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A Water Sustainability Index for West Java – Part 1: Developing the Conceptual Framework

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Abstract Sustainable water resources management is essential since it ensures the integration of social, economical and environmental issues into all stages of water resources management. The development and application of water sustainability indices to achieve sustainable water management has been successfully done in the last few years. Although existing water sustainability indices have successfully provided information on current conditions of water resources and prioritised water related issues, they have been developed for specific case study areas. This study therefore aims at developing a water sustainability index for West Java, Indonesia. The overall steps for developing the index include developing a conceptual framework, application of Delphi technique to finalise the components/indicators of the index, applying the index to case studies and robustness analysis of the index. This paper, which is the first in a two-part series, discusses the first step, namely developing the conceptual framework of the West Java Water Sustainability Index (WJWSI). It outlines the criteria for identifying the initial set of components/indicators and based on those criteria, a detailed justification for selecting each component and indicator is also presented. The second paper of the series presents the application of Delphi technique to finalise the framework of WJWSI based on feedback from selected stakeholders. The remaining steps of developing WJWSI will be undertaken in the future.

Keywords sustainability index; water resources; West Java; Indonesia.

INTRODUCTION

As the population in West Java increases, the demand on clean water also increases. In 2006, the combined water demand for domestic, industrial and irrigation purposes was approximately 17.5 billion m^3, and is predicted to increase as much as 1% each year (Rahmat & Wangsaatmadja, 2007). To supply the demand on clean water, the West Java province relies on both surface and groundwater. The availability of water during the rainy season is abundant due to high rainfall in most areas of West Java. However, this abundance of water has not been properly managed, which has resulted in water shortage in some areas during the dry season. In terms of water quality, both surface and groundwater in West Java are mostly polluted by domestic, agricultural and industrial activities. For rivers in particular, regular monitoring by the Environmental Protection Agency of West Java shows that most water quality parameters fall below the threshold values set by provincial and national governments (Rahmat & Wangsaatmadja, 2007).

The provincial and national governments have implemented some programs to improve the quality of the rivers, as well as implemented regulations to ensure that demand on quantity of water for various activities is met. However, these programs and regulations have not been able to satisfy the needs of different stakeholders. Currently, the quality of surface water is decreasing and the quantity of groundwater is depleting. It is therefore, critical to identify all factors contributing to the sustainability of these water resources, both surface and groundwater. A water sustainability index can be a useful tool with the following benefits:

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(i) It can be used to identify all factors contributing to the improvement of water resources (Sullivan, 2002; Chaves & Alipaz, 2007; Policy Research Initiative, 2007), so that the resources can be used to fulfil the present and future needs.
(ii) The index can also be used to assist decision makers to prioritise issues and programs related to water resource management.
(iii) It will also be useful to communicate the current status of existing water resources to the wider community (Policy Research Initiative, 2007).

In the recent past, three indices related to water resource sustainability have been developed. They are the Water Poverty Index (WPI) by Sullivan (2002), Canadian Water Sustainability Index (CWSI) by the Policy Research Initiative (Policy Research Initiative, 2007) and the Watershed Sustainability Index (WSI) by Chaves and Alipaz (2007). Even though there have been some successful experiences with the implementation of these existing sustainability indices, they are not fully applicable in other regions or in other countries, since some of these indices have been developed for use in specific regions or countries. Therefore, a new water sustainability index, which is specifically developed with the involvement of local and national water experts and based on Indonesian natural and socio-economic characteristics, is needed to help improve the water resources management in Indonesia, particularly in West Java Province. The index will be able not only to assess the sustainability status of water resources in West Java, but also to prioritise water issues for use in integrated water resource management. This study aims at developing a water sustainability index for the West Java Province, called the West Java Water Sustainability Index (WJWSI).

To develop the WJWSI, this study aims to undertake the following steps:
(i) Development of conceptual framework to identify an initial set of WJWSI components/indicators
(ii) Application of Delphi technique to refine and finalise the index
(iii) Applying the index to case studies
(iv) Robustness analysis of the index

The identification of components/indicators will provide a conceptual framework of the WJWSI. Generally, the identification of initial set of components/indicators is undertaken through extensive literature review (Chaves & Alipaz, 2007; Policy Research Initiative, 2007; Sullivan & Meigh, 2007). For WJWSI, once the initial set of components/indicators is developed, it is refined through the application of Delphi technique. In the past, this technique has also been used to refine water quality indices (Cude, 2001; Dinius, 2007).

