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Framework for Assessing Efficient Water Consumption Attributes and Their Relative Importance in Office Complexes

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Abstract: Globally, the water availability is getting difficult due to over extraction of ground water and rapid population growth. The Indian national water supply is expected to fall down by 50% below the demand by 2030. In the last decade, in spite of alluvial aquifers of the Indo-Gangetic plains, the over extraction of the ground water is making the scene catastrophic in the state of Uttar Pradesh (U.P.), India. Therefore, to overcome this water stress condition in the urban areas of U.P., it is needed to achieve water sustainability in office complexes (major consumers of the drinking water supply of a city) based on the analysis of water resource management of the area. In this study, to develop water management attribute framework for office complexes, expert opinion based Delphi technique followed by Analytic Hierarchy Process (AHP) is adopted.

The determination and pairwise comparison of the components are computed using Delphi technique, while AHP is used to calculate the weights representing their relative importance. Finally, the water supply, consumption and financial aspects are found as crucial components with 0.378, 0.422 and 0.20 relative weights respectively. Thus, the developed framework rates the attributes (components, indicators and sub-indicators) with their relative importance (based on weights) which would intelligently assist decision makers to design priority issues and programmes for efficient water management system in the geographical area under consideration.

Key words: Water sustainability, office complexes, AHP, Delphi, India.

Introduction

Nowadays, the urban scenario clearly reflects the fact that water resources management is an intricate issue, which contains dependence upon environment to help in the prediction of indefinite climatic events, i.e., rainfall events. These fluctuations in urban hydrological cycles are mainly due to intensified anthropogenic pursuits. As a result, this is causing prevalent flooding and dry events to be ordinary for countries like India. The foremost reasons for urban water conflicts include anthropogenic activities, such as an excessive runoff from concrete surfaces, restricted infiltration, and fragile management decisions and policies. The requirement of freshwater resources intake is intensifying worldwide (Morrison et al., 2000); equally, the ecological deterioration and inconsistent use of limited natural resources are creating pressure on urban water systems. Worldwide, as the complexity of urban water issues has intensified, a wide-ranging research has been done to use the sustainability measures with water resource problems (Loucks et al., 2000; Ashley et al., 2004; Starkl and Brunner, 2004; Mays, 2006; Giuppponi et al., 2006).

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Water is a basic requirement for a variety of ecological and socio-economic needs—from ecosystems, habitats, biodiversity and agricultural necessities through industrial, commercial and recreational activities. It expedites political stability for problem solving related to fresh urban water availability and accessibility. Therefore, more than ever before, water supply and urban water management have become a necessary requirement for the attention of governments, local authorities, relevant organizations and property owners.

Presently, the water sustainability is one of the most significant issues worldwide. The growing population and urban agglomeration have provoked the water demand. The execution of sustainability thoughts ensures the responsible consumption of water resources for human society. Mays (2006) highlighted three prime realms i.e. scope, scale and governance for Integrated Water Resource Management (IWRM). The distinction of 'Dublin' statements on IWRM, stating that water is a vital resource, to be used sustainably. Jakeman et al. (2005) discussed several issues, i.e., water demand and supply, agricultural landscapes planning, poverty alleviation, and forest conservation in IWRM.

Natural resources are the mainstay of every national economy, especially the water systems. Additionally, the costs of our resource use in terms of bearings on the environment may prompt radical shifts that may cross the carrying capacity of the natural environment. Urban water quality and availability is essential to humankind and critical to economic productivity. Water is crucial for variety of commercial activities from production, manufacturing, to energy generation. The viable use of water in urban settings encompasses the controlling of assorted and conflicting burdens on a limited natural resource, i.e., water. The urban planners have to involve with handling aquatic systems to ensure sustainability. Water scarcity is a multidimensional problem, which must be fixed, while sustaining water in the face of growing urbanisation. Controlling of surface water as well as groundwater has major repercussions for the conservation of urban water resources. Primarily, protecting the quality of urban waters is all about land use management, while keeping the amount of water is about handling its demand and encouraging an understanding of the vitality of aquatic systems. Developing strategies to protect water resources into the future of urban conurbations is a great challenge, and recognized as fundamental to the country's socio-economic and green health index.

