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THEORETICAL FRAMEWORK OF URBAN WATER SECURITY IN INDONESIA

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Abstract – For years cities in Indonesia have experienced massive urban and economic developments which involved conversion of land to economic areas and human settlements. These cause some cities in Indonesia to face critical condition is providing clean waters and services of urban sanitation. As a consequence of clean water demand, industries and household explore ground water as a source of clean water. Over abstraction of ground water has impacted declining of groundwater table and land subsidence. Due to the problems that have been created by aspects above, it is necessary to acquire a framework dealing with the complexity of urban water problems in Indonesian cities that could explain the urban water security, and to be used to monitor and evaluate the progress of the cities in improving their urban water services. This paper is describing the dimensions that give affects to urban water security with their phenomena and problems in Indonesian cities and build the theoretical framework of urban water security. The result of this research is a theoretical framework of urban water security, consists of five key dimensions of urban water security, such as: Water Supply Management, Stormwater Management, Wastewater Management, Groundwater Management and Solid Waste Management.

***Keywords*:** Urban water; water security; theoretical framework, Indonesia

1.0 INTRODUCTION

Indonesia is an archipelago country with significant water resources. The average annual rainfall reaches about 2,500 mm around this region. However rapid population and economy growth with massive land reform have led some regions in Indonesia to experience water supply shortages. That should be a main concern for a city with major activities such as economy, governance, industry, and high density of population. A growing city is challenged by increasing water demand, water pollution, surface run off and ground water. Subsequently the majority of the population and industries may not have access to clean water. In 2015, the Directorate General of Cipta Karya [1] mentioned that only 67.7% of the urban population in Indonesia had adequate water supply, the rest experienced limited clean water supply, with wastewater treatment at 77.15%. Due to the limitation of clean water availability, the people and industries are extracting ground water with boreholes. Overabstraction of ground water has resulted in declining groundwater table and land subsidence. Kementerian Energi dan Sumber Daya Mineral Republik Indonesia [2] and Muhli [3] mentioned that land subsidence of some cities in Indonesia such as Semarang and Yogyakarta are around 7 to 30 cm each year.

It is necessary to acquire some parameters that could explain urban water security. The main goal of urban water security should be delivered to improve the quality of life for urban people. Water security has multiple components, including supplies of sufficient good quality water to users and the environment, mitigating risks, hazards and avoiding conflicts over shared waters. Therefore the parameters selected should reflect the urban water security situation in Indonesia.

Water security dictates that every person has access to enough safe water at affordable cost to lead a clean, healthy and productive life, while ensuring the environment is protected and enhanced [4]. Cheng et al. [5] also defined water security to include access to safe water at affordable cost to enable healthy living

and food production, while ensuring the water environment is protected and water-related disasters, such as droughts and floods, are prevented. Grey and Sadoff [6] then stated that water security is focused on the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water-related risks to people, environments and economies. Lautze and Manthrithilake [7] stated that a conceptual water security framework contains four components: basic needs, agricultural production, the environment, and risk management and [6] stated it covers issues related to water for national security or sovereignty.

Water security involves all issues related to water. These are the problems faced by many people, which good water management should solve or at least alleviate. It is also about mitigating water-related risks, such as floods and droughts, addressing conflicts that arise from disputes over shared water resources, and resolving tensions among the various stakeholders who compete for a limited resource. Water is recognised as a central plank of the green economy. It is critical to sustainably managing natural resources and it is embedded in all aspects of development: poverty reduction, food security, and health and in sustaining economic growth in agriculture, industry, and energy generation. Water security has three key dimensions: social equity, environmental sustainability, and economic efficiency, also known as people, planet, and profit [8]. Social dimension covers aspects of: ensuring equitable access to water services and resources for all through robust policies and legal frameworks at all levels, and building resilience in communities in the face of extreme water events through both hard and soft measures. The environmental dimension in managing water sustainably is as part of a green economy, and restoring ecosystem services in river basins to improve river health. The economic dimension is in increasing water productivity and conservation in all water-using sectors, and sharing economic, social, environmental benefits in managing transboundary rivers, lakes, and aquifers [9].

