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CAIRNS, AUSTRALIA 13 – 17 JULY 2009

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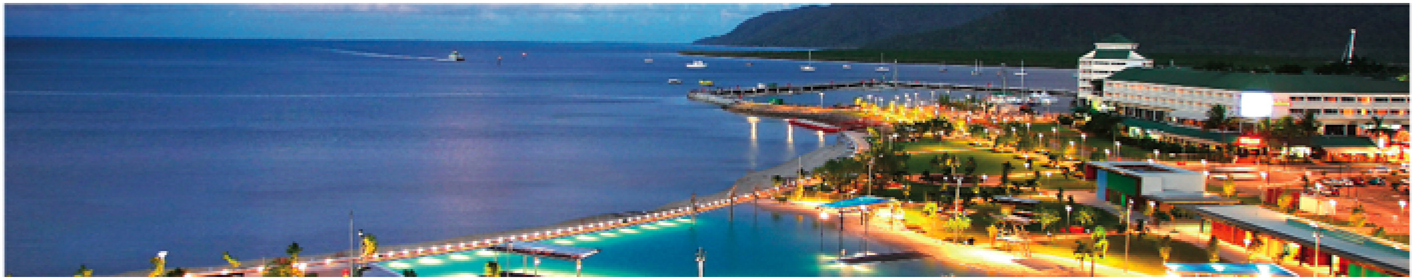

13 – 17 JULY 2009 **CAIRNS AUSTRALIA**

- Plenary Papers
- Keynote Papers
- Papers by Session
- Author Index
- Sponsors
- Organising Committee
- International Advisory Board
- Contacts

Queensland Government

Plenary Papers

Solving environmental problems with integer programming: Recent experience and challenges
__Boland, N.__

Multiscale mathematical modelling in medicine and biology
__Chapman, S.J.__

Why are simple models often appropriate in industrial mathematics?
__de Hoog, F.R.__

Hydrologic context for modelling nutrient cycles
__Hornberger, G.__

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Karnon, J., M. Mackay and ***T.M. Mills***

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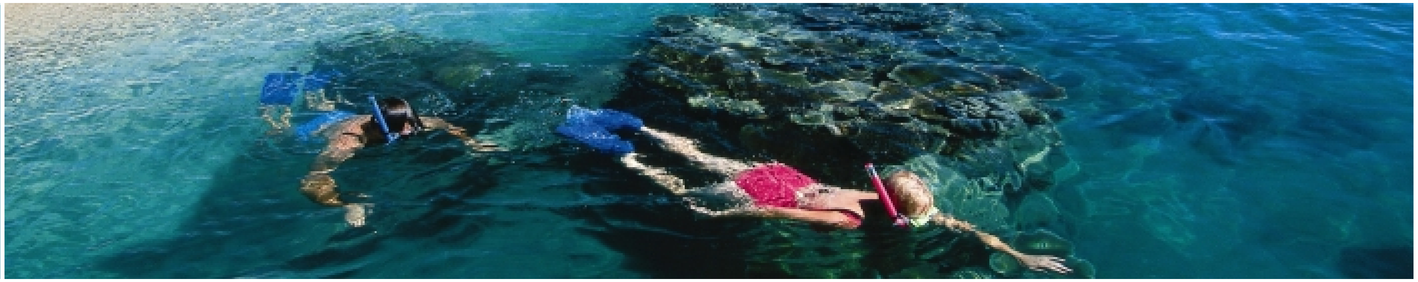


