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Assessing urban water security: case study Jakarta

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Abstract. Water security is the availability of freshwater with sufficient quantity and quality at the right time. The water security is a prerequisite for economic security, as well as for socio-ecology and human security. The concept of water security has received increased attention over the past decade, in both policy and academic cycles. The assessment of water security can be carried out in city, watershed and country scale. The aim of this study is to calculate water security index at the city scale using Jakarta as case study and then to compare the index with another selected city in ASEAN region. When calculated temporally, the water security index can be used to evaluate the improvement of water infrastructure in a city. The assessment was carried using five dimensions and eight indicators, each one assigned with equal weights. The following dimensions were used: a) Domestic water security, b) Economic water security, c) Environmental water security, d) Water-related disaster, e) Governance and management. The selected indicators were water supply access, water quality, economic value of water, extent of water treatment, water quality of natural water bodies, impact of disaster, budget for water management, technological interventions. Based on the assessment, Jakarta is classified as low-medium water security. The dimensions that need strong improvement to increase water security index of Jakarta are environmental water security, water related disaster, and governance and management. The domestic water security was in the medium level but it should be further improved to secure the water, and for economic water security, it was in the very high level in water security. Comparing to Bangkok City, the water security index of Jakarta is slightly lower. Keywords: Jakarta water security, water security dimension and indicator, water security index

1. Introduction

Water security become one of the biggest challenges of 21st century. As population growth, humanity faces the situation of scarcity water supplies due to climate change and as well as increasing demands of water [1]. Nowadays, many people still do not have access to meet hygiene water and adequate livelihood quantity. As human demands increase and water resources become scarce, the water competition between humans and the environment and also between different sectors of the economy and various sections of society increases [2]. Water security is defined as the capacity of a population to safeguard sustainable access to adequate quantities of and acceptable quality water for sustaining livelihoods, human well-being, and socio-economic development, for ensuring protection against water-borne pollution and water-related disasters, and for preserving ecosystems in a climate of peace and political stability [3].

Water security was generally described in an integrative and interdisciplinary way, which can be differentiated into four types with respect to varying priorities [4]. The first type of definition focuses on water availability, whereby water security is defined as a condition in which people have access to sufficient, safe and affordable water to satisfy their basic needs for drinking, washing, and livelihood [5]. The second type puts an emphasis on human vulnerability to hazards; specifically, water security



involves the protection of vulnerable water systems, protection against water related hazards such as floods and droughts, the sustainable development of water resources, and the safeguard of access to water functions and services [6]. The third type pays more attention to human needs, a representative point being that “water security is a condition where there is a sufficient quantity of water at a quality necessary, at an affordable price, to meet both the short-term and long-term needs to protect the health, safety, welfare, and productive capacity of position (households, communities, neighborhoods or nation) [7]. The last type considers sustainability as the most important element, and water security is defined as a condition in which “every person has access to enough safe water at an affordable cost to lead a clean, healthy, and productive life, while ensuring that the natural environment is protected and enhanced [8].

Water Security analyses to date have focused on a range of sectors, such as agriculture, potable water, and ecosystem services. Besides that, it can be focused on scales like household, nation, city, and watershed, or it can be analyzed by drivers (climate change, armed conflict, economic growth), and key responses (water storage infrastructure, water supply technologies). Those analyses have different interpretations for water security with various emphasis on risk rights [9], environmental sustainability and adaptation [10,11], water quality [12], and complexity [13].

Water security can be measured based on many scales such as country, city, or watershed scales to define how secure the condition of water in those scales by using Water Security Index (WSI). Water Security Index is measured by water security assessment that has 5 dimensions with related indicators and variables [15]. Jakarta is a metropolitan city in Indonesia. Assessment in water security in Indonesia is needed and used in planning of developing the city. Water problem in Jakarta is a concrete problem that is needed to solve such as flood and water quality problem. Assessment in water security in Jakarta can be the first step in solving the problem and managing the plan in developing the city.

2. Purpose

The aim of this study is to calculate water security index at the city scale using Jakarta as case study and to compare the index with another selected city in ASEAN region.

3. Methods

The assessment was carried using DPSIR framework. DPSIR framework is a framework that looks at the entire cycle of how the environment is affected by natural and anthropogenic factors, and the societal response to these factors. It consists of Drivers, Pressures, State, Impacts, and Responses or called by DPSIR [14].

Drivers refers to the root causes of the human activities that impact the environment. Pressures are stresses that human activities put on the environment, stemming from socio-economic activities. State is the condition in terms of quantity and quality of resources resulting from the pressures, also called a snapshot of the situation. Impact is the effects of a changed environment and the consequences for human health, the economy, etc. The last, responses are measures undertaken by society to address environmental concerns [14].

