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Water Use and Pollution Recognition from the Viewpoint of Local Residents in Dhaka, Bangladesh

Kazi Shamima Akter [1,2,*], Kiyo Kurisu [1] and Keisuke Hanaki [3]

1 Department of Urban Engineering, School of Engineering, The University of Tokyo, 7-3-1, Hongo, Bunkyo, Tokyo 113-8656, Japan; kiyo@env.t.u-tokyo.ac.jp
2 Department of Environmental, Water Resources and Coastal Engineering, Military Institute of Science and Technology (MIST), Mirpur Cantonment, Dhaka 1216, Bangladesh
3 School of Information Networking for Innovation and Design, Toyo University, 1-7-11, Akabanedai, Kita-ku, Tokyo 115-0053, Japan; hanaki@iniad.org
* Correspondence: shoma_shamima@yahoo.com; Tel.: +88-018-5731-7969

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Abstract: This study focuses on urban and rural house dwellers' opinions about their own as well as commercial, industrial and agricultural water use and pollution issues in Dhaka, Bangladesh. One hundred respondents were asked to make comparative choices on five water use sectors arranged in pairs, about five water issues regarding water shortage, earning money, damage due to water shortage, water pollution and water loss during use. To analyze the homogeneities and variations in perceptions, the respondents were categorized into five clusters (P1–P5), based on the view of comparative importance of each sector, where clusters P1–P3 consisted of mostly urban respondents, while P4–P5 were of rural respondents. Clusters P1 and P5 thought of industries as the most responsible sector for water issues, whereas P2 and P3 clusters thought urban dwellers are more responsible for all water issues, except earning money. The respondents were asked also about their water spending and saving attitudes along with their concern regarding water issues. Two factors regarding water attitude and water issue concern were derived from factor analysis using the water attitude questions. Five clusters showed variations in water attitudes and concerns among them. Some clusters' perceptions about sectoral water issues were found to be influenced by their positive attitudes and concerns. Residential peoples' perception regarding sectoral water use might be useful for policy makers to identify the target groups (urban or/and rural water users) for management intervention.

Keywords: residential users; stakeholder participation; users' perception; water attitudes; water concern; water management

1. Introduction

Water management involves addressing demand management rather than reliance on finding new water sources, re-emphasizing water services to meet basic human needs and incorporating ecological water use into water policy [1]. Recognizing the importance of multi-disciplinary knowledge for making sustainable decisions regarding the water sectors, the Dublin Conference on Water and Environment (1992) addressed the importance of integrated water resources management (IWRM) for the first time and advocated the use of participatory approaches as one of the important principles of IWRM [2–4]. Urban and rural water users, which are much affected by the spatial and temporal aspects of water issues, are the important stakeholders that need to be involved in the sustainable water management process [5]. However, local communities and their local knowledge are still ignored by planners in many cases of developing and managing land use and water resources [6,7]. Water planners deal with water policies and water management plans for a water society, but the nature of vulnerability and adaptation mechanisms towards water issues are mostly determined by local parameters [8,9]. The experiences and knowledge of local people can help to resolve local water issues. Participation of local stakeholders can provide an important platform of local database, experience and ideas that can lead to practical, relevant, achievable and acceptable solutions to water-related problems [10].

Stakeholder participation is a key to represent the full breadth of existing local knowledge in the decision-making process. Accumulation of different knowledge and perceptions through participation makes it important as well challenging at the same time [11]. Divergent knowledge and perceptions regarding water issues, brought into close proximity, during stakeholder engagement in water management, pose great potential for conflict [12]. Such conflicts may lead to mistrust and non-cooperation among the stakeholders [11]. Thus, finding ways to involve stakeholders along with conflict minimization techniques is a key challenge for participatory water resources planning [12]. A framework of stakeholder involvement, aiming to reach a common water goal may reduce the difficulties of the participatory approach of water management [13]. Moreover, mutual understanding/perception among the stakeholders regarding their contribution/importance in water management may foster trust and resolve conflict.