13 – 17 JULY 2009 CAIRNS AUSTRALIA

Queensland Government

Keynote Papers

18TH IMACS WORLD CONGRESS MODSIM09

13 – 17 JULY 2009 CAIRNS AUSTRALIA

Papers Listed by Session

Applied and computational mathematics

Chair: Roger Braddock

Biological systems

Chairs: Bob Anderssen and Markus Hegland

Computer sciences

HOME

Chairs: Andrea Rizzoli and David Swayne

Economic and financial systems

Chairs: Michael McAleer and Les Oxley

Engineering and applications

Chairs: Yaping Shao and Voratas Kachitvichyanukul

Environment and ecology

Chairs: David Pullar and Alexey Voinov

Global change and/or natural hazards

Chairs: Mark Howden and Giulio Iovine

Participatory decision making and modelling social systems

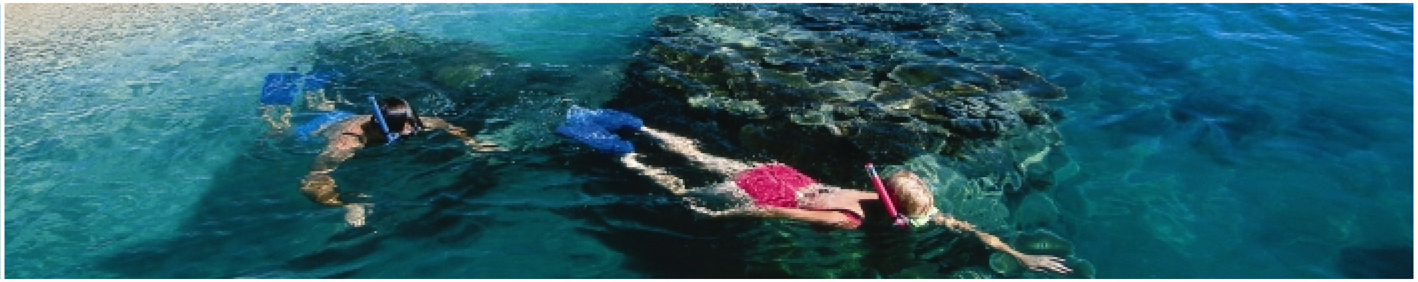
Chairs: Claudia Pahl-Wostl and Blair Nancarrow

Water resources

Chairs: Shahbaz Khan and Robert Argent

General sessions

18TH IMACS WORLD CONGRESS MODSIM09



13 – 17 JULY 2009 **CAIRNS AUSTRALIA**

Author Index

A

General sessions

B

General sessions

18TH IMACS WORLD CONGRESS MODSIM09

13 – 17 JULY 2009 **CAIRNS AUSTRALIA**

- Plenary Papers
- Keynote Papers
- Papers by Session
- Author Index
- Sponsors
- Organising Committee
- International Advisory Board
- Contacts

Author Index

A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z

H

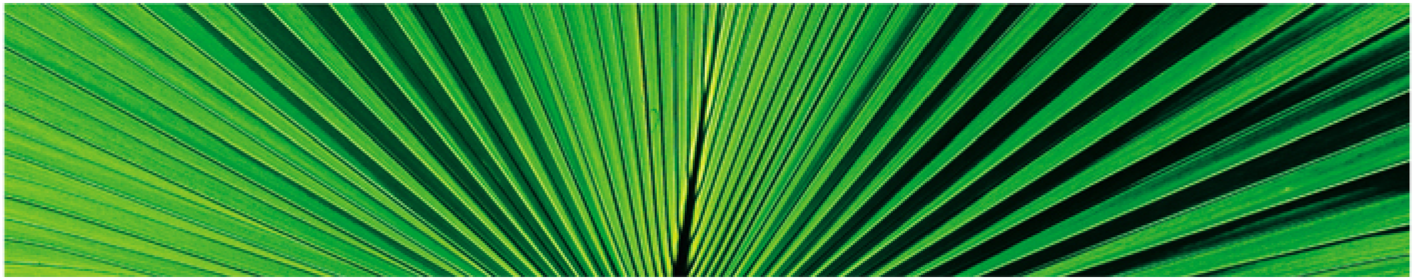
I

J

K

General sessions

18TH IMACS WORLD CONGRESS MODSIM09



- Plenary Papers
- Keynote Papers
- Papers by Session
- Author Index
- Sponsors
- Organising Committee
- International Advisory Board
- Contacts