The accessibility of fresh water in developing nations, i.e., India, is truly difficult due to excessive extraction of groundwater and growing urban as well industrial corridors. The socio-economic concerns of water insufficiency are factual, as are the effects of water issues exaggerated by the global climate change. The water deficiency is a geographic reality for countries like India, which shows monsoonal dependency over the year; nevertheless, it may be consequence of countries' poor water resource management (Asian Water Development Outlook, 2013). The intensification in total water use with exceptional human induced pressure is one of the most effective drivers of the water crisis in the country.

Presently, groundwater scenario in the state of Uttar Pradesh (referred as U.P. hereafter), India, has changed, which results into range of environmental problems. Most of the geographical areas of U.P. lie within the Gangetic river basin; therefore, this condition favours the occurrence of aquifers, but severe anthropogenic activities are building a pressure on these aquifers. In the potential groundwater shallow dynamic zone, an imbalance between 'recharge' and 'discharge' has occurred causing regular depletion of aquifers. In U.P., the rate of ground water exploitation is assessed as 54.31%, 69.00% to 72.16% from the year 2000, 2004 to 2009 respectively.

Urban centres in U.P., ranging from cities to small satellite towns are prone to the water stress and frequent occurrence of natural calamities. The state of U.P. is facing dual pressure of inadequate city water infrastructure and poor supply management. In U.P., a considerable percentage of the population is involved in the non-formal sector with poor economic base and attaining limited water supply. Discovering ways to develop urban water sustainability, which is the foundation for the healthy environment, and its complex extents in the provision of basic facilities, is the major footstep towards developing urban areas more sustainable. In U.P., institutional and commercial buildings use a significant portion of the supplied drinking water, because public demands for the basic infrastructure and natural consumables are too high in the state. An institutional building needs plenty of water including drinking and other uses. The general households and large institutional buildings show a remarkable difference in its water consumption patterns. The office complexes are the major contributors to the resource exhaustion as well as the most persistent components of an organizations' assurance to apply sustainability. The over extraction of groundwater is increasing the probability of devastations in U.P. Therefore, this study advocates the development and implementation of the concepts of urban water sustainability.

The concept of 'multi-criteria decision method based water sustainability' works as a prototype for the assessment of urban water issues (Lai et al., 2008). However, several objectives and stakeholders demonstrate the judgements in urban water resource utilities. The complexity of urban system imposes decision makers to come up with practical judgements; several researchers use Multi-Criteria Decision Making (MCDM) approach to deal with urban water issues, for implementing sustainable development principles. MCDM is widely used in water related decision support systems (Harmancioglu and Alpaslan, 1992; Eder et al., 1997; Tkach and Simonovich, 1997; Tiwari et al., 1999; Gupta et al., 2000; Raju et al., 2000; De Marchi et al., 2000; Mahmoud and Garcia, 2000; Flug et al., 2000; Kholgi, 2001; Hamalainen et al., 2001; Joubert et al., 2003; Srdjevic et al., 2004; Janssen et al., 2005; Fassio et al., 2005; Khalil et al., 2005; Pietersen, 2006; Maia and Schumann, 2007; Zarghami et al., 2008; Qin et al., 2008; Makropoulos et al., 2008).

Several researches have been reviewed, which shows that sustainable urban water management can be achieved with indicator-based approach (Jakeman et al., 2005). Recent studies regarding development of Water Sustainability indices, i.e., development of Water Poverty Index (WPI) Canadian Water Sustainability Index (CWSI), Watershed Sustainability Index (WSI), and West Java Water Sustainability Index (WJWSI), used the MCDM. These water indices are site-specific, which limits their universal aptness. Possibly, the development of a similar type of index will be a solution for the urban water issues in U.P. In this connection, this study provides a preliminary framework to develop water sustainability index for office complexes in the state of U.P.

Methodology

Due to the acuteness of water scarcity and drought challenges in various regions of the country, as discussed above there is a need to conserve this finite natural resource and to achieve water sustainability in buildings, i.e. commercial, industrial, institutional etc. Since, after the residential sector, the commercial (office) complexes are the second largest consumers of water, consuming at an average of approx. 20-25% water of the total consumption of a city (Chanan et al., 2003; EPA Water Sense, 2009; Morton, 2011; Pieterse-Quirijns et al., 2013), assessing the efficient water consumption attributes in office complexes would be a significant step towards water sustainability. Notably, the aforesaid attributes would be much suitable for a mid level office complex where approximately 100 persons work, as these types of offices are large in numbers in this segment, and the application of the outcome of this research would be significant to produce major effects regarding communal water sustainability. In assessing the attributes there is a need to form consensus among the water experts opinions; therefore widely accepted Delphi technique has been used.