This study was comprising five dimensions and seven indicators, each one assigned using scoring method with equal weights [Table1 1; 15]. The following dimensions and indicators were used: a) Domestic water security(water service coverage-%; water consumption-l/c/d), b) Economic water security (water productivity agriculture and non-agriculture -Rp/m³), c) Environmental water security (ratio of treated to total wastewater-%; WQI), d) Water-related disaster (minimum and maximum depth of flood in Jakarta-cm, e) Governance and management(ratio of leakage in water Supply-%). Scoring techniques was used to asses relative value of each indicator and the water security index was determined based on classification criteria as proposed in the literature [16].

Table 1. Dimensions and indicators used for water security index assesment [15]

Dimension	Indicators
Domestic water security	Proportion of service coverage
	Water Consumption(l/c/d)
Economic water security	Water productivity (USD/m ³)
Environmental water security	Ratio of treated to total wastewater (%)
	Water quality index of waterbody
Water related disaster	Flood depth
Governance and Management	Ratio of treated to total wastewater (%)
	Budget for water management (USD/cap)
	Ratio of Leakage in Water Supply

Source: AIT, Bangkok [15]

4. Results and Discussions

4.1. Domestic Water Security

Domestic water security is related to people accessibility to water, adequate quantity and condition of water quality acceptable to the health people. Domestic water security dimension can be expressed by two indicators and some variables that could represent the condition of domestic water. The indicators are water supply and access, and water quality. Water supply and access can be represented by percentage of water service customer and water consumption per capita. The data of percentage of water service customer and water consumption per capita in Jakarta is displayed in the Table 2.

Table 2. Percentage of Water Service Customer and Water Consumption per Capita in Jakarta.

Year	Total Population (People)	Water Service Customer (People)	Water Service Coverage		Water Consumption (l/c/d)	
			(%)	Score		Score
2014	10.197.066	4.652.298	45,62	1	130	2
2015	10.317.800	5.158.900	50,00	1	130	2
2016	10.461.613	6.276.968	60,00	1	130	2
2017	10.605.427	7.423.799	70,00	2	130	2
2018	10.749.240	8.599.392	80,00	3	130	2

Source: PDAM Jakarta

Based on the data, there is an increasing of percentage of water service customer from 2014 to 2018. It means that the state water supply in Jakarta moved from very poor to average category in Percentage of Water Service Customer variable. It also showed that 80% people of Jakarta in 2018 have been used safe drinking water that guaranteed by PDAM Jakarta. Meanwhile, in water consumption, people consumed water 130 l/c/d in average from 2014 to 2018. Water consumption 130 l/c/d is still in poor category in domestic water security. The indicator of domestic water security consisting of water service coverage and water consumption in Jakarta showing score value of 3 (medium water security) and 2 (low water security), respectively.

4.2. Economic Water security

Water has economic value, the water productivity of economic activities in the city should be measured. The selected variables for this dimension are Agricultural and Non-agricultural water productivity. The data required to measure the economic water security are agricultural and non-agricultural GPP and water use in agricultural and non-agricultural sector. Data of sector contribution in agriculture and non-agriculture is shown in Table 3.

Table 3. Sector contribution to Jakarta GDP and respective water use

Sector	GDP-2016 (million IDR)	Water use-2016 (million m ³)	Water productivity (USD/m ³)	Score
Agriculture and Non-agriculture	1,540,078,198	337,14	284	5

Source: BPS 2016

Jakarta has very high water security in economic water security. In agriculture and non-agriculture sector, the water productivity reached 284 USD/m³ or around 4.000.000 IDR/m³. The indicator of economic water security consisting of Agriculture and Non-agriculture showing score value of 5 (very high water security).

4.3. Environmental Water Security

Water-bodies in the city must not be effected from pollution and contamination that are generated by the city. It is related to wastewater treatment and also water quality of natural water bodies. The data required for environmental water security are wastewater data and water quality of each canal in Jakarta is displayed in Table 4.

Table 4. Environmental Water Security

Indicator	Value	Score
Ratio of treated to total wastewater (%)	3	1
Water quality index (WQI) of waterbody	21	1

Source: KLHK

Based on the data from Ministry of Forestry, the ratio of treated wastewater to total wastewater is very low, less than 5%. The wastewater in Jakarta has not treated well. The management of wastewater still in poor level, meanwhile the total of wastewater is in very high level. Water quality index (WQI) of natural water body used to present water-body health assessing the water quality in the canals in Jakarta. The parameters measured are DO, BOD, TCB, FCB, and NH₃. The value of this indicator is also in very high water insecurity. The quality of water in Jakarta is still very poor. It related to the total of wastewater that has not treated well.