13 – 17 JULY 2009 **CAIRNS AUSTRALIA**

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Proceedings

Editors: Anderssen, R.S., R.D. Braddock and L.T.H. Newham

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HOME

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COUNTRY	SUBJECT AREA AND CATEGORY	PUBLISHER	H-INDEX
United States Universities and research institutions in United States	Computer Science └ Computational Theory and Mathematics Mathematics ├ Computational Mathematics └ Modeling and Simulation		7

PUBLICATION TYPE	ISSN	COVERAGE
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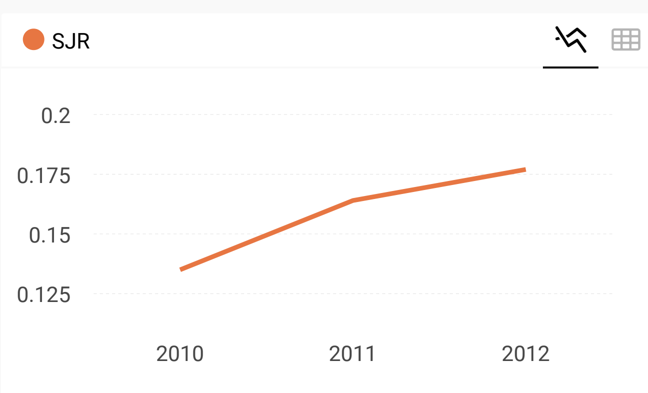

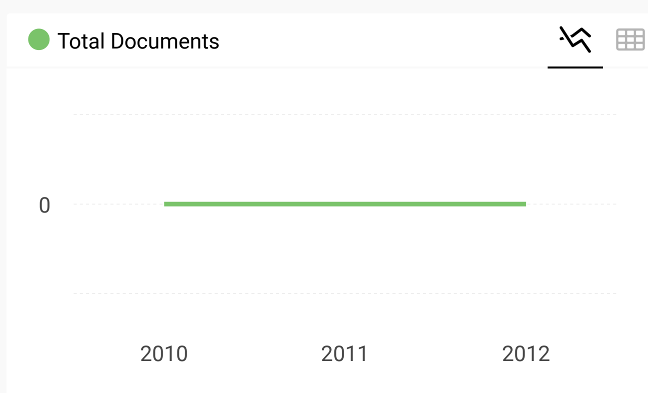

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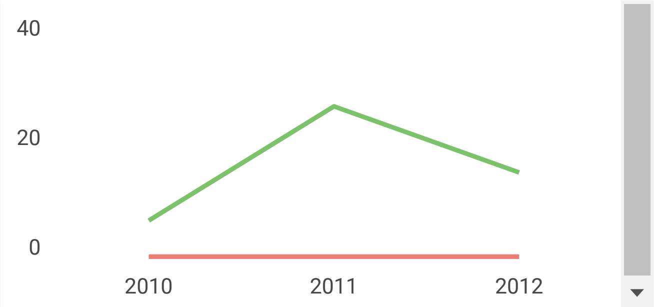