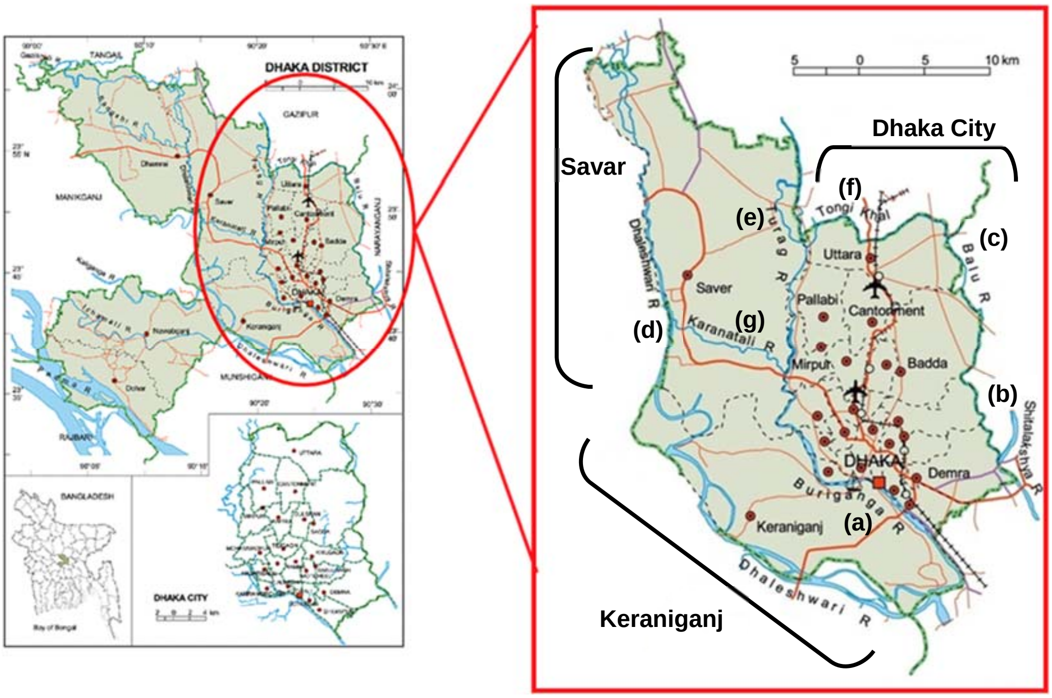
The United Nations estimates that the domestic water consumption of the developing countries will increase by over 50% due to improved water supply, increasing living standards, and adopting advanced/ more water appliances [14]. As a result, serious and chronic water shortages may persist in the developing countries [15]. Bangladesh, a developing country of south Asia, is in critical need of developing better water management strategies to combat with the driving factors of increasing water demand due to increasing population, inadequate water supply, increasing conflict between alternative uses [16], alarming rise in pollution due to unplanned industrial growth and poor sanitation conditions [17], increased pressure on ground water sources [16] and gradual ground water depletion issues. The key water policy documents in Bangladesh—the National Water Policy [18], Development Strategy of the National Water Management Plan [19], and the National Water Management Plan [20]—state the increase of public participation in water projects as one the major goals. According to these policy guidelines, stakeholder participation is to be ensured in different stages of the water resources project cycle. However, in spite of these development guidelines, water users still consider themselves widely ignored in the decision making process in the country [21]. Lack of involvement of local stakeholders in water resources management has led to a lack of experience and of technical know-how of local government and eventually failure to take account of the needs and priorities of the stakeholders [22]. Several studies [23–28] on water management issues in Bangladesh also identified the significant shortcomings due to (i) a lack of integration of major water users/sectors in water policy, planning and implementation; (ii) a communication gap between water stakeholders and policy makers; and (iii) a lack of scope for the citizens to participate in water projects. Dhaka, the mega capital city of the country is under tremendous pressure from inefficient water management generated by a lack of concerted planning among the development sectors and absence of realistic local participation structure in the management process. Hence, more researches focusing on community participation approaches are to be incorporated in water management practices for the city as well as for the country.

Public perception regarding water issues can influence their acceptability to water interventions/ policy [29,30], which in turn enhance public participation in sustainable water management. There are a number of studies on public perception analysis regarding water issues. Perception studies on residential stakeholders encompass: household acceptance of tap water quality over the private water utilities [31], awareness regarding water consumption patterns and corresponding water bills [32]. In contrast, multi-sectoral perception researches include: state of quality of water supply and sewerage services perceived by consumers from households, business and public institutions [33], cross-sectional study on drinking water safety [34]. Again, the literature describes how public perception regarding water quality can be influenced by: risk perception, familiarity with specific water properties, trust in suppliers' past problems that are attributed to water quality and information provided by the mass media and interpersonal sources [35]. However, studies addressing the relative importance/contribution of different water users from stakeholder perspectives/perceptions are not very common in the literature. In this context, the objectives of the study are taken as: (i) analyzing residential water users' perceptions/opinions about their 'relative positions' among other water sectors of commercial institutions, industries and agriculture regarding several major water issues; (ii) identifying homogeneities and variations in opinions of stakeholder clusters about sectoral contributions to water issues; their water use attitudes; water quality and pollution concerns; and (iii) evaluating the influence of stakeholders' water use attitudes and concerns on their opinions about their own contribution to water issues.

This study, the first of its kind in Bangladesh, will play an important role in the understanding of water users' relative contribution/importance in a water management scenario and promote inter-sectoral trust, leading to effective community participation in water planning and management. Moreover, the policy makers/water managers can get a directive of public acceptability of water policy/interventions from such a relative perception study, as delineated in this paper.

2. Study Area and Stakeholders

The study area encompasses Dhaka city, the capital of Bangladesh and its two western sub-districts, named Savar and Keraniganj, within Dhaka district (Figure 1). The area is located within 90°47′ N latitude to 90°18′ E longitude. There are several major rivers such as (a) Buriganga; (b) Shitalakhya; (c) Balu; (d) Dhaleshwari and (e) Turag and also small streams such as (f) Tongi khal and (g) Karantali river. The study area covers about 750 km^2 within the total area of 1464 km^2 of Dhaka district and supports a total population of 11.1 million [36]. The details of the area are given in Table 1.