Delphi Technique is a method to extract opinion from experts through the distribution of series of questionnaires, without having the experts congregate at an agreed time and place (Delbecq, Ven & Gustafon, 1975). Using this method, the experts are allowed to assess, modify and change components/indicators provided in the conceptual framework. The experts selected for this study were university lecturers, governmental officials, environmental consultants and water experts from non-governmental organisations, who were asked to add, modify or remove any components and/or indicators listed in the questionnaire.

The structure of WJWSI, finalised using the Delphi technique, will be applied to three case study catchments in West Java. One of the outcomes from these case studies will be the prioritisation of water resource issues for each case study. The next step, namely robustness analysis is also an

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important step of index development because it will analyse any assumptions used in the inputs, which might lead to variation in its outputs.

This paper, which is the first in a two-part series, discusses the development of the conceptual framework for WJWSI. Since the WJWSI is developed specifically to suit the water and related environmental, social and economic characteristics of West Java, this paper first outlines these issues. The available concepts and guidelines related to sustainability and water resources, and the existing water sustainability indices are also used as criteria for developing the conceptual framework; therefore these are discussed next. Finally, the development of the conceptual framework of WJWSI is presented with a detailed justification for the selection of various components and indicators.

The second paper of this series presents the second step in developing WJWSI, which is the application of Delphi technique through distribution of a series of questionnaires to experts in West Java to finalise the framework of WJWSI. The remaining two steps, namely of applying the WJWSI to case studies from West Java and conducting a robustness analysis of the index has not yet been undertaken and will be done in the future. For WJWSI, robustness analysis will be undertaken based on input uncertainties, to investigate how these different input assumptions affect the outputs. By doing this, attempts will be made to significantly reduce the uncertainties associated with WJWSI in its development.

WATER RELATED ISSUES IN WEST JAVA

The West Java province is located in the Island of Java, the island with the highest population density in Indonesia. The province occupies a total area of 44,354 km^2. The average annual rainfall is 2,000 mm in most areas, and up to 5,000 mm in the mountain areas located in the central part of the province. The population growth in 2004 was approximately 2.6%, which then slightly decreased to 2.1% and 1.9% people in 2004 and 2005 respectively. In 2008, the growth had reached 5.1%, with the total population of 40.74 million and population density of 1,088.71 m^2 per person (Rahmat & Wangsaatmadja, 2007).

As illustrated in Figure 1, housings and industry are mostly located in the upper part of the province. However, as the population increases, scattered housings have also been built in other parts of the province. The increase demand of housing has given serious stress on the land use, which in some areas were dominated by forestry. Rahmat & Wangsaatmadja (2007) noted that the forestry area in West Java has decreased considerably in the last decade and has resulted in the decrease of groundwater levels in the area, as less rainfall infiltrates to the ground. As for water quality, the decrease in forestry will cause more erosion and increase the runoff, degrading the quality of surface water.

