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WSI_{OC}: The Water Sustainability Index for Office Complexes

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Abstract: Water as a natural resource although covering almost two-third part of the universe, a fifth of the global population is facing acute water scarcity and unavailability of fresh drinking water due to the increasing anthropogenic pressure worldwide. In the Indian sub-continent ~23% of the total population is classified as under the class of absolute water scarcity, and ~54% people are facing high water stress condition. In spite of alluvial aquifers of the Indo-Gangetic plains water table has declined in the northern region of the country, which may lead to a disaster. Water sustainability so should be our priority. This study aims to assess the building water management systems with a relative importance of certain associated attributes. Thus, a water sustainability index (WSI_{OC}) is developed for office complexes (e.g., 26 sampled buildings) of major cities of Uttar Pradesh (U.P.) India, based on the framework of water sustainability attributes comprising water supply, consumption and financial aspects.

The framework attributes were determined using Delphi technique followed by AHP and linear regression method. The $(WSI_{OC})_{absolute}$ value ranges from 31 to 74, which represents the building water management performance as moderate and high, respectively. In order to revive the menacing scenario related to the water efficiency in buildings, a need for priority action is evaluated accordingly. Certainly, the developed WSI_{OC} will act as a guiding tool for the water policy makers, consultants and architects to formulate their ideas for sustainable urban environment.

Key words: Water scarcity, water sustainability index (WSI), office buildings, WSI_{OC}.

Introduction

Nowadays, the water availability to every human on the earth is getting difficult. In spite of the global availability of water and having renewable characteristics, a fifth of the world's population is facing water scarcity (Hering and Ingold, 2012). The United Nations reports reflect that 85% of the world population lives in the driest part of the earth, while ~6 to 8 million people die every year due to water related diseases (KPMG, 2012; UN-DESA, 2013). The international water management institute (IWMI) estimated that ~1.4 billion people of the world population will experience severe water scarcity in the first quarter of the 21st century (Seckler et al., 1999). Several studies show that due to the rapid population growth and climate change ~37 countries of the world are facing high water stress with a score > 80% stress index. The burgeoning industrial development and urbanization are the foremost reasons for the water crisis (Singh et al., 2002; Dixit and Tiwari, 2008). In the changing world, the water management practices should gradually be improved accordingly.

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Water sustainability may be an effective approach to overcome the water scarcity problem for urban areas, and it depends on the water resources and services catering the need of the present, as well as for future, without significant deterioration in the system. Several studies related to the effective water management have been conducted to ensure the availability of fresh drinking water for the future generations (Madungwe and Sakuringwa, 2007; Hoque et al., 2006; Mossalanejad, 2011).

In case of the Indian sub-continent the national water supply is expected to fall down 50% below the demand by 2030, if the fact is not taken and act upon seriously (Shiao et al., 2015). As of April 2015, the usable water resources are estimated as 1123 billion cubic metre (BCM)/yr, against the total availability of 1869 BCM/yr (Suhag, 2016). In last decade, the over extraction of ground water is making the scene catastrophic in the state of Uttar Pradesh (U.P.), India. Therefore, this study advocates the development and implementation of the concepts of urban water sustainability. In spite of alluvial aquifers of the Indo-Gangetic plains water table has declined in the northern region of the country; consequently the state of Uttar Pradesh (U.P.) is facing critical geo-environmental problems, e.g., sanitization of the surface water. The disproportionate extraction of ground water, traditional agricultural mechanisms, absence of institutional monitoring for rainfall, industrial and domestic water demands, with an inadequate water resources management are the causal factors for water stress in this region.

In last decade, the average decline of water table in Allahabad, Gautambudh Nagar (Noida), Ghaziabad, Kanpur, Lucknow, Meerut and Varanasi being 0.62, 0.76, 0.79, 0.65, 0.70, 0.91 and 0.68 m/year respectively (UP-GWD, 2016) shows that these cities are prone to severe water scarcity. In the state of U.P. the annual replenishable ground water resource, net annual ground water availability, and annual ground water draft are as 76.35, 70.18, and 48.78 BCM, respectively. The stage of ground water development was 69% (2004), 72% (2009) and at present is 70%. The number of stressed blocks in the year 2011 were 261, of which the over exploited, critical and semi-critical blocks are listed as 111, 68 and 82 respectively. The area identified for artificial recharge of ground water is ~45,180 km^2, with a quantity of surface water to be recharged is ~14,022 MCM (UP-GWD, 2016).