(**A**) (**B**)

Figure 1. Study area: (**A**) from Banglapedia [38]; (**B**) modified by author, where the surrounding water bodies are—(**a**) Buriganga River; (**b**) Shitalakhya river; (**c**) Balu river; (**d**) Dhaleshwari river; (**e**) Turag river; (**f**) Tongi canal and (**g**) Karantali river.

Table 1. Details of study area [36,37].

Study Locations	Area Covered (km^2)	Population Density	Residents (Million)		Water Consumption (lpcd)	
			Urban	Rural	Urban	Rural
Dhaka city	303	37,000	9.2		110–120	
Savar	280	4900		1.9		80–100
Keraniganj	167	4760				

From the perspective of demographics, residential urban and rural people constitute the largest stakeholder group in the study area (Table 1). Residential people also form the largest water-use sector, though there are other water using sectors, like commercial institutions, agriculture, industries, etc., in the study area. In Dhaka city, DWASA (Dhaka Water Supply and Sewerage Authority, Dhaka, Bangladesh) is the responsible institution for water supply. DWASA withdraws surface water from the Shitalakhya River (Figure 1) and groundwater from a number of tubewells throughout the area. About 91% of DWASA water supply is used in the domestic sector, and the remaining 9% is used by commercial and industrial sectors [37], which make the residential water users the major stakeholder for the study. In the rural area of Savar and Keraniganj, BADC (Bangladesh Agricultural Development Corporation, Dhaka, Bangladesh) supplies irrigation water especially for paddy cultivation.

The wastewater discharge from Dhaka city dwellers is about 1.22 million m^3/day, where the capacity of only one sewage treatment plant in Dhaka, namely "Pagla Sewage Treatment Plant" is 0.12 million m^3/day [36]. As a result, a large volume of untreated wastewater is discharged to nearby surface water bodies, which causes severe water pollution in the study area. The rural people of the study area generally collect water from tube wells, ponds, rivers and other water bodies. Due to a lack of proper sanitation and using the water bodies for household purposes, severe water pollution is occurring in these water bodies. Therefore, in the water use and pollution scenario of the study area, urban and rural residential people make quite a significant contribution; and their inclusion, recognizing their contribution towards water issues and their water use attitude, is important for making water management plans for the area.

The ability of local communities, in terms of education, awareness, and economic status [39], is important to consider when gathering rational perceptions about water issues. Thus, in this study, urban and rural house dwellers were selected from different gender, age, income and education groups.

3. Methodologies

In this study, using a random sampling technique, 50 urban and 50 rural house dwellers were selected from the study area for the questionnaire survey. The respondents were asked to make comparative choices based on their perceptions regarding the five water-use sectors: (1) urban house dwellers; (2) rural house dwellers; (3) commercial institutions; (4) industries; and (5) agriculture. The questions encompassed which sector causes more (i) "water shortage", which is more important as a livelihood and also in economy for (ii) "earning money", who suffers more (iii) "damage due to water shortage", who causes more (iv) "pollution" and who causes more (v) "water loss during use". Considering the small number of respondents [40,41], Analytic Hierarchy Process (AHP) [42] was used to make pair-wise comparison of the water use sectors. To obtain a relative evaluation on each sector, five sectors were arranged in 10 pairs using the AHP [42], regarding each of the five water issue questions, mentioned above.

Each of the respondents was asked—from the viewpoint of each water issue (like "water shortage")—which sector he/she thinks would be more responsible than another one. The respondents were asked to answer the question by comparing 10 pairs, formed by five sectors for each water issue. An example is shown in Figure 2. Each water issue is shown in the (*) underlined part, and two sectors are placed in the left and right boxes. Seven-point Likert's scale was used.

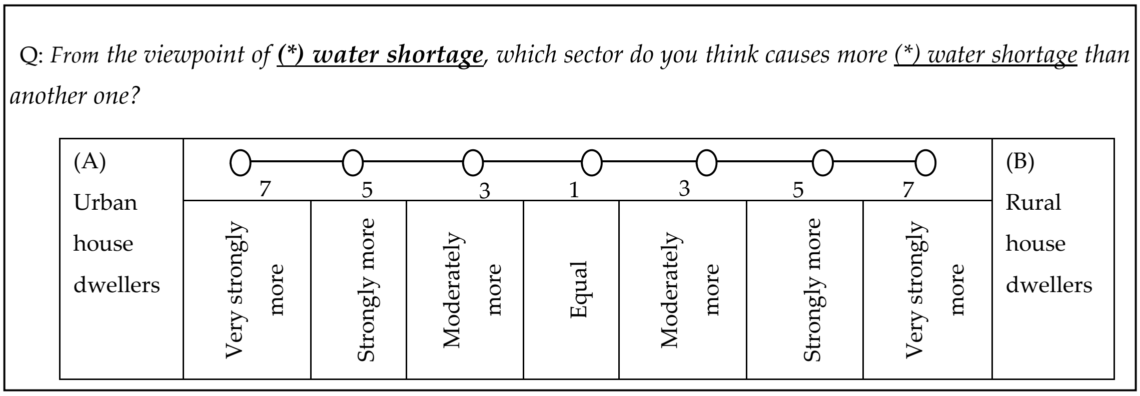


Figure 2. Example of pair-wise question.