A comprehensive framework for national water security was developed by Asian Water Development Outlook in 2013 [10]. It was an outcome-based approach and crafted the comprehensive vision of water security recognising the need for security in households, economies, cities, the environment, and resilient communities. The framework transformed the vision of water security into a quantitative assessment in five key dimensions. The key dimensions of water security are related, interdependent, and should not be treated in isolation. Measuring water security by aggregating indicators in these key dimensions recognised their interdependencies. Increasing water security in one dimension may simultaneously increase or decrease security in another dimension and affect overall national water security. Asian Water Development Outlook [10] and Mason & Calow [11] had similar approaches and identified a limited number of key dimensions of water security, but Mason & Calow specified governance within in its five key themes.

Water security relies on effectively integrating water resources management at various scales, in particular at national, river basin, and local scales and includes the essential elements of economic efficiency, social equity, and environmental sustainability. People assign meaning to the concept of water security depending on the scale at which it is applied. Most reports to date address water security at a national scale. This, together with food and energy security, underlines the critical importance of water security to countries' sustainable development. Most commonly, water security is addressed at country, river basin, city, and community scales. In some cases, water security may be considered for a specific region or unit, such as a large metropolitan area, a delta, or an island. Although the broad definition of water security is applicable at all scales, it is logical, at each scale, to focus on specific issues. Applying the concept at community level puts more emphasis on individual water users and their social and environmental context [8].

The selection of potential parameters to develop an urban water security key dimension should meet the criteria of relevance, availability, credibility, universality, and statistical independence. Additionally, they should consider the water quantity and quality aspects (state) of the channel, the main driving processes (climate and human pressures) affecting them, and existing (or lacking) societal responses. Once the urban water security indicators are developed they must go through sensitivity analysis and validation processes, using a wide range of scenarios, before their final application [4].

Integrated Water Resources Management (IWRM) and water security have the same general objective – improving the conditions related to water for human wellbeing. Achieving water security is always a challenge because conditions will change, demand for water will continue to grow, and limited financial resources will constrain. IWRM helps to improve water security provided that the amount and quality of resources are available in the effort. IWRM and water security are symbiotic and this is factored into the continuous IWRM planning cycle (Figure 1). An important step in the planning cycle is the situation analysis in which the problems are identified and goals set. Water security quantifies those goals by identifying the dimensions of water security and specifying indicators to measure this, preferably including clear targets. In practice, IWRM offers a framework for addressing water-related problems and issues [8].

Urban water management has a mutual influence with water resources management in the river basin level. Consequently, coordination and cooperation among cities and regencies should be developed in river basin level [12], [13].