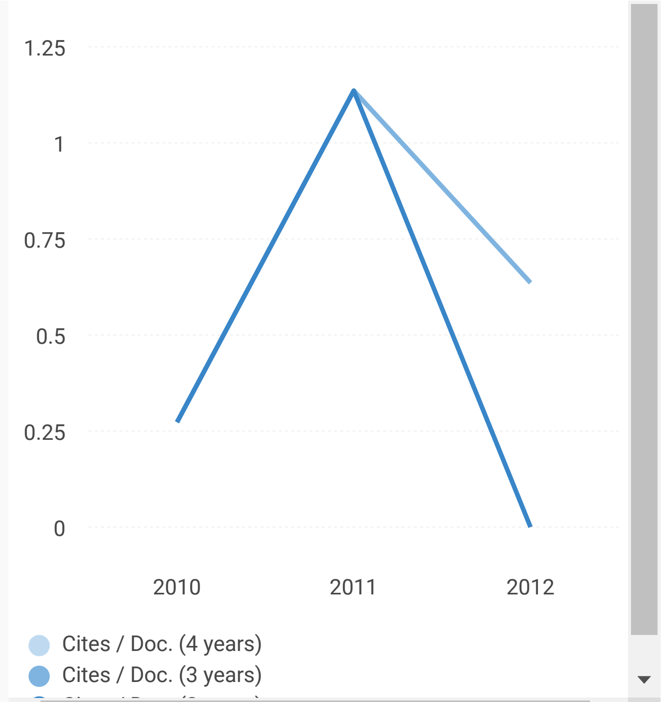

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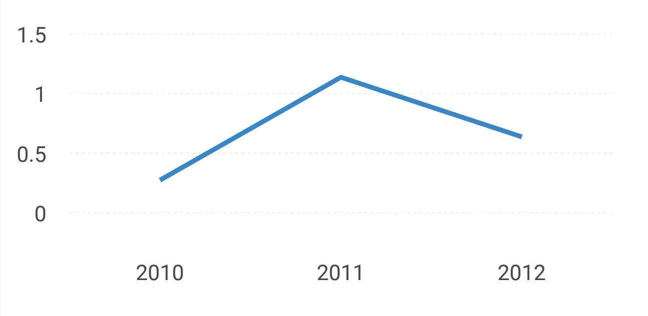

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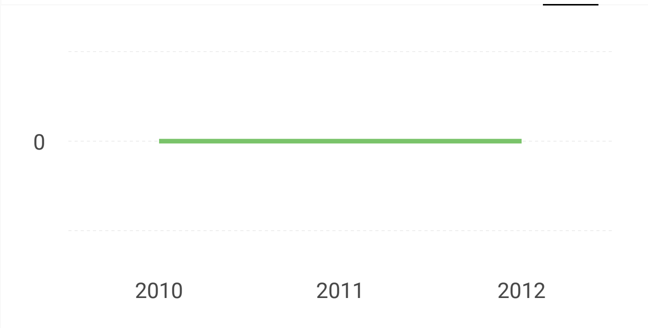

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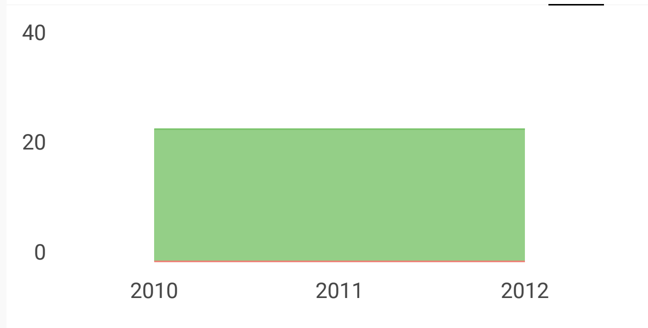

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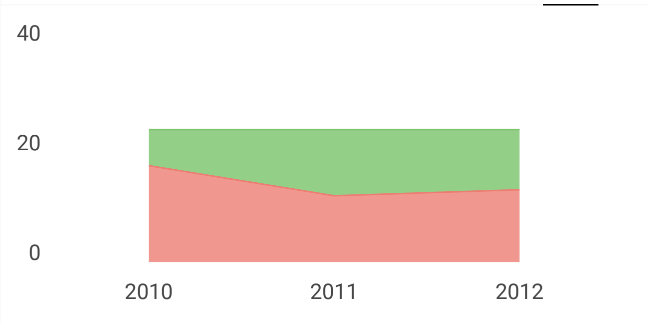

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Conceptual framework for the development of West Java water sustainability index

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Abstract: Water resources management in Indonesia, particularly on the Island of Java, faces severe water problems. In its annual report released in 2008, the National Planning and Development Council of Indonesia predicted that cities in Java Island would suffer critical water deficits in 2025, if the current excessive use of water resources continues. This excessive use was mainly caused by the sporadic groundwater extraction for various purposes, including agriculture, industry and household. In the West Java Province, the situation is even worse by the high level of pollution of rivers, in addition to excessive water use.

