to manage the expense for sewage treatment and rubbish collecting and environmental awareness to maintain and keep local river and waterway clean with their hands is a “proactive” measure which prevents or minimizes the cause of contaminants. In short, water environmental issues in the cities are indeed the issues of economy and education.

In Jakarta, construction of underground water discharge channels connecting the Ciliwung River and East Flood Canal is under way. However, such a plan for channels alone is not adequate to deal with flooding. Comprehensive flood control including the land use plan in the wider areas at each basin is necessary. In Jakarta, included in the structure plan in the 1980s, the east-west development strategy was launched and measures were taken in order to slow down the development of the upper reaches of the rivers in the south, seen as water source cultivation areas (Konagaya, 1997). Fig. 4 shows that although such measures brought some success, they are not entirely satisfactory as the development from forests to farmlands continues. Although there is development restriction in the highly elevated and steeply sloped areas for water source forest conservation, these areas are relatively small for the overall basin. In order to reduce flooding and slow down land subsidence, it is necessary not only to successfully complete construction of the East Flood Canal and control the land use in the areas alongside the canal, but also to build facilities to store rainwater and to cultivate groundwater at each basin and to facilitate systems to make a good use of such water.

Acknowledgements

I would like to thank Professor Dr. Robert M. Delinom and Dr. Rachmat Fajar Lubis, Indonesian Institute of Sciences, for their cooperation and assistance for my field survey. This study is financially supported by JSPS Grant-in-Aid for Scientific Research B (No. 26284129, representative is Yuji Murayama).

References

Delinom, R. M., Assegaf, A., Abidin, H. Z., Taniguchi, M., Suherman, D., Lubis, R. F. and Yulianto, E. (2009): The contribution of human activities to subsurface environment degradation in Greater Jakarta Area, Indonesia. *Science of the Total Environment*, **407**, 3129-3141.

Konagaya, K. (1997): Urban planning and urban structure of DKI Jakarta. *The Quarterly Journal of Economic Studies (Kikan Keizai Kenkyu)*, **20(2)**, 85-99. (in Japanese)

Taniguchi, M., Burnett, W. C. and Ness, G. D. (2009): Erratum to “Integrated research on subsurface environments in Asian urban areas”. *Science of the Total Environment*, **407**, 3076-3088.

Yamashita, A. (2011): Comparative analysis on land use distributions and their changes in Asian mega cities. *In* Taniguchi, M. ed., *Groundwater and subsurface environments: human impacts in Asian coastal cities*. Springer, Tokyo, 61-81.

Yamashita, A. (2013): Land use change and its correlation with topographic condition in Ciliwung-Cisadane River Basin, Indonesia. *Papers and Proceedings of the Geographic Information Systems Association*, **22**. (in Japanese with English abstract)

Yoshikoshi, A. (2011): Urban development and water environment changes in Asian mega cities. *In* Taniguchi, M. ed., *Groundwater and subsurface environments: human impacts in Asian coastal cities*. Springer, Tokyo, 35-59.

Received 25 August 2014
Accepted 27 October 2014