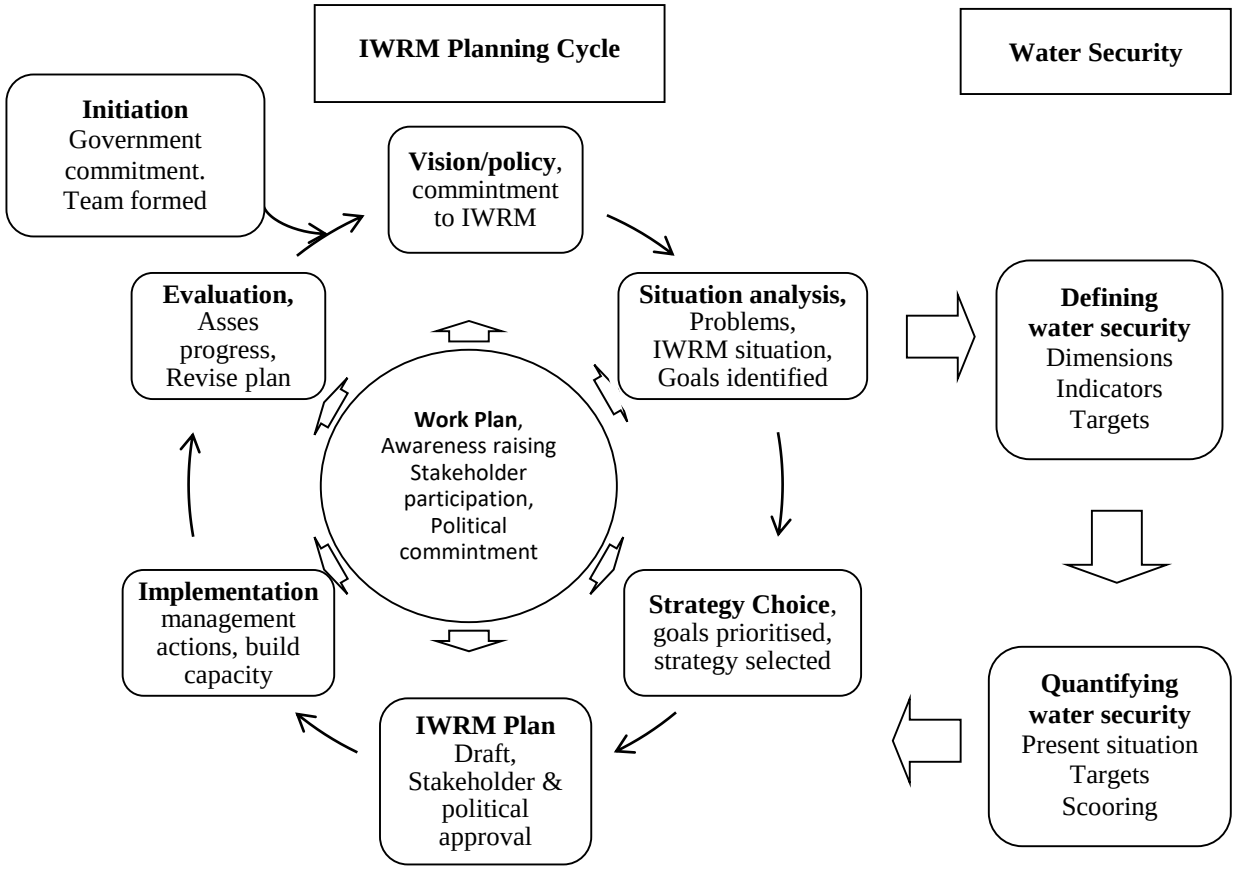

Figure 1. Factoring Water Security into the IWRM Planning Cycle [8]

The Government of Indonesia in its National Strategic Development Plan 2015 – 2019 used water security as the goal of water resources development. Infrastructure development during that period is intended to ensure water security for supporting national security. Six objectives that will be achieved during that period are: (1) To fulfil raw water demand for domestic, municipality, and industry; (2) To fulfil the demand of irrigation water and raw water for urban areas; (3) To increase the performance of irrigation management; (4) To accelerate the utilization of water resources for electricity (hydropower); (5) To increase the prevention to water related disasters; and (6) To optimize water balance management.

The data from Badan Pusat Statistik [14] indicates that the number of urban population in Indonesia has exceeded 50% with the rate of growth 2.75%, while the national rate of population growth is 1.17%. Badan Pusat Statistik [15] estimated that the number of urban population in 2015 is 53.3% which will grow to 60,0% in 2025, and achieve 66.6% in 2035. This high rate of urbanization shows the critical condition of urban water service in Indonesia. Today, the level of water supply service by public water

supply enterprise (Perusahaan Daerah Air Minum = PDAM), for example, is still under 50% of the total urban population. It means that this urbanization rate become a serious threat to urban water security. Up to now, the understanding and involvement of the decision makers to the issue of water security and especially urban water security is still very limited. Tjandraatmaja et al [16], developed a framework for water security assessment and capacity building and used the framework in assessing urban water security and climate change adaptation in Makassar, Indonesia. But so far, the developed framework has not been implemented nationally to measure the level of urban water security in other Indonesian cities.

Badan Pusat Statistik [14] also indicates that Java Island is the most urbanized area, followed by Sumatera, Sulawesi, and Kalimantan. Among those cities, 11 cities have population more than 1 million, 15 cities have population between 500,000 to 1,000,000, 20 cities have population between 200,000 to 500,000, 32 cities have population between 100,000 to 200,000, and 21 cities have population less than 100,000. It means that urban water problems in Indonesia vary from the metropolitan cities, big cities, to small cities with their own characteristics of geographical condition and water resources potential, social and economic activities, which will influence their water demand and water related problems.

