ASSESSMENT OF WATER RESOURCES SUSTAINABILITY AT A WATERSHED USING INTEGRATED INDEX

MIN GOO KANG[1], JEONG KON KIM[2], and GWANG MAN LEE[3]

[1] Senior Researcher, Korea Institute of Water and Environment, Korea Water Resources Corporation (KOWACO), Daejoen, Korea, 305-730.
(Tel: +82-42-860-0435; Fax: +82-42-860-0347; e-mail: kmg90@kowaco.or.kr)
[2] Principal Researcher, Korea Institute of Water and Environment, Korea Water Resources Corporation (KOWACO), Daejeon, Korea, 305-730.
(Tel: +82-42-860-0430; Fax: +82-42-860-0347; e-mail: jkkim@kowaco.or.kr)
[3] Head Researcher, Korea Institute of Water and Environment, Korea Water Resources Corporation (KOWACO), Daejeon, Korea, 305-730.
(Tel: +82-42-860-0341; Fax: +82-42-860-0347; e-mail: lkm@kowaco.or.kr)

Since the Brundtland's report was published in 1987, the concept of sustainable development has become the basic philosophy in setting up the development of strategies on economy, society, environment, industry, and water resources and so forth. Many developed countries such as England, Germany, Japan etc., and international organizations including UN, OECD, and EU have developed various indicators to accurately measure the sustainability of various sectors. In recent years, the sustainability also has become more important factor at water resources development and management works. The sustainability of water resources has been defined as various meanings. Most popular one is "to use the present water resources on consideration of posterity's desires, to satisfy the users' request in view of water quantity and quality conserving the eco-system, and to develop the social and cultural system closely related with water resources".

In order to develop and manage water resources based on the sustainability, it is necessary to continuously monitor the state of water resources. In the past, water resources were evaluated with engineering approach such as water budget method, simulation technique, and optimization method. However, these approaches generally provide a simple criterion known as reliability, vulnerability and resiliency of the system. In general, the factors for sustainability assessment are interconnected each other and are difficult to be separated into a single variable. Therefore, a multi-variable index is necessary, which is able to asses the sustainability which reflects social, economic, and environmental conditions. Considering the complexity of water resources system, the parsimony of indicators is necessary to simplify the sustainability assessment. Also, indicators need to be able to deliver the implied meaning to the public digitally and understandably.

Index is composed of many indicators, evaluates the present state, and provides the digital values to the public. Statistical values relevant to water resources have been published in many fields such as civilization, sociology, economics, and environment. The sustainability of water use and management is to be measured using the index composed of above values. The water resources of watershed have been investigated with various items, which are independent single-variables. These items are difficult to represent the comprehensive state of water use and management. Therefore, an assessment index is necessary to incorporate each indicator and provide synthetic results. The index can be

divided into several sub-indexes, which have any specific meaning and are composed of several indicators, respectively.

WRSI (Water Resources Sustainability Index) which was developed in this study is composed of economic efficiency index, social equity index, environmental conservation index, and maintenance capacity index. Each sub-index assesses the state of water use and management using several indicators, respectively. Economic efficiency index assesses the extent of the efficiency of water use in a watershed. The sub-index is composed of four indicators, water intake, supplementary water resources, economic benefits, and objective water quality. Social equity index assesses the extent of the equity of water use in a watershed. The sub-index is composed of five indicators, waterworks diffusion, sewage diffusion, industrial water use, agricultural water use, and instreamflow. Environmental conservation index assesses the extent of the environmental conservation in a watershed. The sub-index is composed of three indicators, streamflow quality, groundwater quality, and eco-system conservation. Maintenance capability index assesses manpower, economic power, and technological level that are necessary to maintain and enhance the water resources sustainability. The sub-index is composed of four indicators, education level, investment on culture and education fields, investment on water resources field, and water saving.

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