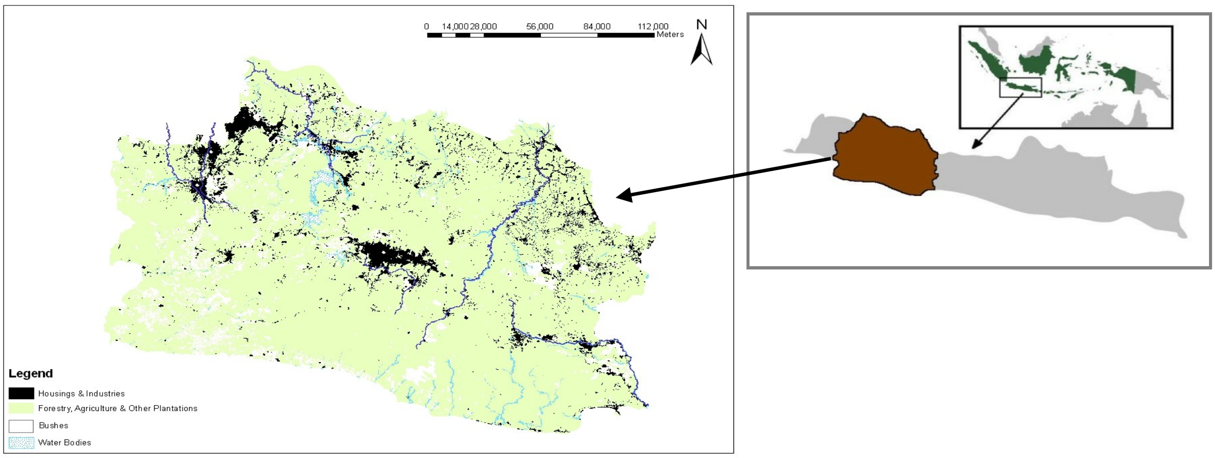

Figure 1. Landuse Map of West Java

High level of rainfall, particularly in the central part of the province, provides abundant surface flow for the community in the rainy season. However, rapid flow fluctuations between rainy and dry seasons, combined with the lack of storage facilities, have resulted in inadequate supply to meet water demand during the dry season of the year.

The surface water quality of majority of streams in urban areas of West Java such as in Bogor, Depok, Bandung and Cirebon are very poor, especially in the downstream sections. Most streams are highly polluted by domestic activities, and worsened by the industrial effluents. For example, polluted streamflow from the Citarum River into Saguling reservoir, one of the biggest reservoirs in West Java, has regularly caused huge fish kills and loss of other aquatic life.

Groundwater is also of very poor quality as a result of contamination from domestic and industrial activities. The groundwater sources have also been excessively exploited, indicated by the decrease of groundwater level. At this stage, up to 60% of the industries in West Java rely on groundwater, especially in urban areas of Bandung, Bogor and Cirebon (Rahmat & Wangsaatmadja, 2007).

SUSTAINABILITY CONCEPTS AND EXISTING INDICES

Since various sustainability concepts and the structure of existing indices on water resources and sustainability have been taken into account in developing the conceptual framework for WJWSI, they are discussed in this section.

Sustainability Criteria

Sustainability is defined as:

> *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"(Brundtland, 1987)*
>
> *"meeting human needs while conserving the Earth's life support systems and reducing hunger and poverty" (Palmer et al., 2005)*
>
> *"to maximise simultaneously the biological system goals (genetic diversity, resilience, biological productivity), economic system goals (satisfaction of basic needs, enhancement of equity, increasing useful goods and services), and social system goals (cultural diversity, institutional sustainability, social justice, participation)" (Barbier, 1987)*

Based on those definitions, sustainability principles are developed. One of the most well-known sustainability principles is the "triple bottom line approach", which includes environmental, economic and social aspects of sustainability (Farsari & Prastacos, 2002; Ekins et al., 2003; Cui et al., 2004). These principles have been widely used to develop other sustainability frameworks in various disciplines. These principles urge all stakeholders, concerned with the sustainability of the environment, to consider at least these three aspects of sustainability. However, it was found difficult to implement these principles without any criteria to measure or monitor the progress for achieving sustainability (Farsari & Prastacos, 2002).

Parkin (2000) introduced capital flow concept, which stated that any development for achieving sustainability (called sustainable development), needs to manage different capital flows in the long

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term. The capitals are natural, human, social, manufactured and financial. Any development proposal has to contribute to improving, or at least maintaining, these five different capitals (Parkin, 2000).

Another way of measuring the sustainability is by using a set of indicators, known as sustainability indicators. One example of sustainability indicators is the work by Spangenberg and Bonniot (1998), in which they developed the indicators based on the so called "prism of sustainability" (presented in Figure 2). This prism, reflecting sustainability, has four dimensions which are described by environmental, institutional, economic and social indicators. Under the institutional dimension, participation, justice and gender balance indicators are derived. For the environmental dimension, resource use and state indicators are developed to measure the sustainability. For the social dimension, health care, housing, social security and unemployment indicators are identified. Finally for economic dimension, Gross National Product (GNP), growth rate, innovation and competitiveness indicators are used (Spangenberg & Bonniot, 1998).