This study is intended to attract stakeholders in considering the importance of using urban water security as a measure in managing urban water systems. Implementing a framework of urban water security will help stakeholders in developing strategies for improving urban water service based on its own characteristics, water resources potential, and urban water problems.

2.0 METHODOLOGY

This paper is a result of literature study on urban water related problems in Indonesia. A simple analysis was done to the available secondary data related to water supply service in the cities in Indonesia, which are assumed to represent the general water supply condition in other cities. Analysis was also done from the available data on sewerage systems constructed in Indonesia. Comparing the results of the analysis with personal daily observation of surface water pollution, solid waste management, and other information on groundwater degradation in some urban areas, resulted in a comprehensive explanation on the complexity of urban water problems in Indonesian cities, in which the threats to urban water security are identified.

This section covers the dimensions that give more affect to urban water security with their phenomena and problems in Indonesia cities and build the theoretical framework of urban water security.The first step is building the framewok of complexity for urban water problems in Indonesian cities. The second step is to determine the relevant dimensions of water security. The dimensions selected will depend on the situation, and the specific objectives of stakeholders and decision-makers. A third step is to select indicators that reflect the main characteristics of the key dimensions. Indicators selection involve the selection of appropriate indicators for the field of research given their relevance to current issues, their appropriateness to the area in question, their scientific and analytical basis plus their ability to effectively represent the issues they are designed for (measurability). This involved an investigation of indices such as the Water Poverty Index [17]; [18]; [19], Sustainability Index [20]; [21]; [22]; [23], Water Stress Index [24] and Water Security Index [7];[10].

3.0 RESULTS AND ANALYSIS

Indonesian cities are facing complex urban water problems which are inter-related among the provision of water supply, water pollution, water related disasters, groundwater degradation, and poor solid waste management. Managing urban water system in Indonesian cities should be integrated with municipal solid waste management as well as groundwater management, due to its inter-related impacts to urban water security.

Water Supply Service

Table 2 presents the number of population and house connection from public water supply enterprise (PDAM).

Table 1 Public water supply service in the ten capital city in Indonesia

No	Province	Capital	Population	PDAM Connection	Coverage(%)
1	Sumatera Utara	Medan	2.210.624	472.809	95,18
2	DKI Jakarta	Jakarta	10.177.924	830.857	40,82
3	Jawa Barat	Bandung	2.481.469	152.841	30,80
4	Jawa Timur	Surabaya	2.599.796	526.688	81,04
5	Banten	Serang	643.205	514	0,40
6	Bali	Denpasar	880.600	80.356	45,63
7	Kalimantan Barat	Pontianak	607.438	98.032	77,14
8	Kalimantan Selatan	Banjarmasin	675.440	166.361	99,01
9	Sulawesi Selatan	Makassar	1.449.401	162.985	56,22
10	Maluku	Ambon	411.617	10.505	12,76

The reason of this still low level of service is the limited capacity of the public water supply enterprise to respond to the increasing demand from the high rate of population growth and the fast economic development of the cities. Around 50% of the urban population in Indonesia depends on shallow groundwater, because of its easy access using dug wells, boreholes, hand pumps, or electric pumps. Social and business activities such as schools, offices, hospitals, malls, and hotels usually use deep groundwater for their water supply sources. New developed housings and apartments usually find their own water supply service. In slum areas people usually get their water service from public hydrants, while in the areas with high water scarcity like North Jakarta, people spend more money on water from vendors. In peri-urban areas, sometimes people use water springs, develop a distribution system, and manage it as a community based water supply.

Stormwater System

Most Indonesian cities are experiencing flooding and inundation. The City of Jakarta, Semarang, Surabaya, Pontianak and others are flooded every year. Generally the cause of flooding in Indonesia is due to lack of drainage arrangements, unconnected channels, the amount of solid waste in the channel and the influence of tides.