4.4. Water Related Disaster

This dimension is intended to capture the effects of floods and droughts in the city. In Jakarta flood is more affected to people than drought. The variable that can be measured related to flood in Jakarta is the minimum and maximum depth of flood in Jakarta. The data from 2013 to 2016 is showed in the Table 5.

Table 5. Minimum and Maximum Depth of Flood in Jakarta (cm).

Month/Year	2013		2014		2015		2016		Score
	Min	Max	Min	Max	Min	Max	Min	Max	
January	10	400	10	400	10	150	10	80	1
February	10	175	10	300	10	200	5	200	1
March	10	250	10	200	10	200	5	300	1
April	10	100	10	150	20	100	5	360	1
May	0	160	10	200	20	100	5	200	1
June	0	150	30	200	0	0	5	90	1
July	10	180	10	200	0	0	10	190	1
August	20	300	30	150	0	0	10	120	1
September	0	0	0	0	0	0	5	170	1
October	20	100	0	0	0	0	10	100	1
November	10	100	20	400	20	300	5	150	1
December	10	200	10	200	10	60	-	-	1

Source: PPID Jakarta

The flood depth represents the damages from immediate contact with flood water. The maximum depth of flood in Jakarta in 2013 to 2016 is 400 cm and the minimum is 0 cm. Based on the data, the condition of flood depth is still in poor category.

4.5. Governance and Management

Although water governance is central to the management of water resources in the basin, it has rarely been considered in water security assessment frameworks in the past. A possible reason for this could be that water governance is implicitly reflected in the assessment of every dimension of water security. However, for this study, we decided to make this important aspect explicit, and assign a dedicated dimension for water governance. This dimension captures the ability of the government to manage the water sector and plan for anticipated changes [15]. One of the variables that can be measured to represent the government and management dimension is the ratio of leakage in water supply. The more leakage ratio in water supply, the less water supply management of the government. The data is shown in Table 6.

Table 6. The Ratio of Leakage in Water Supply in Jakarta.

Year	The Ratio of Leakage in Water Supply (%)	Score
2014	40,26	1
2015	39,50	1
2016	39,00	1
2017	38,50	1
2018	38,00	1

Source: PDAM Jakarta

The ratio of leakage in Jakarta was in very poor category because it was still more than 25% in 2014 to 2018. Yet, it showed a significant decreasing from 2014 to 2018. Based on the data, Government should be more effective in taking care of the leakage, so it could be used fully by people in Jakarta. Besides the leakage in water supply in Jakarta, governance and management in water security is also measured by budget for water management and the ratio of water reuse to total wastewater. Table 7 showed the data for both.

Table 7. The Ratio of water use to wastewater and budget for water management

Indicator	Value	Score
Ratio of treated to total wastewater (%)	<3	1
Budget for water management (USD/cap)	6.8	1

Ratio of treated water to total wastewater means that the treated water can be reused, so the value of its indicator is still the same with the treated water which is still in the very high insecurity. Actually this condition is the effect of the budget for water management that is still in very low level. The budget for water management is still in category 1, which is still in the very high water insecurity.

4.6. Water Security Index in Jakarta

Water security index in Jakarta can be measured by the indicators from that five dimension. The indicators is very flexible based on the availability of data that can represent the condition of the city. Each indicator is given score to uncover the index of water security in Jakarta and the score is combined for all indicators. The combined score can be concluded in Table 8.