In past years, Delphi technique has been used for selection of indicators or parameters in various fields, i.e., education fields, different information systems, transportation, surface engineering, various strategic planning, water quality, etc. This technique has the advantages of using several judgements of diverse respondents from different backgrounds. Delphi is based on the information derived from consensus of respondents and stakeholders, thus it underpins the initial settings for mass decision-making. Significantly, in Delphi technique, minority views (e.g., a small group of respondents) are not always overlooked and consequently used in decision-making process.

Jolson & Rossow (1971) and Rowe & Wright (1999) mentioned that application of Delphi technique produces more accurate, less uncertain and bias-free results as compared to other alternative group decision-making methods. The Delphi technique has a better accuracy rate as it eliminates variance up to an admissible limit. Notably, the variance can be reduced as some of the respondents change their opinions (e.g., not their judgements) as they get aware of the facts presented in previous rounds by the other respondents. In general, the primarily designed framework can be included in the first questionnaire, which can refine or update the existing acquaintance of respondents.

It has been observed that Delphi technique has been extensively used in decision-making process, and it is supposed that this technique can be a useful method for attaining consensus in the selection of components, indicators and thresholds for the development of a water sustainability index.

To develop the primary framework for water sustainability assessment, a set of parameters is to be conceptualized. Therefore, similar types of water sustainability indices developed earlier in different regions of the world were rigorously reviewed and studied. Some of the relevant and available indices are Water Poverty Index (WPI), Canadian Water

Sustainability Index (CWSI), Watershed Sustainability Index (WSI), and West Java Water Sustainability Index (WJWSI). It is found that these indices have certain parameters (Components/Indicators/Sub-indicators), i.e., water resources, access, water use, environment, infrastructure, human health, hydrology, policy, water conservation etc. These were finally selected based on the application of Delphi technique in due course of time with the help and involvement of water stakeholders/experts/consultants/community groups and related academicians from universities and professional organizations. The selection of the water stakeholders and experts is one of the most important and critical step in the application of this technique, as they are supposed to be one of the best experts of their fields and having vast knowledge, experience along with their strong interests in the development of the water sustainability issues and concepts in the northern region of the country.

At first hand, a list of 39 experts from the abovementioned categories of the northern region was prepared. They were being communicated/interacted for their availability and making contribution for the development of the water sustainability index for office complexes. As a result 32 experts showed their interest and acceptance for the same. Similarly, 26 office complex caretakers from the 26 office complexes (one public and one private each) of 13 'A' class cities of Uttar Pradesh were also interviewed regarding the issue, at the time of data collection (water supply/demand and consumption details) for the determination of the threshold values of the concerned parameters. Therefore, almost all of 58 stakeholders/experts from northern region possessed extensive knowledge of the concepts and facts related to water resource management and sustainability in the geographical area under consideration.

A meticulous analysis reveals that the water sustainability in an office complex mainly depends on the water supply/demand and consumption in different activities for performing the daily needs along with the contribution of human efforts (Planning/Management etc.) and related financial aspects. The water supply in an urban office complex consists of water availability made by the local authority, ground water through bore wells, and rainfall. The water consumption in the office complex may be easily classified in different activities e.g. toilet, pantry, maintenance of building etc. along with the major consumption in cooling (desert coolers, air conditioners) and irrigation of landscaped areas. These activities may be performed effectively, when there is application of latest technologies and water management strategies.

Based on the outcome of the different case studies, experts' opinion and the related water operated activities in an office complex, the first questionnaire was framed intelligently. Based on the existing water sustainability indices, related literature and experts' consultation, a proposed framework (survey questionnaire) for the selection of the components, indicators and sub-indicators (decisive in the water consumption in office complexes) was prepared to make the consensus among the experts opinion. The questionnaire was circulated to the respondents in three rounds including their in-depth interviews. The feedbacks in the form of suggestions and modifications received from the respondents after each round has been studied and analyzed. Where 67% (two third opinions to form a consensus) of the respondents agreed or suggested corrections for the related parameters, modifications are incorporated in the framework accordingly.