For analyzing the results, Saaty's [42] comparison scale was applied (7, 5, 3, 1 = Equal, 3, 5, 7) and the pair-wise matrix was made as shown in Equation (1) [43,44]. The scale scores derived from pair-wise comparisons of the sectors can be shown as a reciprocal matrix of weights (w), (Equation (1)) where the assigned relative weight enters as an element α_{ij}, whereas the reciprocal of the entry $1/\alpha_{ij}$ goes to the opposite side of the main diagonal of the matrix [43]. In this matrix, $\alpha_{ij} = 1$, for $i = j$, i.e., the diagonal elements of the matrix is 1. Here, α_{ij}represents how much the respondent thinks the sector "i" is more important than the sector "j", based on the Saaty's scale. The geometric average of each row (i) is calculated to get the priority vector (U_i) [44]. Then, the weighted factor for a sector, k, is estimated by standardization of W_k (= $U_i/\sum U_i$).

The weighted factor, also called the "Comparative Contribution Factor" (CCF) in this study, implies the comparative importance of a sector over other sectors. CCF scores can range from 0 to 1, and the summation of each stakeholder's CCF scores on five water sectors for each water issue is 1. Following the same procedure mentioned above, five matrices representing five water issues were formed for each respondent and the corresponding CCF scores were also estimated for each.

(i) If the selected score is on the left side of 1, actual score enters the matrix [44]; (ii) If the score is on the right side of 1, the reciprocal of the score is entered [44].

$$A = (\alpha_{ij}) = \begin{bmatrix} 1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & 1 & \cdots & w_2/w_n \\ \vdots & \vdots & \cdots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & 1 \end{bmatrix} \quad (1)$$

Using the distribution of the CCF scores among 100 respondents, cluster analysis was conducted to categorize the respondents into several groups and to identify homogeneities and variations in stakeholders' perceptions. The stakeholders' clusters give representative groups that share common characteristics and play an important role in understanding the perception dynamics regarding water issues within a group/cluster [45]. The average CCF score given by a water use sector cannot show the variations of perceptions within that sector, whereas cluster analysis advances the understanding regarding group homogeneities as well as variations. Euclidean distance with Ward's method [45] was used for cluster analysis. Entering the CCF scores of 100 respondents into SPSS 16.0 (SPSS Inc., Chicago, IL, USA, 2007), a dendogram was plotted using the Euclidean distance coefficients [46]. Upon careful observation of the dendogram, five representative clusters were selected to analyze the similarities and dissimilarities within the clusters as well as among the clusters.

Besides the sectoral comparison questions, the questionnaire also included five questions regarding people's attitudes to water: whether they try to use water as much as possible (spending tendency); whether they try to reduce water loss during use (saving tendency); whether they are concerned about water quality during use, water pollution after water usage and groundwater depletion issue in the study area. The answers were to be given on an attitude scale from "I have no idea" to "I strongly agree", using Likert's scale ranging from 1 to 6. Based on the assumption that the users who tend to spend more water are less prone to water saving, the respondents who gave the similar answers to "water spending" and "water saving" questions, were excluded from the analysis; their answers were considered to be invalid. To extract the common latent factors influencing these answers, the factor analysis was performed using a maximum likelihood method with Promax rotation [47] by SPSS 16.0.

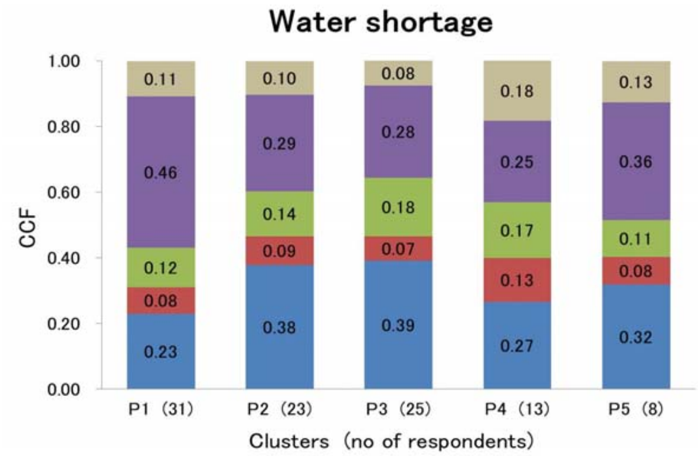
The questionnaire also involved questions about socio-demographics, such as gender, income, and age. The questionnaire sheets were prepared both in English and Bengali (the native language of the respondents). The respondents were selected randomly within the survey area by the survey company, named 'Parade Foundation' and the authors conducted the workshop for training the interviewers prior to the survey. The survey was conducted through a face-to-face interview from 6 August to 4 September 2012.

