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Assessing sustainable water use and local economy in Korea

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Background

With increasing concerns about limited water resources, international organizations have launched a plenty of frameworks to assess water sustainability in country-level throughout the globe (Esty et al., 2005 for ESI; Hsu et al., 2013 for EPI). The purpose of this study is to develop a Sustainable Water Index (SWI) to estimate the extent of water use sustainability within administrative level in Korea. From previous studies, we found that a global assessment on water security (Vörösmarty et al., 2010) showed accurate data in threat indicators (pressure in water use) while fails to aggregate available data on reactive indicators which aims to alleviate threats (Kim et al., 2014). As we anticipate decreased amount of available water resources from climate change in Korea, it is crucial to take responsive factors into consideration in evaluating sustainable water use in order to implement proper countermeasures. Without considering alleviating factors in water use, it would misinform current status as more exacerbated way neglecting its capacity to deal with the risks. Additionally we evaluated the relationships between current threat and responsive indices to local economy in order to determine how financial status of a region can be interrelated to imminent threats and capacity to relieve threats in water use.

Method

In order to establish a framework to assess water use sustainability in Korea, we adopted Pressure and Response structure from OECD(1993)'s PSR framework. Indicators in Pressure Index represents imminent threats in water use while indicators in Response Index will be comprised of countermeasures alleviating threats. After reviewing a wide-range of previous studies, we established a hierarchic framework comprised of P-R system, four thematic categories (availability, use, pollution, and management capacity), and 23 indicators (Table 1).

Thematic index	Pressure index		Response index	
	Sub-theme	Indicators	Sub-theme	Indicators
Water availability	Climate (discharge)	Monthly variability	Water storage	Effective water storage
		Inter-annual variability	Alternative water resources	Water reuse, rainwater harvesting
	groundwater	Groundwater level change		
Water use	Consumption	Water consumption	Water access	Water supply coverage
	Demand	Human water stress		
	Intensity	Water use intensity		
Water pollution	Sanitation	Sanitation	Sanitation	Sanitation coverage
	Wastewater	Wastewater		

	Sediment	Sediment loading	Wastewater	Sewerage coverage
	Water quality	BOD		
		Phosphorus loading		
Management Capacity	Watershed environment	Impervious areas	Watershed environment	Environmental areas
	Finance	Water supply price	Financial investment	Investment on water supply
		Sewerage service price		
	Efficiency	Water leakage		Investment on sewerage

Table 1 Framework for Sustainable Water Index

Each indicator was estimated with available datasets from national statistics and then normalized with cumulative distribution function (CDF) to distribute raw data to a scale from 0 to 1. Then elements were consecutively aggregated using equal weights; indicators to thematic indices and thematic indices to P-R indices. Then using a simple calculation - "1-(Pressure index * (1- Response index))" adopted from Vörösmarty et al (2010), Sustainable Water use Index (SWI) was calculated for 109 watersheds in Korea. Furthermore, local economic status was evaluated using Gross Regional Domestic Income (GRDP) from each administrational level from national statistics in 2010.

Results

SWI in 2010 (Figure 1) depicts that highly populated watersheds including major cities have moderate SWI than other regions due to the higher Response index in spite of high level of Pressure. Previous studies which only consider threats such as pollution or water use intensity used to fail in capturing the effect of sufficient capacity to relieve those threats. Rather, watersheds in densely irrigated areas in which consume lots of water showed high SWI, even though they had relatively low amount of pollution and climatic variabilities. Also underdeveloped regions including island and rural regions with limited infrastructure and resources showed poor level of SWI. Upstream mountainous watersheds in northeastern areas showed low pressure and low response resulting in high SWI.

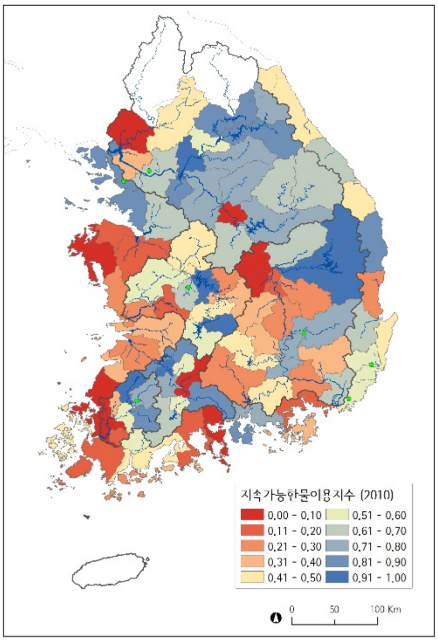

Figure 1 Sustainable Water Index in 2010

Supplementary analysis comparing indices (Pressure, Response and SWI) to financial status of local governments buttressed the importance of Response index in SWI. In terms of economic status, Pressure index showed low variability among watersheds (0.42-0.67) while Response index showed distinctive differences throughout the country (0.21-0.71) (Figure 2-a, 2-b).

Consequently the extent of financial availability is concluded as a crucial factor in determining the level of sustainable water use in Korea (Figure 2-c).

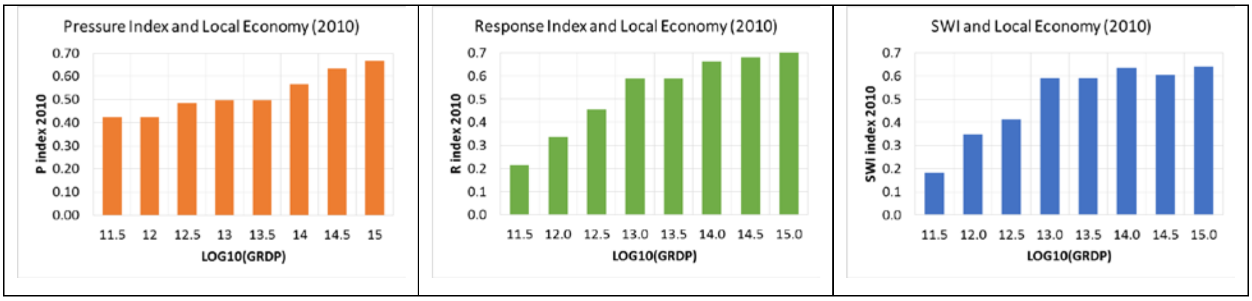

Figure 2 Relationship between Local Economy and Pressure(a), Response Index(b), and SWI(c)

Discussion

The result indicates that rich regions with more budgetary allowance can invest or subsidize in infrastructures to reduce pollutants and secure additional source of water against upcoming threats on water use. Yet low-income governments are discouraged to introduce countermeasures when they have excessive level of threats in water use. So far, many concerned the possible threats in water use in major cities but rarely focused on mid- and small-sized cities. Large and wealthy regions are more capable of take measures to adapt to exigent problems even they have excessive extent of threats. Therefore central government and decision makers should spare more concerns on underprivileged regions in terms of climate change adaptation.

In this study, we suggested a framework to analyze current threats and responses to water use. If the set of assessment can be conducted regularly, policymakers can be informed to decide vulnerable regions to prioritize adopting pertinent infrastructures in planning process. As an effective platform to diagnose current water use, it enables to understand the condition of each region based on the extent of Pressure and Response Index, and facilitate to implement site-specific policies. In addition, this framework can allow a persistent guidance to navigate national strategy on sustainable water use.

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