In the past, to address these problems, the local government of West Java Province implemented some programs to manage the use of water resources, such as the enactment of new groundwater regulations and the campaign for clean river. However, these programs were not successful due to lack of awareness and support from various water resource stakeholders (Rahmat & Wangsaatmadja, 2007). The lack of people awareness occurred because there was no effective communication on current water sustainability conditions. The lack of stakeholder support was due to different sectors implementing their own programs without appropriate consideration on the sustainability of water resources (Wangsaatmaja, 2004).

A sustainable and integrated water management to engage all stakeholders is therefore needed; such water management has demonstrated to be capable of integrating all issues of water resources management (Loucks & Gladwell, 1999; Jakeman et al., 2005). One approach to achieve sustainable and integrated water management is through the application of the indicator-based approach (Jakeman et al., 2005). In the past, this approach has been used to develop water sustainability indices, namely Water Poverty Index (WPI) by Sullivan (2002), Canadian Water Sustainability Index (CWSI) by the Policy Research Initiative (Policy Research Initiative, 2007) and Watershed Sustainability Index (WSI) by Chaves and Alipaz (2007). All these three indices have common objectives to provide information on current conditions of water resources, provide inputs to decision makers and prioritise water-related issues (Lawrence et al., 2003; Chaves & Alipaz, 2007; Policy Research Initiative, 2007).

This paper will discuss a framework for developing the West Java Water Sustainability Index (WJWSI). It will outline major water issues in West Java, available concepts and guidelines related to sustainability and water resources, existing water sustainability indices, identification of components and indicators for WJWSI and justification for the selection of WJWSI components and indicators. It will emphasise on the conceptual framework of the WJWSI, which integrates the socio-economic aspects and natural resource aspects, for use in integrated water resource management in West Java, Indonesia.

The components and indicators for WJWSI have been identified through an extensive literature review, considering concepts on sustainability, as well as an in-depth review on the existing water sustainability indices. Two main criteria were used for the selection of components and indicators: (1) the suitability of particular components/indicators to environmental, social and economic backgrounds of West Java and (2) the likely availability of required data for the case studies.

Keywords: *sustainability, index, water resources, West Java, Indonesia*

1. INTRODUCTION

The increase of population in the province of West Java has resulted in the increase of demand on clean water. In 2006, the combined water demand for domestic, industrial and irrigational purposes was approximately 17.5 billion m^3, and is predicted to increase as much as 1% each year (Rahmat & Wangsaatmadja, 2007).

With regards to its water sources, 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 the quality of surface and groundwater in West Java, they 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 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. At this stage, the quality of surface water is decreasing and the quantity of groundwater is depleting.

It is therefore, crucial to identify all factors contributing to the sustainability of these water resources, both surface and groundwater. A water sustainability index can be used as a tool to identify all factors contributing to the improvement of water resources (Sullivan, 2002; Chaves & Alipaz, 2007; Policy Research Initiative, 2007), so the resources can be used to fulfill the present and future needs. The index can also be used to assist decision makers to prioritise issues and programs related to water resource improvement. In addition, it will also be useful to communicate the current status of existing water resources to the wider community (Policy Research Initiative, 2007).

This paper will discuss a framework for developing the West Java Water Sustainability Index (WJWSI). It will outline major water issues in West Java, available concepts and guidelines related to sustainability and water resources, existing water sustainability indices, identification of components and indicators for WJWSI and justification for the selection of WJWSI components and indicators. It will emphasise on the conceptual framework of the WJWSI, which integrates the socio-economic aspects and natural resource aspects, for use in integrated water resource management in West Java, Indonesia.