4. Results and Discussions

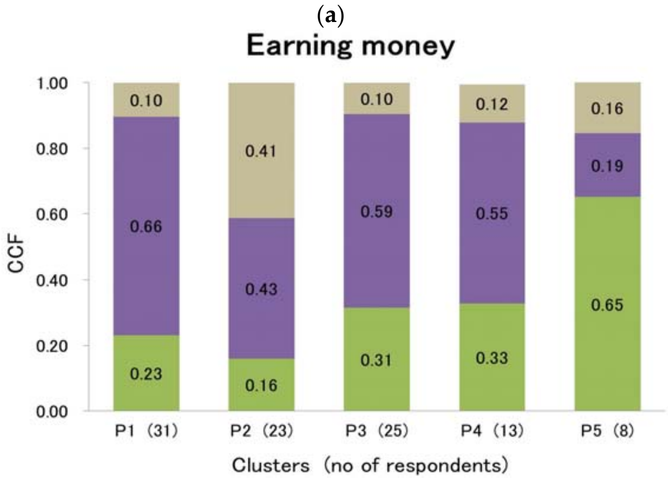
The respondents (n = 100) were categorized into five clusters (P1–P5) based on their CCF scores by the cluster analysis, as explained earlier in the "Methodologies" section of the paper. The average CCF scores for each cluster are shown in Figure 3a–e. Figure 3a shows the residential clusters' perceived scale of importance/contribution of each of the stakeholders regarding the water shortage issue of the area. To explain the perceptions of the clusters, the socio-demographic details of the clusters are also important, which is shown in Table 2. Here, cluster P1 consists of the highest number of respondents (31), while P5 is the smallest cluster (8). Clusters P1, P2 and P3 are dominated by urban house dwellers (having lower percentage of rural respondents) with the age range of 21–40 years and income level of 5–20 thousand Tk, as found in Table 2. The clusters of P4 and P5 predominately consist of rural house dwellers from the age range of 30–50 years and income level of 15–30 thousand Tk and 5–20 thousand Tk respectively. Lower female percentages in the clusters does not necessarily indicate their inability to give opinions regarding water issues, rather it might reflect their unwillingness to participate in the questionnaire conducted by unknown personnel due to privacy issues, which is very common in the cultural context of Bangladesh.

In Figure 3a, P1, the largest cluster (n = 31) gave the highest CCF score to industries (0.46) for water shortage, indicating that the cluster perceived the industries as the most responsible sector for causing water shortage in the study area. In addition, they thought that the contribution of urban residential people in water shortage issues was comparatively lower (0.23). Again, this cluster gave comparatively higher scores to industries for earning money (0.66), damage due to water shortage (0.45), water pollution (0.51) and water loss during use (0.49) (Figure 3a), while the scores for urban people were comparatively lower for earning money (0.23), damage due to water shortage (0.26), water pollution (0.23) and water loss during use (0.21), as shown in Figure 3b–e. Hence, the P1 cluster thought the industrial sector was the most responsible sector causing water shortage, pollution and water loss issues and at the same time they thought that the industries were the most important money earning sector for the study area.

Unlike cluster P1, the clusters P2 (n = 23) and P3 (n = 25) gave higher scores to urban people for all the water issues, except water pollution, as found in the Figure 3a–e. They thought that industries caused the most water pollution in the study area. The perception patterns of these two clusters are quite similar, except for the earning money issue. On that issue, P2 thought industries (0.43) and agriculture (0.41) (Figure 3b) were almost equally important from money earning perspectives, while P3 thought industries (0.59) (Figure 3b) were the most important money earning sector, similar to cluster P1, mentioned earlier.



(**a**)



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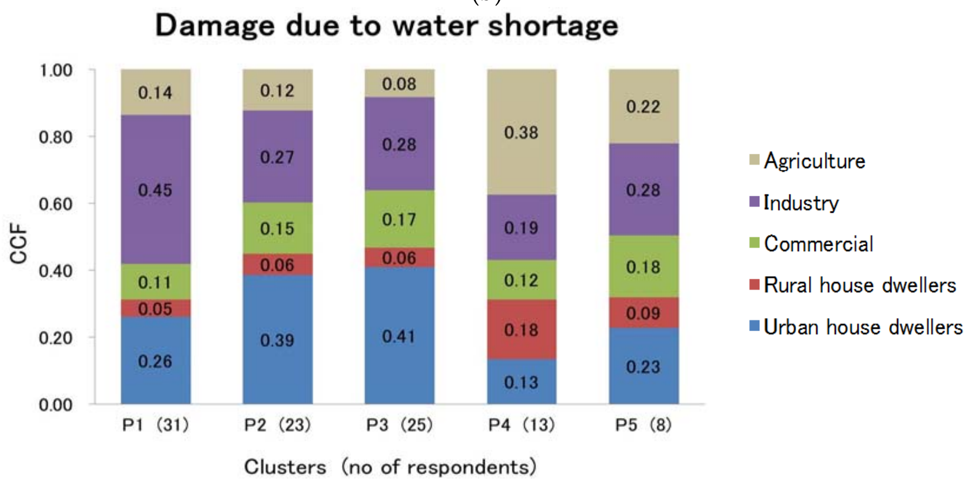
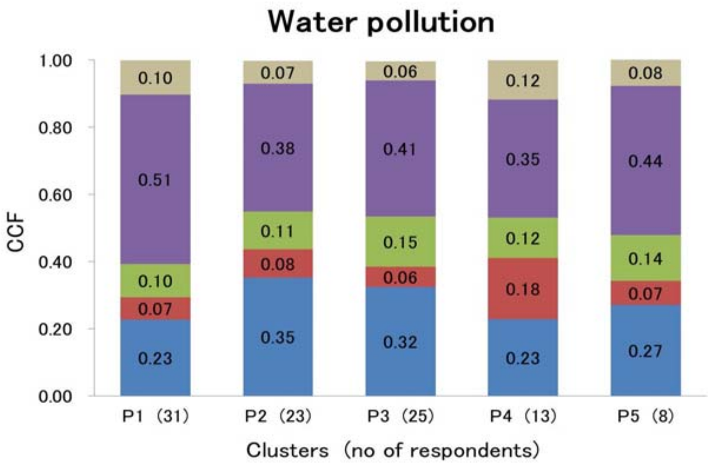


