

SOCIAL SUSTAINABILITY ASSESSMENT FRAMEWORK FOR GROUNDWATER RESOURCES IN HANOI, VIETNAM BY AHP APPROACH

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1. INTRODUCTION

In Hanoi, Vietnam, the people heavily depend on groundwater resources for both domestic and industrial uses due to the seriously polluted situation occurred in most of the river-streams system¹⁾. Hanoi is the target area addressing sustainability issues of the groundwater resources because not only the rapid exploitation of the groundwater has caused a series of adverse impacts such as drying up of shallow wells, decline of groundwater level²⁾ and land subsidence but the critically polluted problems³⁾ are existed also. There have been a number of our previous Hanoi-targeted studies regarding each aspect individually such as quantity²⁾, quality and its health effects on the community³⁾. However, there have been no existed studies dealing with the integrated sustainability assessment for the valuable resource in Hanoi, thus the understandings of the sustainable development for the valuable resources are extremely poor.

In order to assess the sustainability of groundwater resources in Hanoi by applying Analytical Hierarchy Process (AHP) approach, this study develops a sustainability framework including the series of foremost components contributing to the sustainability goal. In order to cope with the limited data availability of groundwater sustainability assessment, this study focuses on the framework from the social point of view since social aspect is one of three bottom-line sustainability concepts. These components cover mainly the local groundwater problems and the social situation related. The framework defined is the basic step for the further sustainability assessment of the groundwater resources.

2. STUDY AREA

Fig.1 shows the study area. Hanoi area is around 3324.5 km² and includes 30 separated districts. The population of about 7,095,900 habitants in 2014 accounts for the highest population density in Vietnam. Hanoi belongs to

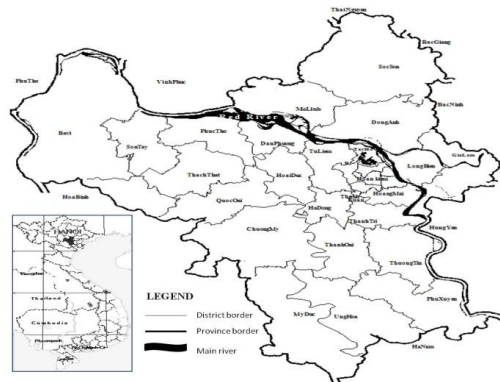


Fig. 1 Study area and main rivers and lakes

the tropical monsoonal area with the annual rainfall is about 1,550 mm. Evaporation is quite high with an annual average of 933 mm¹⁾

3. METHODOLOGY

AHP approach can be referred to Satty (1987).

4. RESULTS AND DISCUSSION

Table 1 shows the foremost components of SSA framework. Those sustainability components are carefully selected based on the actual problems of groundwater resources. The situation of groundwater quantity, quality and management are considered as three main criteria. About the quantity, SSA focuses on how much contribution the resources can make to meet the current social demands based on the five-core sustainability indicators. About the quality, the four-core indicators are defined as the ratios between the numbers of local residents who are currently using the contaminated groundwater to total population. SSA also focuses on the indicators presenting how importance of the government management which currently affect to groundwater quantity and quality control in the last criteria.

Keywords: Groundwater resources, Social, Sustainability, framework, Hanoi, Vietnam

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Table 1. Social Sustainability Assessment (SSA) Framework for Groundwater Resources in Hanoi

Criteria	Indicator	Indicator Name	Description and Formula of the Indicators (units)	Sources
Groundwater Quantity (S ₁)	S ₁₁	Actual groundwater use	Ratio of groundwater use to total water use	This study
	S ₁₂	Groundwater use	(Groundwater renewable resources)/Capita ((m ³ .year ⁻¹)/capita)	Vrba and Lipponen ⁴⁾
	S ₁₃	Insufficient water use in the rural area	Ratio of people who have insufficient water use to total population in the rural area.	Vrba and Lipponen ⁴⁾
	S ₁₄	Insufficient water use in the urban area	Ratio of people who have insufficient water use to total population in the urban area.	Vrba and Lipponen ⁴⁾
	S ₁₅	Groundwater use for agriculture activities	Number of farmers dependent on groundwater for agriculture activities/ Total population	Vrba and Lipponen ⁴⁾
Groundwater Quality (S ₂)	S ₂₁	Residents are affected by arsenic contaminated groundwater	Ratio of the number of local residents who currently use the arsenic-contaminated groundwater to total population.	This study
	S ₂₂	Residents are affected by nitrogen contaminated groundwater	Ratio of the number of local residents who currently use the nitrogen-contaminated groundwater to total population.	This study
	S ₂₃	Residents are affected by coliform contaminated groundwater	Ratio of the number of local residents who currently use the coliform-contaminated groundwater to total population.	This study
	S ₂₄	Groundwater treatment requirements	Ratio of the areas with groundwater treatment requirements to total study area	Vrba and Lipponen ⁴⁾
Groundwater Management (S ₃)	S ₃₁	Groundwater rights and regulation	Ratio of a number of the legally registered groundwater abstraction wells to total wells	This study
	S ₃₂	Groundwater awareness and education	Ratio of a number of local residents who are educated for sustainable groundwater resources to total population	This study
	S ₃₃	Groundwater pollution control	Ratio of a number of legally registered discharge sources to total sources discharged into water bodies	This study

5. CONCLUSION

The main object of this study is to develop a sustainability framework from the social point of view as the basic step for sustainability assessment of the valuable groundwater resources in Hanoi by applying the indicator-based approach, AHP. In this study, we successfully investigate the appropriate list of three main criteria and twelve core social sustainability indicators, appropriately presenting for the local groundwater situation.

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