After the execution of round-3 the different attributes e.g. components, indicators and sub-indicators are finalized with a requirement to list their respective threshold values (minimum and maximum values). To determine the same a survey questionnaire was prepared to collect the primary data from the office buildings (Public and Private each, where approx. 100 persons are working) of all the 'A' class cities of U.P. There are 13 cities divided in four zones (e.g., Awadh, Budelkhand, Eastern and Western) of the state approximately covering entire U.P. state. So, the relevant primary data is collected from the 26 office complexes (one Public and one Private each) of 13 cities of U.P. and the threshold values are determined on the basis of it. These threshold values were inserted in the table of framework finalized in round-3 with their respective components, indicators and sub-indicators to prepare the questionnaire for round-4.

To assess the relative importance of the attributes, it is again necessary to form a consensus among the opinions of the respondents regarding the pair-wise comparison between the attributes. Hence, the round-4 was conducted and the feedbacks received were studied and analyzed by applying AHP technique as shown in Figure 2. The results obtained thus are the relative weights of the components, indicators and sub-indicators, which represent the relative importance of each of them as mentioned in Table 1.

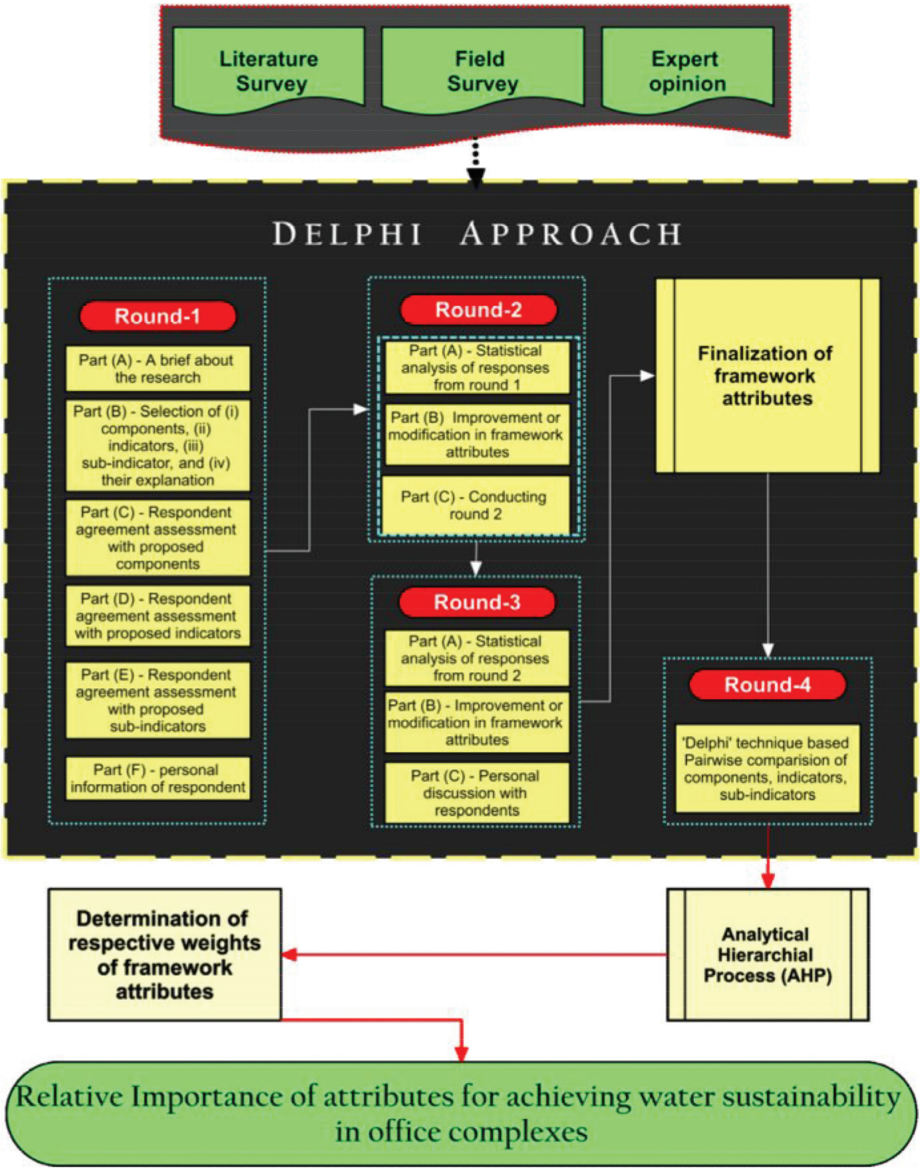

Figure 1: The methodology for preliminary framework for selection of attributes.