(**c**)

Figure 3. *Cont.*



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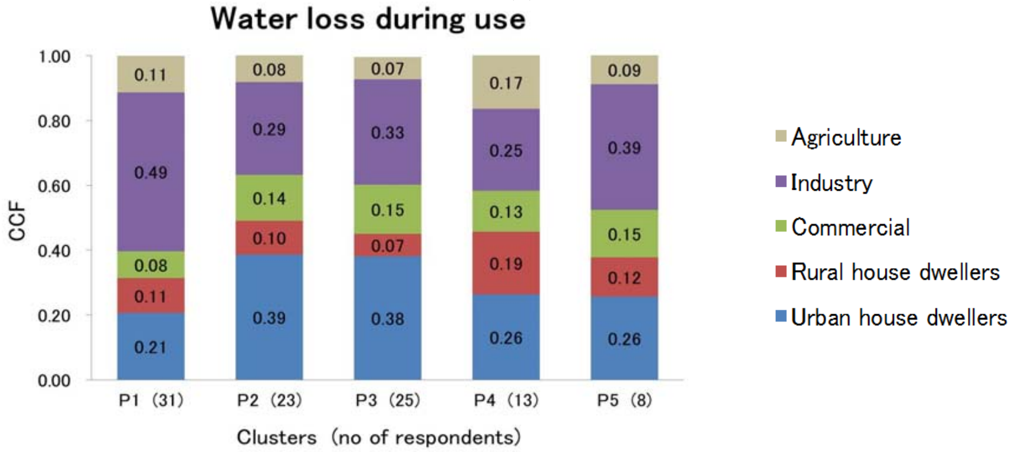

(**e**)

Figure 3. (**a**–**e**) Sectoral evaluations by urban and rural residential clusters.

Table 2. Socio-demographics for each cluster.

Clusters	No of Respondents (*n*)	Rural Respondent (%)	Female (%)	Age Level [1]	Income Level [2]
P1	31	45.2	26	1.6	2.9
P2	23	43.5	9	1.8	3.6
P3	25	44.0	20	1.9	3.4
P4	13	69.2	31	2.8	4.1
P5	8	75.0	0	2.0	1.9

[1] Age: 1(21–30), 2(31–40), 3(41–50), 4(51–60), 5(61 and above). [2] Income (thousand Tk): 1(1–5), 2(5–10), 3(10–15), 4(15–20), 5(20–30), 6(30–40), 7(40–50), 8(50–60), 9(60–80), 10(80–100), 11(100 and above). Age range and Income levels are based on authors' judgement of getting experienced/matured opinions and to incorporate opinions of water users from low to high income level.

Now, if the urban clusters P1, P2 and P3 are observed more closely along with their socio-demographic information (Table 2), it can be found that the respondents of P1 are from a lower income level than those of the P2 and P3 clusters. Thus, P1 might have less access to water supply compared to the P2 and P3 clusters, making them think about their (urban residents) lower contribution to water shortage, pollution and water loss issues. However, more access to water by P2 and P3 clusters (due to higher income) might have influenced their higher/significant scores to urban residents.

Cluster P4 (n = 13), dominated with rural respondents, shows the highest female percentage with the most elderly respondents (Table 2). The distinguishing characteristics of the perception of cluster

P4, which made them different from other clusters, were that the respondents gave significant scores to agriculture and rural people for water shortage, pollution and water loss issues (Figure 3a–e). Another observation for the cluster is that they thought the agriculture sector would suffer the most damage due to water shortage (0.38), as found in Figure 3c. This might be due to their close observation to agricultural and rural water use in their living areas.

Cluster P5 ($n = 8$) gave a significantly higher score to commercial activities for earning money (0.65) (Figure 3b) and thought industries were more responsible for causing water shortage (0.36) (Figure 3a), water pollution (0.44) (Figure 3d), water loss during use (0.39) (Figure 3e) as well as suffering more damage due to water shortage (0.28) (Figure 3e). Besides, the cluster thought agriculture would suffer significant damage due to water shortage (0.22) (Figure 3e) as well. This might be due to their familiarity with agricultural activities in their localities, as mentioned for cluster P4 earlier.

Although Figure 3a–e shows a variation in perceptions among the five clusters regarding the sectoral contribution/importance for the selected water issues, sectoral relative positions for each of the issues can be deduced and this is shown in Table 3. It is found from Table 3 that industries were perceived as the most responsible/important sector for all water issues, whereas urban house dwellers were in the second position of importance among the water sectors regarding the water issues concerned in the study.