2. 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 total population in 2003 was approximately 38.13 million people, which then increased to 39.14 and 39.96 million people in 2004 and 2005 respectively. In 2006, the population had reached 40.74 million, with the population density of 1,088.71 m^2 per person (Rahmat & Wangsaatmadja, 2007).

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 parts 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 (West Java Environmental Protection Agency, 2009). For example, polluted stream flow from the Citarum River into Saguling basin, one of the biggest basins 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 Bandung, Bogor and Cirebon urban areas (Rahmat & Wangsaatmadja, 2007).

3. REVIEW ON AVAILABLE CONCEPTS AND GUIDELINES

3.1. Sustainability Criteria

This study aims at developing a water sustainability index for West Java, thus it is important to highlight the existing principles of sustainability. One of the most well-known sustainability principles is the triple bottom line approach; the environment, economic and social (Goodland, 1995; Farrell, 1996; Crawford, 2002; 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.

Later, it was found difficult to implement those principles without any criteria to measure or monitor the progress for achieving sustainability. 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 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).

The other 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 (2002). He developed the indicators based on the so called "prism of sustainability". This prism, reflecting sustainability, has four dimensions which are the environmental, social, economic and institutional. Based on this prism, various indicators are then identified to measure each of the four dimensions. In addition, another set of indicators are also developed to measure the inter linkage dimensions (Spangenberg, 2002).

3.2. 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.

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.

3.3. Existing Indices on Water Resources and Sustainability

Up to this stage, there have been three indices related to water resources. They are: Water Poverty Index (WPI) by Sullivan (2002), Canadian Water Sustainability Index (CWSI) by Policy Research Initiative (Policy Research Initiative, 2007) and Watershed Sustainability Index (WSI) by Chaves and Alipaz (2007). In terms of their structure, all three indices are made of a set of components covering various water resources related aspects. A component of an index, also known as a sub index (Liou et al., 2004), consists of one or more indicators (Pesce & Wunderlin, 2000; Swamee & Tyagi, 2000). If necessary, there can be sub-indicators for each indicator. The number of components and indicators of WPI, CWSI and WSI are summarised in Table 1.

Table 1. Components and Indicators of Water Resources Indices

INDEX	NUMBER OF COMPONENTS	NUMBER OF INDICATORS
WPI	5	17
CWSI	5	15
WSI	4	15

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 (Lawrence et al., 2003). 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. One of the benefits of CWSI was to present relevant water-related information to the six surveyed 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, 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).

4. WEST JAVA WATER SUSTAINABILITY INDEX

Considering all available concepts and guidelines on water resources and sustainability, a conceptual framework for West Java Water Sustainability Index (WJWSI) was developed. Two main criteria were used for identification of components and indicators. The first criterion was the suitability of the proposed components and/or indicators with the environmental, social and economic backgrounds of West Java. The second criterion looked at the likely data availability of respective indicators for use in the case studies. Table 2 shows components and indicators for WJWSI that have been identified through extensive literature review.

Table 2. Components and Indicators of WJWSI

COMPONENT	INDICATOR
Water Resources	Availability
	Demand
	Quality
	Land Use Changes
Water Provision	Coverage
	Water Loss
	Finance
Capacity	Poverty
	Education
Human Health	Access
	Sanitation
	Health Impact

4.1. Justification for the Components

The four components identified in the conceptual framework of WJWSI reflect all the components used in water sustainability indices of WPI, CWSI and WSI. At the same time, the identified components maintain their suitability to Indonesian social, environmental and economic backgrounds. The first component, the 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. Thus, the inclusion of water resource as one of water sustainability components is inevitable.

Another vital component of water sustainability management is the infrastructure (Loucks et al., 2000; Policy Research Initiative, 2007). 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).

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.