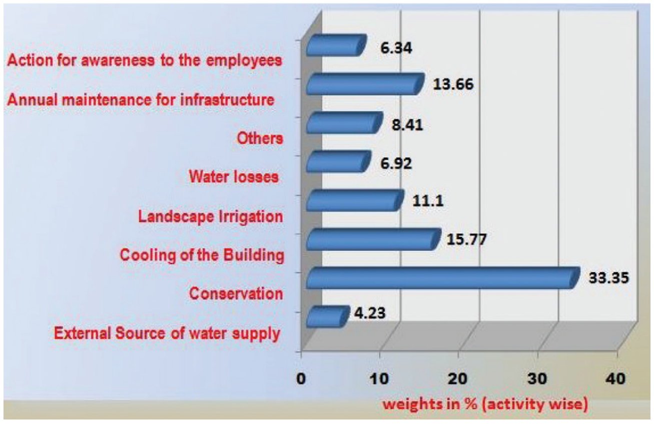

Figure 2: Weights (%) of different activities for efficient water management in office complexes.

Result and Discussion

The Delphi technique is quite helpful in developing "Group response" or "Expert consensus" by analyzing the opinions/feedbacks/suggestions of the group experts through a series of intelligently designed questionnaires incorporating relevant information/details/contents. Delphi technique consists of the introduction of weighted opinions of a group of individuals as a whole for achieving a group response through a structured group communication process; thus, initial solution frameworks can be designed for complex decision problems. Based on the literature study, expert opinions, adoption of Delphi technique to form a consensus among the opinions of the respondents to

Table 1: The overall weights (%) of the attributes for the efficient water management in office complexes

Sl.	*Components*	*Pair wise Comparison Weight (Principal Vector) Component Weight CW_i*	*Indicators (Sub components)*	*Sub-indicators*	*Pair wise Comparison Weight by (Principal Vector) Sub-ind. Weight SIW_{ii}*	*Weight (%) SIW_{ii}*	*Average water consumption (%) in different activities (as per different literature studies) Chanan et al., 2003; Bint, 2009, EPA Water Sense, 2009*	*Over all weight (%)*	*Total weights (%) (activity wise)*	*Remark*
1.	Water Supply		**External Source of water supply (Ground water through Bore well)**	-----	0.112	11.2	-----	4.23	**4.23**	-----
		0.378	**Conservation**	Adopting Water Savings Techniques	0.164	16.4	------	6.19	**33.35**	This activity is considered to be the most important, as it weighs 1/3 of the total weights for the action to achieve efficient water management in the complex.
				Reuse	0.469	46.9	------	17.72		
				Rainwater harvesting	0.255	25.5	------	9.64		
2.	Water use (Consumption)	**0.422**	**Water Demand**	**Cooling of the Building**					**15.77**	Cooling of the Building and Landscape Irrigation weights are considerably higher as compared to other activities, therefore they impart a major important role in the efficient water management process.
				Air Cooling (Desert Coolers)	0.131	13.1	**33.0**	5.52		
				A.C. (Cooling towers)	0.243	24.3		10.25		
				Landscape Irrigation	0.263	26.3	**26.0**	11.10	**11.10**	

(*Contd.*)

				Water losses (leakages & Misuses)	0.164	16.4	**18.0**	6.92	**6.92**	Water losses should be minimized, as it also carries a considerable amount of weight regd. efficient water management issues.
				Others						The total of the activities mentioned in this section, jointly play an important role regd. the efficient water management process in the complex.
				Toilets	0.061	6.1		2.58		
				Pantry (Including Drinking)	0.040	4.0	**23.0**	1.69	**8.41**	
				Maintenance (Floor Cleansing etc.	0.098	9.8		4.14		
3.	Financial Aspect	**0.20**	**Annual maintenance for infrastructure**	Motors supply pipelines & plumbing items.	0.430	0.430	------	8.6	**13.66**	This activity is equally important as cooling & landscape irrigation, hence should be dealt carefully on priority basis.
				S.T.P./Waste water treatment plant	0.253	0.253	------	5.06		
			Action for awareness to the employees	Activities for promotion of awareness for water savings	0.317	0.317		6.34	**6.34**	------

select the different attributes (components, indicators, sub-indicators) along with their pair-wise comparisons, and therefore applying AHP technique, results for their respective mathematical values (Table 1), which can be considered as their weights.