Table 3. Relative positions of water sectors.

Issues	Perceived Major Sectors *	Cluster (Respondent No)	CCF Scores *	Relative CCF Scores **	Relative Position
Water shortage	Industry	P1 (31) P5 (8)	0.46 0.36	0.44	1
	Urban house dwellers	P2 (23) P3 (25) P4 (13)	0.38 0.39 0.27	0.36	2
Earning money	Industry	P1 (31) P3 (25) P4 (13)	0.66 0.59 0.55	0.61	1
	Commercial	P5 (8)	0.65	—	2
	Agriculture	P2 (23)	0.41	—	3
Damage due to water shortage	Industry	P1 (31) P5 (8)	0.45 0.28	0.42	1
	Urban house dwellers	P2 (23) P3 (25)	0.39 0.41	0.40	2
Water pollution	Industry	P1 (31) P2 (23) P3 (25) P4 (13) P5 (8)	0.51 0.38 0.41 0.35 0.44	0.43	1
	Urban house dwellers	P1 (31) P2 (23) P3 (25) P4 (13) P5 (8)	0.23 0.35 0.32 0.23 0.27	0.28	2
Water loss	Industry	P1 (31) P5 (8)	0.49 0.39	0.47	1
	Urban house dwellers	P2 (23) P3 (25) P4 (13)	0.39 0.38 0.26	0.36	2

* Perceived major sectors and CCF scores are taken from Figure 3a–e. ** [Σ(respondent No × CCF Score)]/Σ(respondent No).

In Figure 3, residential people from some clusters emphasize on their own sectoral contribution to cause water shortage, water pollution and water loss during use, which showed an acknowledgement of their concern about their relative sectoral position within other water sectors regarding the water issues. Some clusters identified industries as the most responsible sector for water problems; however, at the same time, they also considered the industries to be more important for earning money and to suffer more damage due to water shortage. The statistical data, generally found in the literature, may give industrial income or damage in monetary terms, but the peoples' perception about industrial damage or contribution to the economy formed the socio-economic basis of the issue, which will foster more realistic decision making about exploring alternatives of industrial replacement or relocation, the frequently advised management decision.

Using the water attitude scores for the valid 66 respondents out of 100 (34 respondents, giving contradictory answers about their water attitudes, were considered invalid for analysis), two factors were extracted, as shown in Table 4. Here, the factor scores for each question, under Factor 1 and Factor 2, represent the average factor loadings for 66 respondents. Here, the factor loadings can be thought as the coefficient of correlation between the Factors (Factor 1 and Factor 2) and the variables (5 questions in Table 3) [48]. Based on the factor loadings, Factor 1 was termed as 'water use and saving attitude', as significant factor loadings in this category took into account the questions related to water spending and saving attitude of the respondents. Significant factor loadings for Factor 2 were found for questions related to the respondent's concern about a selected water issue, and hence the Factor 2 was named as "water issue concern". The Eigen value in Table 4 indicates how much variance in the data is explained by a factor [48]. The average factor scores/loadings of five clusters (for valid 66 respondents) were plotted against Factor 1 and Factor 2, which is shown in Figure 4.

Table 4. Results of factor analysis.

Questions "Do you Think That....."	Factor	
	1	2
(i) you try to reduce water loss during water usage	0.87	0.01
(ii) you try to use as much water as possible	−0.57	−0.02
(iii) you are concerned about ground water depletion	−0.16	0.84
(iv) you are concerned about water pollution	0.19	0.50
(v) you are concerned about water quality during use	0.21	0.39
Eigen value	2.1	1.2
Cumulative variance (%)	42.4	65.3

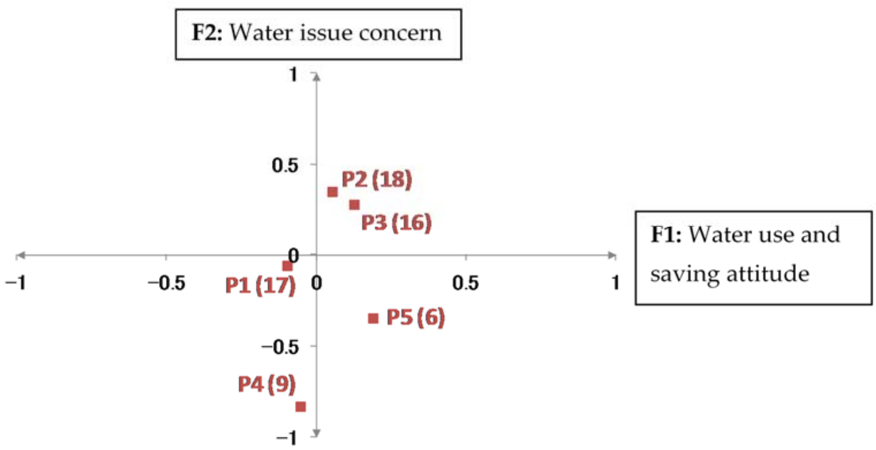

Figure 4. Water attitude factor score plot for urban and rural clusters (The number shown in parentheses indicates the respondent number of each cluster).