Waste Water Management System

In general, waste water management in Indonesian cities is still dependent on on-site systems. Most households and public buildings rely on individual septic tanks. Some new simple housing areas have developed communal septic tanks, while in some real estate projects developers have installed sewerage system and advanced waste water treatment plants. Conventional sewerage systems have been developed in some Indonesian cities since the 1980s. However, only parts of the capacity are utilized, due to technical and financial problems.

Poor sanitation systems and very limited capacity of the sewerage system increases water pollution in streams and rivers across the cities. Poor sanitation systems in slum areas that depend on individual septic tanks which are not well constructed results in groundwater pollution, whereas the same groundwater are also used as water supply sources. Improving sanitation condition, Indonesian cities should develop innovative approach in sewerage and sanitation system. At least, new developed housing should implement a communal sewerage or small bored sewerage system combined with appropriate technology of wastewater treatment plant such as constructed wetlands or stabilization ponds.

Table 2 Sewerage Systems in Indonesia in 2016

No	City	System	Total Capacity(m^3/hari)	Used Capacity (m^3/hari)	Used Capacity Percentage (%)	House Connection
1	Medan	UASB	10.000	5.650	56,50	12.370
2	Prapat	Aerated Lagoon	2.000	115	5,75	253
3	DKI Jakarta	Aerated Lagoon	38.800	704	1,81	1.407
4	Bandung	Stabilization Pond	80.835	49.769	61,57	99.538
5	Cirebon	Stabilization Pond	20.547	9.667	47,05	13.165
6	Yogyakarta	Aerated Lagoon	15.500	7.314	47,19	11.000
7	Surakarta	Aer-Fac Biofilter	9.504	6.325	66,55	11.978
8	Bali	Aerated Lagoon	51.000	31.185	61,15	8.647
9	Banjarmasin	RBC	10.000	2.568	25,68	8.968
10	Balikpapan	Extend Aeration	800	800	100,00	1.452
11	Tangerang	Oxidation Ditch	2.700	600	22,22	1.200
12	Batam	Oxidation Ditch	2.852	150	5,26	300

Groundwater Degradation

Overabstraction of groundwater pumping, especially for industries and business activities resulted in groundwater degradation in some urban areas. In coastal areas of Semarang City and Surabaya City, groundwater depletion followed by land subsidence has resulted in negative impacts to drainage systems, increasing the risks to sea water flooding. The problems of groundwater degradation are also experienced by cities in Java and Sumatera.

Urban water problems in Indonesia

Figure 2 shows the complexity of urban water problems in Indonesian cities. Economic activity causes urban population growth. The high rate of population growth in urban areas due to urbanization causes increasing water demand and land coverage. Increasing water consumption will increase wastewater production which in turn will cause pollution to the water body, due to the lack of wastewater management system. Increasing land coverage will increase direct runoff which results in problems of flooding and inundation. Increasing water consumption will decrease capacity of public service enterprises, forcing consumers to turn to groundwater abstraction and thus causing land subsidence and groundwater degradation. These processes give affect to flooding and inundation problems. Poor drainage and flood control systems also increase flooding and inundation problems. Growing economic activities influence wastewater production, with the pollution of the water body becoming a main constraint for the public water supply to increase their capacity to response the increasing demand in the cities. Economic activities also increase solid waste volume due to lack of solid waste management and this impacts the water body.

