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Strategic decision making for urban water reuse application: A case from Thailand

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ABSTRACT

Planned and implemented water reuse (WR) is an eco-efficient way to reduce water stress and improve sustainable water management. However decision making systems have been typically devoted to its economic and technical aspects, with less consideration of indirect impacts and sustainability, and have been mostly limited to landscape irrigation option. Thus, this study's objective is to create a strategic decision making system (DMS) incorporating multiple criteria, available alternatives, and environmental externalities for urban WR application. This study adopted a system development process including analyzing existing systems, developing a DMS, and applying the system based on a case of Pattaya City (PC), Thailand. Specific techniques, e.g. multi-criteria decision making, were used to conduct and/or analyze data from secondary sources, together with interviews of key informants and questionnaire surveys of households. The developed DMS can provide a new set of criteria encompassing multiple aspects and externalities, and their relative importance for strategic decisions on WR application. This DMS was proven to be a straightforward method for giving not only an appropriate application but also the strengths and weaknesses of the alternatives. Applying this DMS could contribute to proper strategies to WR management, and to be an accessible tool for communicating with stakeholders.

1. Introduction

Many studies have shown that planned water reuse (WR) is an eco-efficient way to reduce water stress and make water management more sustainable in countries where income is high and/or water is scarce [1–5]. However, the practical implementation of WR needs a proactive policy from the interested stakeholders, devoted mainly to gaining knowledge of the benefits of the practice, without forgetting its hazards and risks [6]. But it was difficult to find studies of the decision making system which covers all WR aspects and externalities, especially in developing and/or water-stress countries including Thailand, where the context differs from those of developed countries.

Due to its rapid urbanization and high economic growth, Thailand is expected to be a water-stress country by 2025. Also, the ratio of water withdrawal to renewable water resources in Thailand has increased to a level comparable to Europe and Japan [7], 22.8% of water available [8]. In 2003–2004, Thailand had a serious water shortage due to irregular rainfall, especially in the eastern region, leading to water conflict between urban and rural users. Thus, WR was considered for increasing water use efficiency and ensuring water sustainability. However, low amount of total treated wastewater is through WR, limited mostly to landscape irrigation. This could be because WR typically requires long-term planning which is complicated by integrating the water and wastewater sectors and the sustainability concept, and due to a decision making system that is devoted to economic and technical aspects without considering positive and negative external impacts and the principle of sustainability.

Therefore, this paper aims to create a decision making system (DMS) incorporating multiple criteria, available alternatives, and environmental externalities focused on WR in the strategic level of urban areas. It is based on a case study of Pattaya City (PC), Thailand. The effluent from central wastewater treatment plant (CWTP) would be focused to reuse with the aim of sustainable urban water management. This paper presents an overview of current situation and trend of WR practices in Thailand. Next, study findings in the case study are explained and discussed, including a broad overview of the general characteristics and water conditions in the case study, followed by gaps in the existing DMS, the development of DMS, and the results of DMS implementation. Recommendations for enhancing the DMS are also made as a means of providing a systematic guide for making decisions about WR in urban areas.

Abbreviations: Alt., Alternative; CWTP(s), Central wastewater treatment plant(s); DEQP, Department of Environmental Quality Promotion; DIW, Department of Industrial Works; DMS, Decision making system; EastWater, Eastern Water Resources Development and Management Public Company Limited; EIA, Environmental impact assessment; IOC, Importance order of criteria; MCDM, Multi-criteria decision making; ONEP, Office of Natural Resources and Environmental Policy and Planning; PC, Pattaya City; PCD, Pollution Control Department; WA, Water Works Authorities; WR, Water reuse.

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2. Research approach

The present study was conducted in PC as the case study, because there was a high potential area for a water shortage. It followed the system development process: analyze existing system, develop the DMS, apply the DMS, and evaluate the DMS. The existing system of WR decision making in the study area was explored for gaps between the existing system and sustainability. To fill these gaps, the DMS was developed to identify key elements and processes through multi-criteria decision making techniques and stakeholder analysis. The DMS was implemented in the case study and its results were compared with the existing system. Then it was evaluated and improvements were recommended.

Primary data were collected from key informants and households in PC. Personal interviews of representatives from key informants in WR management were conducted with 33 interviewees, such as local government officials, central governmental officials, and researchers. The interview questions were asked concerning the activities on the stakeholders and their views on the WR management. Specific data gathered from key informants through questionnaire surveys included importance order of criteria (5-rating scale questions) and driving factors (ranking questions) for WR, and from consulting with city staff from PC's Sanitary Division. Questionnaire surveys were randomly carried out for a total of 200 households in PC to investigate participation level in existing WR practices (dichotomous questions), public acceptance of each WR application (5-rating scale questions), and environmental economic values of WR (dichotomous questions). The study also used specific techniques, such as contingent value method to evaluate environmental economic values and statistical analysis to analyze the data for this study.

