

論文内容の要旨

論文題目

Localization of sustainability assessment for urban water systems: an application to Hanoi city

(都市上下水道システムに対する地域の特性を考慮したサステイナビリティ評価手法の開発とそのハノイ市への応用)

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The term sustainability or sustainable development recognizes that economic growth alone is not enough to solve the world's problems and to provide human beings a better quality of life. This concept is based on the observation that environment, society and economy are strongly inter-connected and inter-influenced. The socio-cultural and historical background of each country is unique, but the fundamentals of sustainability apply to all. The sustainability of urban water and wastewater systems, as a technical system, is dependent on the local conditions, like cultural tradition, geographical/climate uniqueness, and institutional and legal frameworks. Therefore, the development of sustainability assessment methodologies that allow for systematic analysis and discussion of local contexts is essential.

This study aimed at developing a general methodology for assessing the sustainability of urban water systems which systematically takes into account the local conditions. Specifically, the research objectives are to: (1) have an overview of approaches developed for assessing the sustainability of urban water systems; (2) develop a generic methodology for assessing the sustainability of urban water systems; (3) localize the general sustainability principles and aspects defined for a sustainable urban water system into local indicators for the current urban water system in Hanoi city; and (4) evaluate the selected indicators through the case study of the current urban water system in Hanoi city.

This dissertation comprises 7 chapters. Chapter 1 presents the concept of sustainability, the current global

water crisis, the role of urban water systems in the move towards a sustainable society, and the study objectives. A description of the structure of this report is presented afterwards.

In Chapter 2, an overview of the approaches and tools developed for assessing the sustainability of UWSs was presented. The literature review revealed that several approaches and tools have been developed and employed for the analysis of the sustainability of UWSs. These approaches were categorized into five main groups: (1) Sustainable Development Indicators (SDI); (2) Life Cycle Assessment; (3) Exergy Analysis; (4) System Analysis; and (5) Cost Analysis. Also the review results shown that most of the studies have been conducted about cities in developed countries.

Among these approaches, the SDI was most frequently employed. The number of papers using employing this approach accounts for more than 55% of the total reviewed paper. In reviewing the papers using SDIS approach, I found that the types of used SDI and the ways of selecting SDI are diverse. A summary of approaches used for selection of SDI was prepared.

The development of a general methodology for assessing the sustainability of UWSs was done in Chapter 3. In developing the methodology, a framework for analyzing the sustainability of UWSs was proposed for the definition of general principles of sustainability for UWSs. Three general principles of sustainability for UWSs were defined. Then the defined principles were translated into general aspects of sustainability for UWSs. A basic framework showing the relationship between the principles and aspects of sustainability for UWSs were proposed.

Chapter 4 presents information about the case study and the field studies conducted there. Fields surveys were conducted 4 times in 2008 and early 2009 in order to collect data necessary for evaluating the performance of the system. Data related to the groundwater resource capacity and its quality, the annual exploitation of groundwater, the coverage of the public drinking water supply, the coverage of the drainage and sewerage system, the amount of wastewater discharged and its fate in the environment, and the quality of surface water were obtained. Also during field studies, interviews with professionals working in the area of water and wastewater management in Hanoi were conducted. Based on findings obtained from the field studies, issues important to the local situation of Hanoi have been identified.

In Chapter 5, Section 5.1, the process of localizing of the defined general aspects of sustainability for UWSs into local indicators for the case study of the current UWS in Hanoi city was presented. The localization process has systematically taken into account all the issues identified to be important to the local situation of Hanoi city. Totally, 24 indicators covering every issue specifically important to the local situation of Hanoi were locally adopted. The quantification and evaluation of individual indicators through the case study of the current UWS in Hanoi was presented in Section 5.2.

In Section 5.3 of Chapter 5, an overall discussion about the progress towards sustainability of the current UWS in Hanoi city was presented. The indicator evaluation offered an overall look at the current state of the UWS in Hanoi and its progress towards sustainability. In particular, results from the evaluation of indicators for the aspects of human health and environmental protection indicated that the existing water and wastewater systems in Hanoi perform quite well in terms of provision of basic water supply and sanitary services to the people.

However, in terms of environmental protection, the indicator quantification indicated that there are rooms for improvement toward sustainability. Currently, there is no secondary wastewater treatment in the city (less than 2 % of the total generate domestic WW is treated before discharge). This problem is closely interlinked with the economic development aspect because of the fact that Hanoi is a developing city, and in the past economic development has been the first priority. In the near future, once the municipality has enough financial resource to invest for new wastewater treatment plants, the water environment pollution can be solved. On the other hand, the economic development will inevitably lead to the increased consumption and higher demand on infrastructure systems, like water supply system. Increased water consumption will lead to increased amount of wastewater discharged. And this will exacerbate the water pollution if no appropriate wastewater management is introduced.

The indicators of affordability of the system and of social aspects are also influentially interlinked with the economic aspects. For example, an increase in household income is usually the result of economic development. The increased income will help people to afford to pay the service price that is set to make sure the financial self-sufficiency of the system. This will ultimately help the system to financially sustain by itself. Also the socio-economic development coupled with education will increase people awareness on environmental protection.

Based on the indicator evaluation results, a systematic thinking approach was proposed to analyze the inter-influential linkages between different aspects of the sustainability of the UWS in a systematic way. The system thinking approach has indicated how three prominent problems of groundwater level depletion, water pollution, and groundwater contamination that the current UWS in Hanoi is facing are interconnected. The influential linkage of socio-economic development aspect with these problems was also explicitly shown. The key message from this systematic analysis is that only by judging the current situation of the UWS in Hanoi from a systematic and holistic point of view taking every aspects of sustainability into consideration, the decision makers can make decision that lead the system towards sustainability.

Section 5.4 of Chapter 5 presents a discussion about the developed methodology. The characteristic point of the proposed approach is that the indicator selection process is both theory and context based. The preliminary application to the case of Hanoi and its results have demonstrated the applicability of the proposed methodology. A conclusion is that the proposed methodology can offer a

holistic view about the performance of a UWS towards sustainability when it is applied to case study. However, it is not as strong as other approaches when it comes to analysis of individual aspect of sustainability, like exergy analysis or cost analysis. A combination of the proposed approach with others may be necessary in order to have a more concrete conclusion about sustainability.

A discussion about the future UWS in Hanoi city was presented in Chapter 6. Key features of the future desired UWS in Hanoi have been discussed based on the findings and indicator evaluation conducted in Chapter 5. In particular, the future water supply system should shift to demand side management that focuses on water use efficiency and reuse of treated water for non-potable purposes. The calculated water balance shown that if treated water is used for non-potable uses, the total drinking water demand in urban in 2030 with the projected population of 5.1 million will be 702,000 c.m/day. This amount is approximately equal to the capacity of the groundwater resource in Hanoi city.

This study developed a general methodology for assessing the sustainability of UWSs which systematically takes into account the local conditions. A conclusion can be drawn is that the developed study has offered a roadmap for analyzing of the sustainability of UWSs. The study also presented a way of localizing the general aspects of sustainability into local indicators used for analyzing the sustainability of UWSs. The applicability of the developed methodology has been demonstrated through the application to the case of Hanoi city. Lastly but not less, the methodology developed in this study, along with others previously developed, can be one of the potential tools for assessing the sustainability of UWSs.