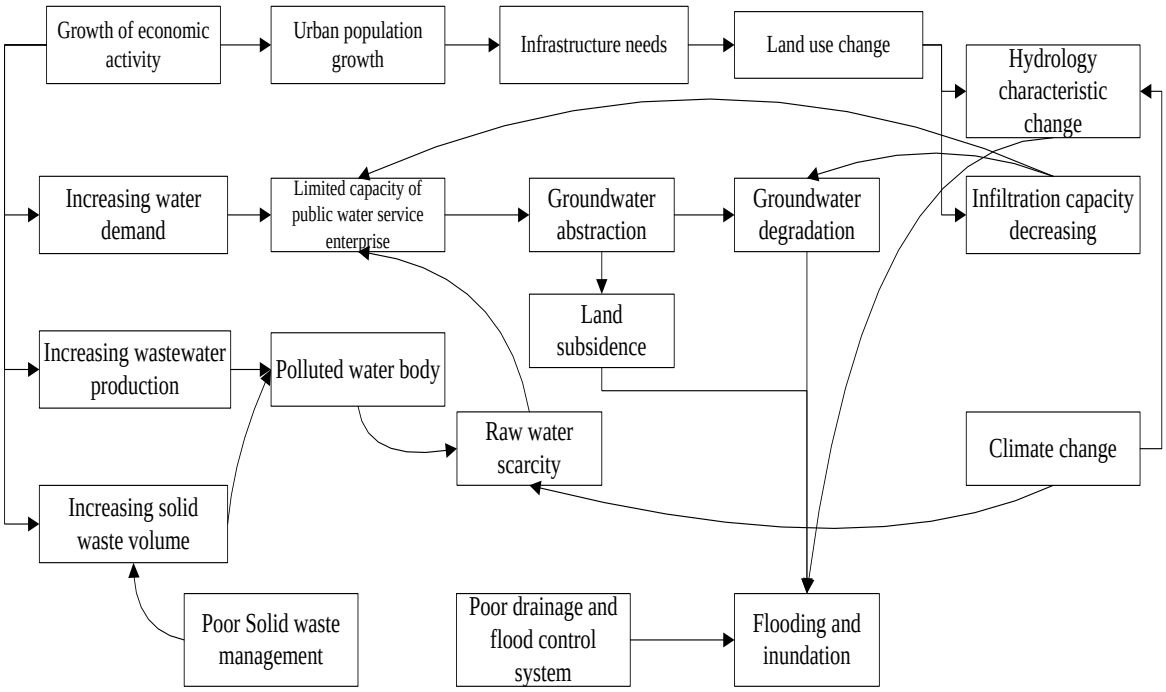

Figure 2 Complexity of urban water problems in Indonesian cities

Figure 3 Theoretical framework of urban water security in Indonesia

From the explaination above, the theoretical framework of urban water security consists of five key dimensions: 1) Water Supply Management, 2) Stormwater Management, 3) Wastewater Management, 4) Groundwater Management, and 5) Solid Waste Management. The purpose of indicator in every key dimension is to explain what will be measured and all of substantial indicators urban water security. The purpose of the first key dimension is measuring the satisfaction of piped and non piped water. The second key dimension is measuring how well drainage channels are developed and managed to sustain ecosystem

services. The third key dimension is measuring the coverage area of wastewater public service and the water body quality. The fourth key dimension is measuring how the city uses groundwater and the quality of groundwater.The fifth key dimension is measuring how the city manages the solid waste and the water body quality. The following figure is a theoretical framework of urban water security (Figure 3) and a matrix of Urban Water Security key dimensions (Table 3).

Table 3 Urban water security key dimensions

No	Key dimension	Purpose of indicator
1	Water Supply Management	measuring the satisfaction of piped and non piped water
2	Stormwater Management	measuring how well drainage channels are developed and managed to sustain ecosystem service
3	Wastewater Management	measuring the coverage area of wastewater public service and water body quality
4	Groundwater Management	measuring how the city uses groundwater and the quality of groundwater
5	Solid waste Management	measuring how the city manages solid waste and water body quality

4.0 CONCLUSIONS

From the above discussion, it can be concluded that

1. Indonesian cities are facing complex urban water problems which are inter-related among water supply, water pollution, water related disasters, groundwater degradation, and poor solid waste management.

2. Five key dimensions of Water Supply Management, Stormwater Management, Wastewater Management, Groundwater Management, and Solidwaste Management are acquired from the main theoretical framework and are connected with the level of urban water security in Indonesia. Every key dimension has certain relations with one another and could be integrated in the interconnected framework.

3. The implementation of the theoretical framework in measuring urban water security will be examined in some selected cities in Indonesia. The assessment of urban water security will be to compare water security among cities or for decision-making or to determine a preferred investment strategy to increase urban water security in a specific case.

4. The next step of this study is to determine percentages for each dimension, indicator, and variable (weight), followed by measuring and scoring indices for each urban water security dimension.

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