Social Impacts Assessment of Water Demand Management Policies on Wastewater System by Using SLCA Method

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ABSTRACT

Urban water demand management policies (UWDMPs) are being proposed as a solution to deal with water scarcity. Applying any UWDMPs can lead to positive/ negative impacts on several aspects including the urban infrastructure (e.g., water distribution networks, or wastewater systems). Besides, studies on the effects of these policies on urban infrastructures have often focused on the water sector, and there is scant evidence in the wastewater section. Hence, in the current study, the impacts of the implementation of UWDMPs on sewage systems (consist of the wastewater collection system and the wastewater treatment plant) from a social viewpoint have been evaluated during different scenarios of demand reduction. For this purpose, the Social Life Cycle Assessment (SLCA) method, as a subset of life cycle thinking, has been applied. In this regard, Baharestan city (located in Isfahan province) is selected. The groups (stakeholders) related to wastewater systems that are affected by the social impacts of UWDMPs have been identified and their characteristics have been determined. Stakeholders contain the social and local community, workers, and consumers (stakeholders that use wastewater or its other products for a specific activity). Then, by compiling a questionnaire and using the experts' opinion, the Analytic Hierarchy Process (AHP) method has been used in order to evaluate scenarios. In this procedure, (1) indicators are scored by the survey from experts, (2) the intensity of the effects of indicators in each scenario is specified, and (3) the social score of all scenarios is obtained. The results showed that social and local community had the biggest weight among stakeholders (weight of 0.45), and safe and healthy living condition was the most important indicator for this stakeholder. Moreover, the scenario that had the least decline in water consumption and sewage production was socially better than the others.

KEYWORDS

Water Demand Management, Life Cycle Thinking, Social Life Cycle Assessment, Analytic Hierarchy Process, Wastewater System.

1. Introduction

Urban water Demand Management Policies (UWDMPs) are considered as a solution to deal with water scarcity and sustainability of the environment [1]. These policies containing water tariffs and water-efficient appliances lead to a decrease in water end-uses [2]. UWDMPs not only decrease water consumption but also affect the wastewater system (WWS), both wastewater treatment plants and wastewater collection networks [3]. There is a wide gap in terms of considering the social impacts of UWDMPs on WWSs which affect different stakeholders. There is some research that assesses the social impacts of WWSs with different viewpoints [4-7]. As an example, Opher et al. considered the social aspects of four scenarios related to greywater reuse in a city by the application of life cycle thinking methods [6].

2. Methodology

Social Life Cycle Assessment (SLCA) is one of the up to date methods. This method considers both positive (e.g., welfare) and negative (e.g., harmful to health) effects of any product or service in its life cycle (cradle to grave) [8]. The steps in using the SLCA method are as follows: 1) Defining goal and scope, 2) Specifying the boundary of the system and the stakeholders, 3) Determining of indicators, 4) Completing questionnaire, 5) Interpretation of results, and 6) Comparing different scenarios. For step 5, the Analytical Hierarchy Process (AHP) method is used [8,9].

AHP is a technical method to categorize and analyze complicated decisions. This method helps the decision-makers to choose the base scenario according to their main goal [10]. To compare different indicators, Saaty's pairwise comparison matrix is used [11]. The aim of this paper is to compare the social impacts of different scenarios of applying UWDMPs on WWS. The WWS of Baharestan city, Isfahan province, Iran is considered as a real case study and the boundary of the research.

3. Alternative scenarios

1. The base scenario (0): This scenario considers the city without any usage of UWDMPs.
2. Scenario 1: The real situation of the city by applying water pressure management is considered. This scenario, as stated by Baharestan Water and Wastewater Company, reduces 20% of wastewater productions in 10 years.
3. Scenario 2: This scenario is adopted from the review of the previous literature and uses water-efficient appliances in the city. It decreases 30% of wastewater productions in a long time.
4. Scenario 3: This scenario is applied the water tariff that reduces 18% of wastewater productions based on the literature review.
5. Scenario 4: This is a hypothetical combination of the above scenarios.