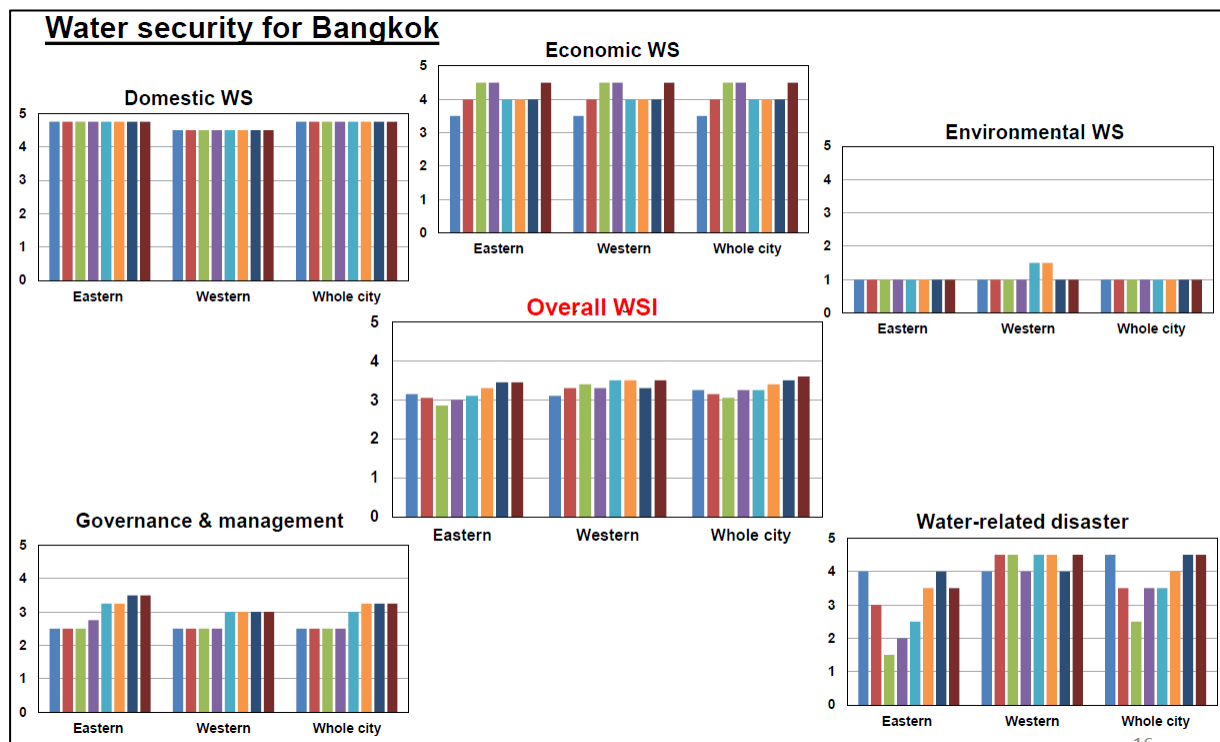
Table 8. Combined score

Dimension	Indicators	Score	Average
Domestic water security	Proportion of service coverage	3	2.5
	Water Consumption(l/c/d)	2	
Economic water security	Water productivity (USD/m ³)	5	5
Environmental water security	Ratio of treated to total wastewater (%)	1	1
	Water quality index of waterbody	1	
Water related disaster	Flood depth	1	1
Governance and Management	Ratio of treated to total wastewater (%)	1	1
	Budget for water management (USD/cap)	1	
	Ratio of Leakage in Water Supply	1	
Average score			2.1

Based on the assessment and classification criteria [16], Jakarta is classified as low-medium water security. The dimension that need strong improvement are environmental water security, water related disaster, and governance and management. For domestic water security, it was in the medium level but it should be further improved to secure the water, and for economic water security, it was in the very high level in water security.

4.7. Comparing Water Security in Jakarta and Bangkok

Bangkok is also a metropolitan city in Thailand. It quite same with Jakarta in Indonesia. Assessment water security in Bangkok is conducted by AIT (Asian Institute of Technology, [15]). Bangkok is assessed by 5 dimensions (Domestic Water Security, Economic Water Security, Environmental Water Security, Governance and Management Water Security, and also Water Related Security) in the eastern and western city. The condition of water security in Bangkok can be seen in the Figure 2. Based on the data, Bangkok has a moderate level of water security over 8 years (2007-2014). The environmental dimension of the lowest level of water security while the domestic dimension of the highest level of water security in Bangkok [15].



Source: AIT, Bangkok [15]

Figure 1. Water Security in Bangkok

Comparing to Jakarta, Indonesia which is the water security index is 2,1, Bangkok, Thailand is slightly higher in whole city. Even, for environmental water security is still needed the maintenance in Bangkok, Thailand.

5. Conclusion

The indicator of domestic water security consisting of water service coverage and water consumption in Jakarta showing score value of 3 (medium water security) and 2 (low water security) respectively. The indicator of economic water security consisting of Agriculture and Non-agriculture showing score value of 5 (very high-water security). The environmental water security exhibits very low score. Based on the assessment, Jakarta is classified as low-medium water security. The dimension that should be strongly improved are environmental water security, water related disaster, and governance and management. For domestic water security, it was in the medium level but it should be further improved to secure the water, and for economic water security, it was in the very high level in water security. Based on the WSI, Jakarta is classified as low-medium water security. Comparing to Bangkok City, the water security index of Jakarta is slightly lower.

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