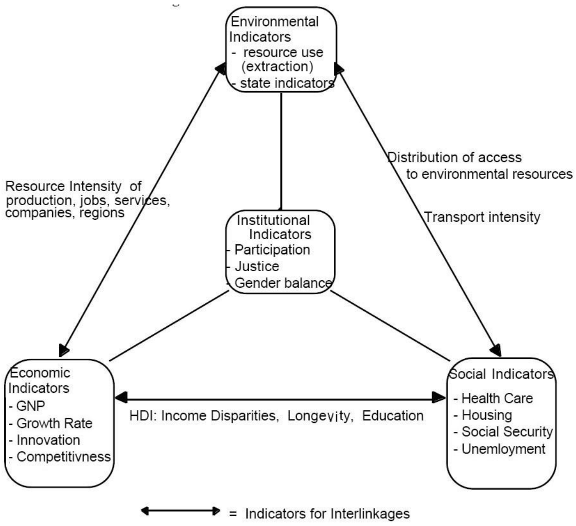

Figure 2. The Prism of Sustainability (Spangenberg and Bonniot, 1998)

Apart from the indicators of individual dimensions, the prism of sustainability also offers a framework to identify the inter-linkage indicators between all dimensions. Theoretically, the inter-linkages can be two, three or even four dimensional. Here, compromises and synergies between different dimensions are sought. As illustrated in Figure 2, indicators based on two dimensional inter-linkages have been identified. Human Development Index (HDI) is an example of indicator of inter-linkage between economic and social dimensions. Distribution of access to environmental resource and transport intensity are indicators derived from the interaction of environment and social dimensions. The inter-linkage of environment and economic dimensions has resulted in indicators such as jobs, services and resource intensity of production (Spangenberg & Bonniot, 1998).

In West Java, issues related to managing water resources are emphasised more on technical and environmental issues, and concerned less on other social and economic sectors (Syarief, 2008). As the complexity of water problems in West Java is increasing, there is a need for the integration of social, economic and environmental sectors in managing water resources in West Java.

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Water Resource Sustainability Guidelines

The concept of sustainability has also entered the field of water resources. As issues related to water resources are becoming complex, there have been extensive studies to combine the concept of sustainability with water resource management issues. By applying the sustainability principles, it is expected that available water resources can be utilised not only by the current generation, but also by future generations. One of the principles is the integration of social, economic and environmental principles. According to this sustainability principle, water-related projects cannot be looked at in its pure technical view, omitting their social and economical concerns (Loucks & Gladwell, 1999). In general, the main characteristic of water resource sustainability lies in the attitude of key stakeholders to constantly review and re-examine their approaches to address the changing problems of water resources. At all times, in all plans and processes, key stakeholders need to strive for decisions that fulfil economic, environmental and social satisfaction, by involving all other stakeholders (Loucks & Gladwell, 1999).

Loucks and Gladwell (1999) provide guidelines for water sustainability, which include the importance of water infrastructure, environmental quality, economics and finance, institutions and society, human health and welfare, as well as planning and technology. In line with those guidelines, Mays (2006) introduced seven requirements to ensure the sustainability of water resource systems. They were: basic water needs to maintain human health, minimum standard of water quality, basic water needs to maintain ecosystem health, long-term renewability of available water resources, accessible data on water resources for all parties, institutional scheme to resolve water conflict, and democratic water-related decision making.

Existing Indices on Water Resources and Sustainability

The structure of the three existing indices of WPI, CWSI and WSI (presented in Table 1) are made up of a set of components covering various aspects related to water resources sustainability. A component of an index, also known as a sub index (Liou, Lo & Wang, 2004), consists of one or more indicators (Swamee & Tyagi, 2000). If necessary, there can be sub-indicators for each indicator. As can be seen in Table 1, the WPI has 5 components and 17 indicators, CWSI has 5 components and 15 indicators and WSI has 4 components and 12 indicators. For these three indices, the components and indicators were identified based on extensive literature reviews and stakeholder consultations at the time of their development (Chaves & Alipaz, 2007; Policy Research Initiative, 2007; Sullivan & Meigh, 2007). The literature review had been undertaken in these studies to produce the initial structure of the index, which consists of components/indicators. For WPI, the initial structure was then brought to the stakeholder consultations or expert meetings to be discussed and finalised in a two-day workshop (Policy Research Initiative, 2007). For the other two indices, detailed information on how their initial frameworks were finalised are not available.