The activitywise threshold values, for water consumption in different activities in the office complexes is somewhat similar to the values recorded during the literature study, which indicates the significance of the field data values and collection methods adopted for primary data collection. Based on the outcome of the present research and different literature studies regarding consumption of water in different activities in an office complex, a comparative analysis can be summarized as mentioned in Table 1.

In Table 1, the respective weights (%) of the sub-indicators are calculated by applying AHP, while the average water consumption (%) in different activities in office complexes is taken from secondary data. Comparing the cooling, landscape irrigation, water losses and others (maintenance of the office complex, toilets, kitchen/pantry) sub-indicators' weight (%) 37.4, 26.3, 16.4 and 19.9 respectively with their consumption values (%) of 33.0, 26.0, 18.0 and 23.0 respectively, it has been found that there is a marginal difference between both of their values. Notably, the approximation equivalence of both values (sub-indicator % weight and % average consumption of the activity) proves that the results of present study are significant and well acceptable to assess the consumption efficiency of water in an office complex. Notably, the framework's component 'Water use' and its sub-indicator 'Cooling' [A.C. (Cooling Towers) including 'Air cooling' (Desert coolers)] are scoring maximum values 0.422 and 0.374 (Table 1) respectively among their groups, which indicates that they are having higher importance over other components/sub-indicators of the group.

Considering the total % weights of different activities, as mentioned in Table 1, it can be concluded that the activities having values over and above 10.0 i.e., water conservation, cooling, landscape-irrigation and annual maintenance activities with a value of 33.35, 15.77, 11.10 and 13.66 respectively, play an important and vital role for water sustainability in an office complex.

Therefore, it is well inferred that the higher weight of the attribute denotes the higher importance in comparison to others, as calculated based on opinions presented by the experts. The significance of the components weights indicates their relative role in the sustainable water use that should be dealt accordingly. On the other hand, any shortcoming or the poor performance of the assessed attribute, which has gained a high importance in weighting process, would definitely produce adverse effects leading to water unsustainability in office complexes. Finally, the proposed framework can be implemented worldwide, if selective geographical properties are accounted for.

Conclusion

There are diverse array of research taking place around the proficient use of water within office complexes. The approach we must develop for 'water efficient urban building' (referred as '$Aqua_{eff}^{U}$' hereafter) has to consider all facets of the concrete environ, which is required for the development of national policy. The ideal $Aqua_{eff}^{U}$ buildings equally require an assimilated and wide-ranging approach, coupled with the factual guidelines that encourage the improved building architecture, through the involvement of stakeholders/participants, and communities to execute the needed alterations to increase the probability of zero discharge. Ultimately, an all-inclusive explication is prerequisite that incorporates individuals, process, green architecture, Sci-tech and engineering of urban buildings with its integral measures. For attaining superior water management outcomes in office complexes, the following recommendations based on the research study should be adopted:

1. Explicit protocols for water-efficient tools are the prerequisite. Operative plans to endorse the user involvement, choice and responsibility for the development of policies for '$Aqua_{eff}^{U}$' buildings, must be constructive. The water consuming activities scoring higher weights i.e. cooling, landscape irrigation and water losses (leakages and misuses) should be bestowed importance wise. In office complexes, justified cooling loads and landscape irrigation systems should be designed logically, as these events are of higher significance and consuming approx. 60% of water of the total consumption (Table 2).
2. Yearly water audit should be performed to monitor the efficient consumption of water in office complexes. More substantiation is still compulsory for '$Aqua_{eff}^{U}$' buildings, i.e., evidence-controlled response culture. Rationale for '$Aqua_{eff}^{U}$' buildings infrastructure needs to be multidimensional, regular, vigorous, convenient and repeatable.
3. Water losses (leakages and misuse) should be closely observed for achieving water efficiency.

Participant inclination is decisive, particularly for the development of an effective and feasible building water-efficiency strategy.

4. System is desired to explain the importance of water and to reckon the development of cost/benefit paradigms of 'Aqua$_{eff}^{U}$' buildings water-competence, interventions and designs.
5. Urban buildings water-efficiency movements should be rationally planned to be less interfering, they should be uninterrupted and focused at refining civic awareness of water processes related to office complexes.
6. To promote an improved verification system, especially in office complexes water consumption pattern, policy makers must provide flawless management strategies and criterions for water-saving fixtures, end-uses and water recycling stuffs. This may be through accreditation, ratings, i.e., Water Efficiency Rating Tool (WERT), survey-level audits, benchmark modelling, performance metrics, cost-recovery methods and ISO certification schemes.
7. Water efficiency programmes must be expanded to city's old domestic buildings with flexible promotional activities with some appropriate incentives.