4. Results and Discussion

The main stakeholders in the considered boundary are 1) Workers and employees: People who work in WWS' operation and maintenance phase. The indicators of this stakeholder encompass working hours, health and safety, and performance monitoring programs, 2) Society and local community: Residents of the city who are concerning with problems of sewer networks such as blockages and bad smells of them. Indicators are community engagement, health and safety living conditions, and satisfaction of the performance with the wastewater network, and 3) Consumers: People and companies who use sludge and treated wastewater. The indicators of this stakeholder contain effluent quality, expenses, demand satisfaction, feedback mechanism, and consumers' satisfaction.

Every stakeholder has some relevant indicators such as health and safety for workers. These indicators and their weights which are extracted from experts' face-to-face interviews through a questionnaire survey by use of the AHP method are shown in Figure 1.

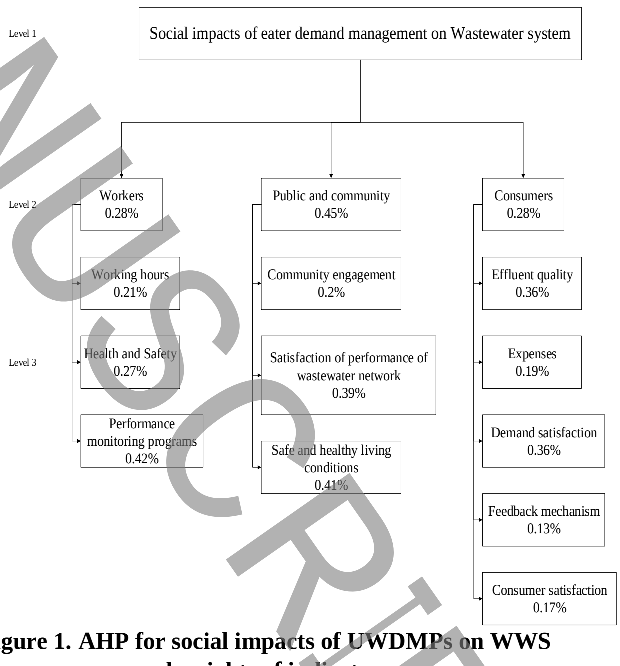

Figure 1. AHP for social impacts of UWDMPs on WWS and weights of indicators.

To evaluate the impact intensities of every indicator in different alternative scenarios, the AHP method is used for qualitative indicators based on the data and information of the case study. On the contrary, the qualitative indicators were computed directly.

5. Interpretation of results

Social benefits of every scenario, computed by multiplying the weight of every indicator by its impact intensity, is depicted in Figure 2. As it is illustrated in this Figure, the base scenario is the ideal scenario in most of the social indicators. The main reason for this result is that the base scenario is not changed at all and it is completely in line with the designing assumptions of the WWS. At last, the aggregated score of social impacts of different scenarios is shown in Table 1. This table shows that by changing a large percentage of the wastewater production volume from its normal and designed amount, the social stakeholders are affected adversely.

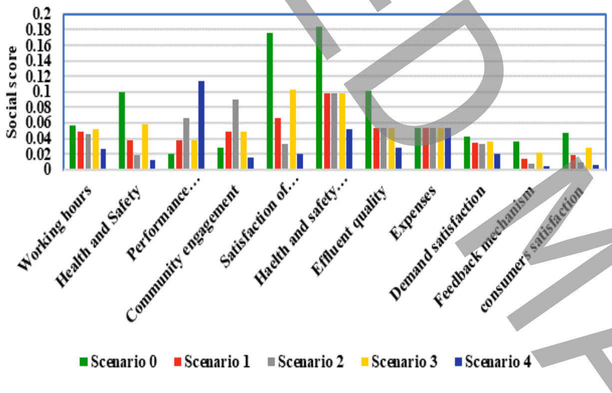

Figure 2. Social scores of different scenarios

Table 1. The aggregated score of social impacts of different scenarios

	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Aggregated social score	0.845	0.510	0.506	0.589	0.352
Normalized social score	1.000	0.603	0.598	0.698	0.417

6. Conclusions

UWDMPs, as a simple solution for water shortage, can affect different aspects of WWSs such as social aspect which is ignored in previous studies. This paper shows the negative effects of decreasing wastewater production flow in the operation and maintenance phase of the WWS of Baharestan city, a real case study.

To reach these results, 22 experts were interviewed. In addition, results show the importance of considering the situation of every site before applying UWDMPs. Also, these results challenge the positive viewpoints about UWDMPs and will help decision-makers to have a comprehensive perspective in applying various scenarios of UWDMPs.

7. References

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