The WPI, which attempts to seek out the relationship between poverty and water issues in different countries, has successfully met its objectives. At the end of its development process, the index has provided a framework, which combined environmental and socio-economic measures, related to poverty and water issues. The five components of WPI are Resources, Access, Capacity, Use and Environment. At the end of its implementation, the WPI has also contributed to the national-level comparison of the status of water access and poverty across the world (Sullivan, 2002).

The CWSI adopted the framework of WPI to develop a water sustainability index for Canada. Its components are Resource, Ecosystem Health, Infrastructure, Human Health and Capacity. One of the benefits of CWSI was to present relevant water-related information to the six surveyed

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communities of the case studies. Nevertheless, it was claimed that CWSI can also be applied in other communities, districts and watersheds in Canada (Policy Research Initiative, 2007). The other benefit was to provide valuable input to water and wastewater infrastructure decisions, such as exploring water storage alternatives and operator training (Policy Research Initiative, 2007).

The WSI, which attempted to integrate hydrologic, environmental, life and policy issues as their components, has shown advantages, both in the process of its development as well as in the implementation. In the process of its development, the WSI has provided decision makers, particularly in Southern Brazil, with a clear and concise framework of water sustainability. During implementation, it has helped various stakeholders to protect remaining forest areas, improve water resources policies and minimize sewage pollution (Chaves & Alipaz, 2007).

Table 1. Components and Indicators of WPI, CWSI and WSI

WPI		CWSI		WSI	
COMPONENT	INDICATOR	COMPONENT	INDICATOR	COMPONENT	INDICATOR
Resources	Internal flows	Resource	Availability	Hydrology	Pressure
	External flows		Supply		State
	Population		Demand		Response
Access	Clean water	Ecosystem Health	Stress	Environment	Pressure
	Sanitation		Quality		State
	Irrigation		Fish		Response
Capacity	Income	Infrastructure	Demand	Life	Pressure
	Mortality		Condition		State
	Education		Treatment		Response
	Income distribution	Human Health	Access	Policy	Pressure
Use	Domestic		Reliability		State
	Industry & Agriculture		Impact		Response
Environment	Water quality	Capacity	Financial		
	Pollution		Education		
	Regulation		Training		
	Information				
	Biodiversity				

DEVELOPING THE CONCEPTUAL FRAMEWORK OF WJWSI

Figure 3 shows the process that was followed in the development of the conceptual framework of WJWSI. As discussed in the previous section, the development of conceptual framework was initiated by reviewing (a) sustainability criteria, (b) water resource sustainability guidelines and (c) the existing water sustainability indices of WPI, CWSI and WSI.

With respect to the sustainability criteria, WJWSI attempts to cover all dimensions of the "prism of sustainability" presented earlier, namely the environment, economic, social and institution, in its components and indicators. The environmental dimension mainly deals with sustainability of

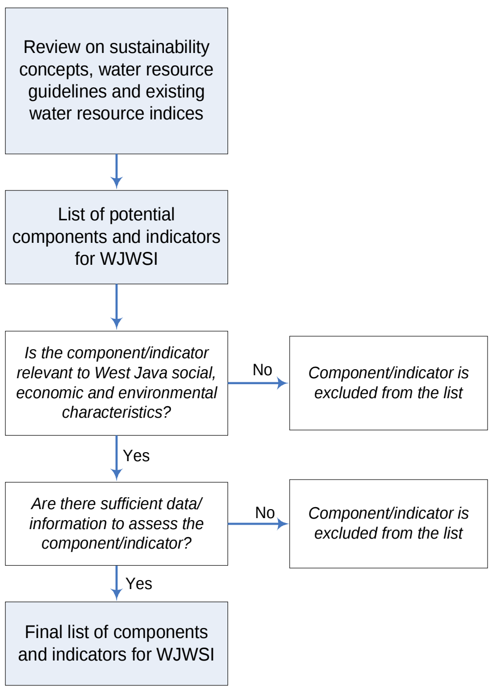

Figure 3. Flowchart for the Development of Conceptual Framework of WJWSI

natural resources and it is covered by including a component of *Water Resources* and its indicators in WJWSI. The economic dimension is addressed through the inclusion of indicators of *finance* and p*overty*, which fall under two different components. The other two dimensions, social and institution are mainly covered in the WJWSI by including the components of *Capacity* and *Human Health*, along with their respective indicators.