Urban planners and hydrologists are trying to define new concepts to lessen the energy consumption substantially in office complexes. The attributes' weights obtained from the present study may have some ambiguity factors so far, as it is based on the personal opinion of the regional experts. A possibility of occurring some experimental inaccuracies may also be there, while conducting the field survey. In this study, the uncertainty analysis has not been carried out; if done, it may yield some more superior outcomes. To use the developed framework the regional settings should be re-scrutinized to attain the required outcome. The outcomes of this study would play a key role in attaining urban water sustainability, and underpinning a prototype for the development of water sustainability indices for the 'Aqua$_{eff}^{U}$' buildings. The lowering down of water consumption and achieving the zero water discharge conditions in buildings by adopting the water efficient tools and practices would be a step towards the solution of the problem. Office complexes being the major consumers of the urban drinking water supply should be given acceleration to achieve water consumption efficiency. As a result, it would regulate the limited water supply with maintaining its quality, reduce energy consumptions and would improve the financial condition of the institute. The cumulative efforts would improve the water resource conditions along with the safeguard of ecosystems of the peripheral urban societies.

References

Asian Water Development Outlook (2013). Measuring Water Security in Asia and the Pacific. Asia-Pacific Water Forum. ISBN: 978-92-9092-988-8 (Print).

Ashley, R., Blackwood, D., Butler, D. and P. Jowitt (2004). Sustainable Water Services. London: IWA Publishing.

Bint, L. (2009). Benchmarking Water Use in Office Building. 1-2

Chanan, V., White, S., Howe, C. and M. Jha (2003). Sustainable water management in commercial office buildings. Innovations in Water: Ozwater Convention & Exhibition, Perth, 6-10 April 2003.

De Marchi, B., Funtowicz, S.O., Cascio, S. and G. Munda (2000). Combining participative and institutional approaches with multi criteria evaluation: An empirical study for water issues in Troina, Sicily. *Ecological Economics*, **34:** 267-282.

Eder, G., Duckstein, L. and H.P. Nachtnebel (1997). Ranking water resource projects and evaluating criteria by multi criterion Q-analysis: An Austrian case study. *Journal of Multi-Criteria Decision Analysis*, **6:** 259-271.

EPA Water Sense (2009). Efficiency in the Commercial and Institutional Sector. Consideration for a Water Sense Program.

Fassio, A., Giupponi, C., Hiederer, R. and C. Simota (2005). A decision support tool for simulating the effects of alternative policies affecting water resources: An application at the European scale. *Journal of Hydrology*, **304:** 462-476.

Flug, M., Seitz, L.H. and J.F. Scott (2000). Multi criteria decision analysis applied to Glen Canyon Dam. *Journal of Water Resource Planning and Management*, **126(5):** 270-276.

Giupponi, C., Jakeman, A.J., Karrssenberg, D. and M.P. Hare (2006). Sustainable Management of Water Resources. Massachusetts: Edward Elgar Publishing Limited.

Gupta, A.P., Harboe, R. and M.T. Tabucanon (2000). Fuzzy multiple-criteria decision making for crop area planning in Narmada River Basin. *Agricultural Systems*, **63:** 1-18.

Hamalainen, R.P., Kettunen, E., Marttunen, M. and H. Ehtamo (2001). Evaluating a framework for multi-stakeholder decision support in water resources management. *Group Decision and Negotiation*, **10(4):** 331-353.

Harmancioglu, N.B. and N. Alpaslan (1992). Water quality monitoring network design: A problem of multi-objective decision making. *Water Resources Bulletin*, **28(1):** 179-192.

Juwana, I. (2012). Development of a Water Sustainability Index for West Java, Indonesia. Ph.D. Dissertation.

Jakeman, A.J., Letcher, R.A., Rojanasoonthon, S. and S. Cuddy (2005). Integrating Knowledge for River Basin Management: Progress in Thailand. Canberra: Australia Centre for International Agricultural Research.

Janssen, R., Goosen, H., Verhoeven, M.L., Verhoeven, J.T.A., Omtzgt, A.Q.A. and E. Maltby (2005). Decision support for integrated wetland management. *Environmental Modelling & Software*, **20(2):** 215-229.