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 and vice versa (Loucks & Gladwell, 1999). Particularly in developing countries, poor management of water resources has resulted in the decrease of health quality in the community. Loucks et. al. (2000) and the Policy Research Initiative (2007) have also emphasised the importance of human health issues by the inclusion of human health as one component of their water sustainability frameworks.

4.2. Justification for the Indicators

As illustrated in Table 2, there are 12 indicators for the WJWSI. The justification for selection of each indicator is described below:

Availability

This indicator looks at how much water is available per year for each person in a particular area. Falkenmark and Widstrand (1992) studied that ideally a person needs as much as 1,700 m^3/year to support his or her life.. 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 fulfill 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.

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. Consequently, social, health and economic aspects of water sustainability can also be affected.

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 Wangsaatmadjaja (2004), there have been considerable land use changes in West Java, which have resulted in the decrease of groundwater level. 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.

Coverage

This indicator looks at the number of WSP customers compared to the total number of 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). This means that the other 40% of the population have to find alternative ways for their water supply.

Water Loss

Loss of water both in production and distribution (of water) 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); Foxon et al., (2002); 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.

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.

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. It is concluded that sustainability of water resources can be effectively achieved as the poverty within the community decreases (Sullivan, 2002).

Education

Education is believed to have an important role in the sustainability of water resources. As indicated by Sullivan (2002), there is a strong correlation between the level of education of a community and the sustainability of its water resources management. It is assumed that people with higher education level have a better water sustainability awareness, compared to those of with lower education level.

Access

This indicator will look at how much water is accessible for the community, particularly water supplied by the water company. It is assumed that community which are provided with adequate water supply will have better health quality compared to those of with inadequate water supply. This indicator will also look at how much water is provided by the company, as the only authorised water service provider, compared to the actual need of the community.

Sanitation

This indicator concerns 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. In addition, basic sanitation has also proven to contribute to the improvement of health quality, such as the reduction of cases of water-borne diseases (MDG Indonesia Team, 2007). Thus, the inclusion of sanitation as an indicator of water sustainability will be highly important.

Health Impact

This indicator will look at the number of water-borne diseases suffered by the community. In the past, insufficient water supply has caused some health issues in the communities (Lawrence et al., 2003). 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.

5. FUTURE WORK

The identification of components and indicators described in this paper is a part of the development of a water sustainability index for West Java. After the completion of the component and indicator identification, the conceptual framework will be brought into fieldwork in Indonesia. The fieldwork component will comprise of the distribution of Delphi questionnaires and case studies in three catchments of West Java. The results of the Delphi questionnaires will be used to finalise the components and indicators, as well as identifying threshold values for respective indicators. Having the components, indicators and threshold values finalised, the method to aggregate those components and indicators will also be determined.

As for the case studies, they will be done in three catchment areas in West Java. One of the potential catchments is the Citarum Hulu catchment. This catchment is one of the largest catchments in West Java, where six millions people live in the area. For the purpose of robustness analysis, additional one or two case studies in different catchment areas in West Java will be undertaken. These case studies will start with data collection and continue with the application of WJWSI for each area using the finalised set of components, indicators and threshold values. Data will be collected from past studies, institution databases and other relevant sources. One of the outcomes from these case studies is the prioritisation of water resource issues for each case study, which will be the basis for recommendation for actions to be taken by the decision makers in respective case study areas on water related issues.

At the end, robustness analysis of the WJWSI will be undertaken based on input uncertainties such as, but not limited to, the inclusion or exclusion of components and indicators, the selection of threshold values, the selection of normalisation schemes and the choice of aggregation methods. The identified sources of uncertainty will be analysed through the sensitivity analysis to accurately point out how these different input assumptions affect the outputs. By doing this, uncertainties attached to WJWSI in its development will be significantly reduced. Results of the robustness analysis will be used to finalise the outcomes of the case studies, so that recommendations can be conveyed confidently to the decision makers to address water issues in case study areas.

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