As far as water resource sustainability guidelines are concerned, general requirements include water infrastructure, environmental quality and availability, institution and human health (Loucks & Gladwell, 1999; Mays, 2006). The WJWSI attempts to meet the water infrastructure and institutional requirements by having *Water Provision* as one of its components. The next requirement, which is environmental quality and availability, is addressed by *availability*, *quality* and *land use changes* indicators under the component of *Water Resources*. And finally, to account for human health, WJWSI has a component called *Human Health* with three indicators, namely, *access*, *sanitation* and *health impact*.

The components/indicators of the three existing indices were also reviewed and included in the list of potential components and indicators of WJWSI. Then, as seen in Figure 3, a further review was undertaken to determine whether the potential components and indicators were appropriate considering water resources, environmental, social and economic characteristics of West Java. If the components or indicators were not appropriate, they were excluded from the list.

Finally, data and information of the remaining indicators (which were not excluded in the previous step) were checked. If sufficient data and information were not available to measure a particular indicator, that indicator was excluded from the list. At the end, the final list of components and indicators of WJWSI was developed for the conceptual framework. As for the threshold values of the conceptual framework, they were identified through the literature review on existing policies, guidelines and regulations.

Table 2 shows components and indicators (with their threshold values) that form the conceptual framework of the WJWSI.

Table 2. Conceptual framework of the WJWSI

Component	Indicator	Threshold Values		
		Unit	Max	Min
Water Resources	Availability	m^3/cap/yr	1700 [a]	500 [b]
	Demand	%	40 [b]	0 [a]
	Quality	-	0 [a]	-31 [b]
	Landuse Changes	-	1 [b]	0 [a]
Water Provision	Coverage	%	80 [a]	0 [a]
	Water Loss	%	15 [b]	0 [a]
	Finance	-	0 [c]	0 [c]
Capacity	Poverty	%	100 [b]	0 [a]
	Education	%	100 [a]	0 [b]
Human Health	Access	%	100 [a]	0 [b]
	Sanitation	%	100 [a]	0 [b]
	Health Impact	*(cases/1000 pop)*	100 [b]	0 [a]

a: preferable; b: not preferable and c: >0 preferable, <0 not preferable

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The following sub-sections discuss in detail the justification for selection of various components and their indicators of the WJWSI.

Justification for the Component *Water Resources* and its Indicators and Threshold Values

The first component, that of *Water Resources*, is selected based on the ultimate goal of sustainable water management, which is to have healthy water resources that can be utilised by present and future generations. Also, currently most areas in West Java face water-resource-related problems, such as inadequate water supply from public water company and extreme water conditions during the dry and rainy seasons. Thus, the inclusion of *Water Resources* as one of water sustainability components is inevitable. The justification for each indicator under this component is discussed below.

Availability - This indicator looks at how much water is available per year for each person in a particular area. Falkenmark and Rockstrom (2004) studied that ideally a person needs as much as 1,700 m^3/year to support his or her life, with the minimum needs of 500 m^3/year. This indicator can be the entry point to any policy for improving the management of water resources. An area with adequate water availability needs to manage the resources so they can be used to fulfil the demand of various activities. On the other hand, an area with low availability may need to find other sources of water. Therefore, the inclusion of this indicator is extremely important for developing a water sustainability index.

Demand - This indicator is concerned with the amount of water used for different purposes compared to renewable water available. This will give an idea of the stress on water resources caused by the consumption of water by the community. High level of stress on water resources will have impact on the sustainability of water resources. This indicator is necessary to assess the current situation of stress on water resources and to take appropriate action for reducing the stress in the future. In West Java, the demand on fresh water is increasing greatly due to the increase of population, which has resulted in the increase of various water-demanding activities. As initial threshold values, the Department of Economic and Social Affairs of the United Nation set the maximum of 40% available water withdrawal that will cause stress to water resources.

Quality - Water quality is an important issue when assessing the sustainability of water resources, due to the fact that poor quality water resource cannot be used for various purposes. If poor water quality is used, social, health and economic aspects of water sustainability can also be affected. According to Wangsaatmaja (2004), water quality monitoring in three major West Java catchments shows that all rivers in these catchments do not meet the Indonesian water quality standards. The inclusion of water quality indicator in the proposed index is also in line with guidelines for water resource sustainability by Mays (2006). As threshold values, maximum and minimum values of the Storet water quality index are used. This water quality index has been used by West Java governments to monitor the quality of water streams in West Java catchments in the last decade.