Joubert, A., Stewart, T.J. and R. Eberhard (2003). Evaluation of water supply augmentation and water demand management options for the City of Cape Town. *Journal of Multi-Criteria Decision and Analysis*, **12:** 17-25.

Jolson, M.A. and G.L. Rossow (1971). The Delphi process in marketing decision making. *Journal of Marketing Research*, **8:** 443-448.

Khalil, W.A., Shanableh, A., Rigby, P. and S. Kokot (2005). Selection of hydrothermal pre treatment conditions of waste sludge destruction using multi criteria decision-making. *Journal of Environmental Management*, **75:** 53-64.

Kholghi, M. (2001). Multi-criterion decision-making tools for wastewater planning management. *Journal of Agricultural Science and Technology*, **3:** 281-286.

Lai, E., Lundie, S. and N.J. Ashbolt (2008). Review of multi criteria decision aid for integrated sustainability assessment of urban water system. *Urban Water Journal*, **5(4):** 315-327.

Loucks, D.P. and J.S. Gladwell (1999). Sustainability Criteria for Water Resource Systems. Cambridge University Press, Cambridge.

Mahmoud, M.R. and L.A. Garcia (2000). Comparison of different multi criteria evaluation methods for Red Bluff diversion dam. *Environmental Modelling & Software*, **15:** 471-478.

Maia, R. and A.H. Schumann (2007). DSS application to the development of water management strategies in Riberias do Algarve River Basin. *Water Resources Management*, **21:** 897-907.

Makropoulos, C.K., Natsis, K., Liu, S., Mittas, K. and D. Butler (2008). Decision support for sustainable option selection in integrated urban water management. *Environmental Modelling & Software*, **23:** 1448-1460.

Morton, J. (2011). Water management: A benchmark for Canadian office building. *Real Property Association of Canada*.

Mays, L.W. (2006). Water Resources Sustainability. McGraw-Hill Professional.

Morrison, G., Fatoki, O.S., Zinn, E. and D. Jacobsson (2000). Sustainable development indicators for urban water systems: A case study evaluation of King William's town, South Africa, and the applied indicators. *Water SA*, **27(2):** 219-232.

Pietersen, K. (2006). Multiple criteria decision analysis (MCDA): A tool to support sustainable management of groundwater resources in South Africa. *Water SA*, **32(2):** 119-128.

Policy Research Initiative (2007). Canadian Water Sustainability Index. Retrieved 5 July 2007, from http://policyresearch.gc.ca/doclib/SD_PR_CWSI_web_e.pdf

Pieterse-Quirijns, E.J., Blokker, E.J.M., Blom, E. and J.H.G. Vreeburg (2013). Non-residential water demand model validated with extensive measurements and surveys. *Drinking Water Engineering and Science*, **6:** 99-114.

Qin, X.S., Huang, G.H., Chakma, A., Nie, X.H. and Q.G. Lin (2008). A MCDM-based expert system for climate change impact assessment and adaptation planning – A case study for the Georgia Basin, Canada. *Expert Systems with Applications*, **34(3):** 2164-2179.

Raju, K.S., Duckstein, L. and C. Arondel (2000). Multi criterion analysis for sustainable water resources planning: A case study in Spain. *Water Resources Management*, **14:** 435-456.

Rowe, G. and G. Wright (1999). The Delphi technique as a forecasting tool. *International Journal of Forecasting*, **15:** 353-375.

Srdjevic, B., Medeiros, Y.D.P. and A.S. Faria (2004). An objective multi-criteria evaluation of water management scenarios. *Water Resources Management*, **18:** 35-54.

Starkl, M. and N. Brunner (2004). Feasibility versus sustainability in urban water management. *Journal of Environmental Management*, **71(3):** 245-260.

Sullivan, C. (2002). Calculating a Water Poverty Index. *World Development*, **30(7):** 1195-1210.

Tiwari, D.N., Loof, R. and G.N. Paudyal (1999). Environmental economic decision-making in lowland irrigated agriculture using multi-criteria analysis techniques. *Agricultural Systems*, **60:** 99-112.

Tkach, R.J. and S.P. Simonovic (1997). A new approach to multi-criteria decision making in water resources. *Journal of Geographical Information and Decision Analysis*, **1:** 25-43.

Zarghami, M., Abrishamchi, A. and R. Ardakanian (2008). Multi-criteria decision making for integrated urban management. *Water Resources Management*, **22:** 1017-1029.