Although the respondent compositions of these clusters (Figure 4) were not completely the same as the clusters shown in Figure 3a–e, the similarities of CCF scores for both cases were first confirmed.

Clusters P2 and P3 showed positive water use and saving attitudes as well as positive water issue concerns, as found in Figure 4. As shown in Figure 3a,c–e, P2 and P3 clusters showed quite a similar tendency in CCF scores for the water issues except for "earning money" (Figure 3b). The proportion of urban respondents was relatively higher in these clusters, and they recognized themselves as contributors to causing water issues in the study area. The results also indicated their higher concern and awareness about water issues.

Cluster P4, with the highest income level, showed clearly low water issue concern and negative water attitude (Figure 4). This might be due to their easy access to water, which might make them less concerned about water saving attitudes and water issues. In contrast, the P5 cluster showed positive water use and saving attitudes, but negative water issue concern. As shown in Table 2, they were from a low income group and might have a water-saving attitude because of economic issues instead of water concerns.

The understanding and practices about water attitudes by the residential clusters, along with their concerns about water quality and pollution issues, might influence the perceptions about their own contribution to water issues. Clusters P2 and P3 showed positive water attitudes as well as positive concerns about water issues (Figure 4), although they gave higher CCF scores to urban people for causing water shortage (Figure 3a) and water loss (Figure 3e). This implies that they were concerned about water saving, but they scored the urban water users from a sectoral point of view and gave higher scores that indicated more water shortage and water loss caused by the urban people than other sectors. On the other hand, cluster P1 showed negative water attitude and concern (Figure 4), and gave a comparatively lower score to urban house dwellers for water shortage (Figure 3a) and water loss issues (Figure 3e). A lack of water issue concern and negative water use attitudes might influence their perceptions towards urban water use sectors.

Finally, it can be said that the study addressed the variations among an apparently homogenous group of people. Although they were termed as a single group of residential people, there were variations in their opinions/perceptions about their own and other water sectors' contribution/importance to water issues, and variations in their own water attitudes and concerns. The clustering approach, used in this study, has offered more insight into smaller groups of stakeholders allowing detailed observations of their opinions and water use attitudes along with their socio-demographic information. Unlike the average observation, clustering will allow the policy maker to identify the target group of water stakeholders more efficiently for water management issues. Again, the clusters also presented variable influence of their water attitude and concern regarding their perceptions. The findings, regarding water use attitudes and water issue concerns of the clusters will, in this study, help the water managers and planners to think about effective measures to be taken to improve the water attitude and water issue concerns of a group. For example, television advertisements may not be effective to reach to the lower income group, but a local announcement may be more effective for them. This is how clustering will enhance the representative grouping of stakeholders and then their perception can be better addressed by the policy makers during water management planning.

5. Conclusions

This study aimed to address residential water users' perceptions of and opinions on the water sectors, regarding: themselves, the water issues related to water shortage, pollution, water loss, damage due to water shortage and money earning issues in Dhaka. Clusterization based on the respondents' perception scores revealed that large variations existed among an apparently homogenous group of residential people, although similarities were also found in some clusters. The clusters (P1–P3), dominated with urban respondents, showed significant variations in their perceptions. Urban clusters (P2 and P3), with higher income level and more probable access to water supply, thought the urban house dwellers were the most responsible sector causing water shortage and water loss. However, the urban cluster (P1), with lower income level, thought the urban people were less responsible for the water issues. However, these clusters perceived industries as the most water polluting sector and the most important money earning sector as well. On the other hand, the clusters with a larger proportion of rural residents (P4 and P5), being more familiar with agricultural activities, thought that the agricultural sector would face the most damage due to water shortages as well as cause significant water loss during use. Thus, it can be said that the use of cluster analysis for this study was effective in addressing as well as explaining the respondents' perceptions in correlation with their socio-demographic features.

The study also presented the relative positions of the water sectors based on the perception scores of the clusters regarding five water issues. It was found that industries got the highest position as a sector, in terms of causing the most water shortage, pollution and water loss in the study area. It was also the highest money earning sector. The urban house dweller, occupying the second position, was also found to be an important sector causing water issues in the study area. These findings will promote better understanding about sectoral importance in water management.

Regarding the water use attitudes and concerns, different tendencies were found among the clusters, and the influences of these tendencies over the respondents' perception were also observed in the study. Two urban clusters (P2 and P3), although showing positive attitudes and concerns, scored urban house dwellers highly for causing water shortage and water loss; and rated them significant in terms of water pollution issues. This might indicate their perception about urban dwellers' contribution to water issues as a sector and which was probably not influenced by their own attitudes and concerns. On the other hand, the urban cluster (P1), showing negative attitudes and concerns, gave comparatively lower scores to urban dwellers regarding the water issues, which might reflect the influence of their own attitude on the perception of their contribution to those issues.

Lastly, the results of the study in terms of residential stakeholders' perception will provide the policy makers with the scope to cross check the water users' opinions with a traditional managerial concept, based on either data (if available) or approximation. In that case, representative grouping of stakeholders through clusterization will foster better understanding regarding the target groups requiring policy intervention to resolve water issues.

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