Land Use Changes – Past studies had shown that changes in land use have a strong relationship with the quality of water resources. As indicated by Rahmat & Wangsaatmadjaja (2007), there have been considerable land use changes in West Java, which have resulted in the decrease of groundwater level. Land use that is dominated by forestry area allows rainfall to infiltrate into the ground, which then increases the groundwater levels. On the other hand, land use that is dominated by impermeable material prevents rainfall from infiltrating into the ground, increasing the runoff volume. The increase in runoff might eventually lead to more erosion and degradation of surface water quality. Thus, changes in land use will have significant contribution to the assessment of water sustainability in Indonesia. Falkenmark and Rockstrom (2004) believe that land use changes contribute not only to the amount of runoff, but also to the level of evaporation and rainfall in respective local areas. For threshold values, the maximum value of 1 and minimum value of 0 are used for this indicator. The maximum value of 1 reflects the maximum flow of runoff, allowing none of the rainfall to infiltrate (not preferable). On the other hand, the minimum value of 0 reflects the maximum infiltration of runoff (preferable).

Justification for the Component *Water Provision* and its Indicators and Threshold Values

Another vital component of water sustainability management is the infrastructure. In Indonesia, issues related to water infrastructure are best explained by the performance of water service providers (WSP). For every city, water is supplied by a single public water company. This company is responsible for treatment and distribution of water to the community in respective cities. The importance of water service provision in the overall water sustainability management has also been emphasised by many authors, such as Foxon et al. (2002) and Butler et al. (2003).

Coverage - This indicator looks at the number of WSP customers compared to the total population. Low coverage of WSP allows non-WSP-customers to 'misuse' water resources as there is lack of government control on the individual use of available water resources, both groundwater and surface water (Rahmat & Wangsaatmadja, 2007). In Indonesia, the official water service providers cover approximately 60% of the total population in their respective areas (Kirmanto, 2007). As far as West Java is concerned, on average, water companies currently supply only about 40% of the total water needs of the West Java population (Syarief, 2008). This means that a large percent of the population have to find alternative ways for their water supply. Ideally, water supply for 80% of the total population in a region is covered by its respective WSP (Kirmanto, 2007).

Water Loss - Loss of water both in production and distribution is considered waste. The importance of using available water resources wisely, especially by reducing water loss, has been emphasised in many studies (e.g. Loucks and Gladwell, 1999; Butler et al., 2003) . Falkenmark and Rockstrom (2004) emphasise that the problems of water scarcity in many places throughout the world can be overcome by reducing water loss. The national government of Indonesia has set the maximum water loss of 15% for every WSP, which will also be used as threshold values for this indicator.

Finance - This indicator concerns with the profitability of WSP. It will compare the earning of the company compared to production cost of water. To maintain the sustainability of the water company, it has to cover all water production expenses. This indicator is included as many water companies in Indonesia complained that the water tariff is too low to cover the production cost (Kirmanto, 2007). The failure to include the willingness to pay by the society will surely affect the sustainability of water resources management. As threshold values, above zero-point balance (profit) and under zero-point balance (loss) are used.

Justification for the Component *Capacity* and its Indicators and Threshold Values

The justification for the third component, the *Capacity*, is based on the fact that the sustainability of water resources is not only determined by the availability of water resources, but also the affordability of the community and the ability to maintain those resources. There are cases where water resources are available and reliable, but the community cannot afford water supply service

(Sullivan, 2002) or has inadequate ability to maintain the resources. The indicators of *poverty* and *education* are included under this component, which are discussed below.

Poverty - Economics is one of the sustainability principles, supported by many authors. Sullivan (2002) has clearly defined the relationship between poverty (as one aspect of economics) and water issues. She concluded that sustainability of water resources can be effectively achieved by reducing poverty within the community. BPS Team (2009) reports that as much as 13.01 % of the population in West Java live under the poverty line in 2008. These people spend most of their income on food, and thus have no allocation from their income for accessing clean water. Their inability to afford legal water service leads to their resorting to illegal water connections, which in turn have caused huge water losses for the water companies. Therefore, poverty is an issue that needs to be taken into account in developing the WJWSI. As initial threshold, zero poverty as the minimum value is used (preferable) and 100% poverty as the maximum value (not preferable) is used.