3. Water reuse management in Thailand

Thailand has tended to rapidly extend its WR development since the water crisis in 2003–2004. Many WR programs were adopted in industrial sectors for economic reasons, although urban WR implementation has been limited by, for example, public acceptance and management issues. National policy has promoted WR adoption, but without regulations or standards, and without documenting concerns about environmental economic value and externalities. On the other hand, WR development seems to be increased with the expectation of reducing water shortages and sustaining water use. Wastewater treatment and purification technologies have developed to the point where it is technically feasible to produce water of almost any quality, and advances continue to be made [9], even in Thailand.

According to a report from the Pollution Control Department, in 2008 there were 86 CWTPs operating to treat wastewater from municipalities throughout the country, which generate about 2 millions m^3 per day [10]. Although this effluent was treated until its discharge quality met suggested WR quality standards, at least for landscape irrigation, the current WR amount has been estimated to be less than 1% of total treated wastewater. Most WR programs have been internal use of effluent from large wastewater treatment plants in CWTPs of municipalities and in on-site treatment plants of large buildings, such as using effluent from CWTPs to irrigate the landscape in public parks, or using effluent from on-site treatment plants in the department stores for toilet flushing. These developments have been aimed at accommodating existing major water demands. The reuse of effluent from CWTPs was major concerned in the feasibility study to build a new CWTP, because it was a condition for allocating investment budget from the central government. In addition, the WR was addressed as an environmental measure in the environmental impact assessment (EIA) by private developers, e.g. the EIA for condominium development.

4. Description of the study area

PC is highly dependent on tourism and related activities. The city had 106,214 registered inhabitants in 2009. This figure excludes the large number of Thais (about 400,000–500,000) who work in PC (many come and go for tourism-related work but remain registered in their hometowns), and many long-term visitors. During January to June 2009, 449,204 Thais and 1,170,247 foreigners were reported to visit PC. This city has seen high economic growth rate from its tourism industries, equaling 90% of GPP. Table 1 shows the most important or the main socio-demographic and water condition figures from the area.

The majority of households and businesses in this area are supplied by tap water inside. However this city has limited water resources due to its geographical condition. It must acquire water from nearby areas including buying from a private agency, Eastern Water Resources Development and Management Public Company Limited (EastWater), at about 8 baht/m^3 (0.25 US$/m^3). It is also occasionally subjected to water deficiency from long periods, such as November 2002 through April 2003 (6 months). In this period, water consumers had to buy water from private water truck sellers at 2–3 times the typical tap water price. Two CWTPs in this area cover about 90% of total city area and are operated well by city staffs. In addition, PC is the first city in Thailand which collects wastewater tariffs from its residents. The current wastewater tariffs are based on the amount of tap water used and the source of wastewater, starting from 3.50 baht/m^3/month (0.1 US$/m^3/month or 41% of tap water price).

Since the unusual dry season in 2003–2004, effluents from CWTPs were developed to reuse for irrigating public parks or roadway medians in the municipal area by a piping system. However, the amount of WR was only about 5% of total CWTP effluent (~1000 m^3/d). In the private sector, hotels regulated by Type A building effluent standards (hotels with 200 rooms or more) were main WR developers, which could reuse their effluent for landscape irrigation, golf course irrigation, and recreational/environmental uses.

5. Analysis of current decision making system of WR development in the study area

As similar direction with WR in other areas of Thailand, the current decision in PC was included in the EIA as an environmental management measure, or one part of a feasibility study for establishing wastewater treatment plants. As all practices in this area were internal reuse, the decision was made by the manager of the organization. Key criteria for the WR decision were quality of effluent and economic benefits. Reviewing official documents and interviewing WR developers show that most decisions were made without considering external impacts such as positive externalities of ensuring the water supply, preventing water pollution, or negative

Table 1
Socio-demographic and water characteristics of PC.

Characteristics	Units	Values
Inland area	km^2	36.00
Registered population in 2009	Persons	106,214
Population density in 2008	Persons/km^2	2950
Numbers of hotels	Hotels	674
Numbers of restaurants	Restaurants	1800
Numbers of department stores	Stores	17
Economic growth rate 1985–2006	%	7.4
Average income in 2007	Baht/person/y (US$/person/y)	270,00 (8438)
Water use	m^3/connection/d	0.19
Number of CWTPs	Plants	2
Area serviced by CWTPs	% of city area	90
Wastewater inflow	m^3/d (% of total capacity)	56,000 (66)

Note: 1 US$ = 32 baht.