Education - Education is believed to have an important role in the sustainability of water resources. Sullivan (2002) claims that there is a strong correlation between the level of education of a community and the sustainability of its water resources management. People with higher education level are believed to have a better water sustainability awareness, compared to those of with lower education level. With regards to formal education, in the year of 2007 only 14.05% of the West Java population have completed basic education (Bappeda Team, 2008). And only recently, environmental issues are included in the curriculum of primary schools in West Java. Syarief (2008) believes that community education is one of the key factors for the successful management of water resources in West Java. As threshold values for this indicator, minimum of 0% (not preferable) and maximum of 100% (preferable) of total population completed basic education are used.

Justification for the Component *Human Health* and its Indicators and Threshold Values

Human health is an important part of social principle of sustainability. Past studies have indicated the influence of human health on the sustainability of water resources (Loucks & Gladwell, 1999). The importance of human health in managing water resources is also acknowledged by Loucks et. al. (2000) and the Policy Research Initiative (2007), by the inclusion of *human health* as a component of their water sustainability frameworks. In West Java, poor management of water resources has resulted in the decrease in quality of health in the community. Past studies show that areas with low access to clean water suffer from high number of water-borne diseases (Wangsaatmaja, 2004). The three indicators included under the component of *Human Health* are discussed below.

Access - This indicator looks at how much water is accessible for the community, particularly water supplied by the water company. It is believed that communities which are provided with adequate water supply will have better health quality compared to those with inadequate water supply. This indicator also looks at how much water is provided by the company, as the only authorised water service provider, compared to the actual need of the community. Since water companies in West Java are not able to meet the water needs of the population, some people are forced to live with inadequate water supply, while others draw the groundwater without appropriate consideration of the sustainability of the groundwater sources. Thus, accessibility to water is included as an indicator under the component of *Human Health*. The threshold values used for this indicator are 0% (not preferable) and 100% (preferable) for minimum and maximum values respectively.

Sanitation - This indicator is concerned with number of people who have basic sanitation facilities. In Indonesia, people with no basic sanitation facilities use river to discharge wastewater, as well as other wastes, from their houses, which then lead to deterioration of river water quality. This is also happening in West Java, which is one of the most populated provinces in Indonesia. Recent studies by the West Java Environmental Protection Agency show that the river quality in three major West Java catchments fail to meet the minimum quality requirements (Badan Pengendalian Lingkungan Hidup Daerah Jabar, 2008). Therefore, the inclusion of *sanitation* as an indicator of water sustainability is highly important. At this stage, no specific threshold values are available for *sanitation* indicator, therefore 0% (not preferable) and 100% (preferable) for minimum and maximum values are used respectively.

Health Impact - This indicator looks at the number of cases affected by water-borne diseases of the community. In the past, insufficient water supply has caused some health issues in the communities (Sullivan, 2002). In West Java, water-borne disease cases are very common, both in urban and sub-urban areas. In urban areas, the diseases are mostly caused by the poor quality of water consumed for everyday life by the poor people. For these people, consuming poor quality water is the only option as they cannot afford well-treated water from the water company. In sub-urban areas, the diseases are mostly caused by the lack of awareness about basic healthy and hygienic behaviour. It is widely accepted that as the community is the main actor of sustainable development, the decrease of human health will affect the efforts of achieving sustainability of water resources. In this early stage, 100 water-borne diseases per 1000 population is used as the maximum threshold value (not preferable) and 0 cases per 1000 population as the minimum threshold value (preferable).

SUMMARY

This paper is the first in the series of two papers on developing a water sustainability index for West Java, called the West Java Water Sustainability Index (WJWSI). The paper discusses the first step in developing the WJWSI, which is the identification of components and indicators in the conceptual framework. Various components and indicators have been included in the conceptual framework taking into account the major water and related issues in West Java, available concepts and guidelines related to sustainability (i.e. triple bottom line approach and prism of sustainability) and also on the structure of existing water sustainability indices. Based on these criteria, a detailed justification for selecting each component and indicator within the conceptual framework of WJWSI is also presented in this paper. The second paper of this series presents the application of Delphi technique through the distribution of a series of questionnaires to experts in West Java to refine and finalise the framework of WJWSI.

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