In urban environment, to achieve the water sustainability in a particular building (Note: in this study, buildings considered are office complex [OC], in which ~100 persons are working), an inclusive knowledge of the current conditions of water resources is necessary along with the demand, type of use, conservation and consumption pattern. Notably, in California and Canada the institutional (office) and commercial buildings consume ~27% (Seneviratne, 2007) and ~19% (REALPAC, 2011) respectively of the total water supply of the city, which is a major part of the supplied drinking water. Whereas, in U.S.A. the office buildings consume almost 9% of the total water consumption of the city (EPA, 2009).

Remarkably, office buildings are not only one of the major contributors to resource exhaustion, they are also the most evident and enduring components of an organization's assurance to implement the sustainability. The indicators are competent to conclude, focus and integrate the complexity of the environment to convenient and significant information (Godfrey and Todd, 2001; Warhurst, 2002). The 'sustainable water management improves tomorrow's cities health' (SWITCH) is an approach to develop scientific, technological and socioeconomic solutions for the effective management of water in the city of the future 2050, begins by defining sustainability indicators (SI) for the urban water system (Feyen et al., 2009).

The development of different WSI's (i.e., water poverty index [WPI], Canadian water sustainability index [CWSI], watershed sustainability index [WSI] and West Java water sustainability index [WJWSI]) have been developed using sustainability dimensions. These indices act as a holistic tool to assess the current status of water related issues, as well as communicating the evaluated information in the community, which in turn will assist to improve the regional water management policy. Particularly, these indices are site-specific that limits their worldwide implementation. Therefore, this study attempts to develop an indicator based WSI_{OC} for city's office complexes that can resolve the issues related to the water scarcity in the state of U.P. The WSI_{OC} would be able to assist decision makers with an evaluation of availability of urban water resources in short and long term perspectives in the U.P. region, and to determine which actions should or should not be taken in an attempt to make society sustainable.

Materials and Methods

Step 1: Development of framework attributes

The consensus among the water experts' opinions has been evaluated to determine the framework attributes using Delphi technique. Based on the experts' consultation, an initial evaluation about water consumption in the office complexes has been performed, and a survey questionnaire was used to determine the components, indicators and sub-indicators. The questionnaire was circulated to the respondents in three rounds including their detailed interviews. The feedback received from the respondents after each round has been analyzed. Therefore, the 67% (2/3 opinions to form a consensus) of the respondents agreed and suggested significant corrections in order to determine the implementation of the parameters, and afterward these modifications were incorporated in the framework (Table 1).

The components, indicators and sub-indicators were finalized with a requirement to list their respective threshold values e.g., minimum and maximum values (Table 1). To determine these respective threshold values a survey questionnaire was prepared to collect the primary data from the office complexes (26 sample buildings, i.e., public and private, from 13 'A' cities of the UP state). These threshold values were used for the next round questionnaire, e.g., round 4, with their respective components, indicators and sub-indicators.

In round 4, the relative importance of the attributes was assessed using a consensus among the opinions of the respondents regarding the pair-wise comparison between the attributes. Afterward, the AHP was used for the analysis of feedback received from the preceding round. The results obtained, are therefore, the relative weights of the components, indicators and sub-indicators.

Step 2: Normalization of the attributes and calculation of modified sub-sub index values for respective indicators.

Clearly, some of the attributes are having different measurement units (Table 1); therefore, here, it is necessary either to convert these units into the similar units for all or make them unitless, which is known as the normalization of the data. The normalization method should take into account the data properties and the objectives of the indicator (JRC-EC, 2005a). Thus, to normalize the primary data and neutralizing the further ambiguities related to the scale effects in Table 1 data, it is necessary to obtain sub-index values for sub-indicators. The sub-sub index values (S_i) of sub-indicators have been calculated as follows.

Case I: When X_{min} is the most preferred value and X_{max} is the least preferred value of the i^{th} sub-indicator.

$$S_i = 1 - [(X_i - X_{\min})/(X_{\max} - X_{\min})] \quad (1)$$

Case II: When X_{max} is the most preferred value and X_{min} is the least preferred value of the i^{th} sub-indicator.

$$S_i = [(X_i - X_{\min})/(X_{\max} - X_{\min})] \quad (2)$$

where X_i is observed value of an i^{th} sub-indicator, in a sample office complex, S_i = sub-sub index value of the i^{th} sub-indicator, X_{min} = observed minimum value of i^{th} sub-indicator, among all the sample office complex, i.e., 26 and X_{max} = observed maximum value of i^{th} sub-indicator, among all the sample office complex, i.e., 26.

Finally, the attribute data have been normalized using Eqs (1) and (2).

Significantly, for index calculation, the inclusion of two major factors (i.e., rainfall and groundwater depletion) is necessary to assess the impact of different climatic and hydrological conditions on the final index values. It has been hypothesized that the effect of these two factors can potentially modify the sub-sub index values. Therefore, the yearly average rainfall for the study area has been calculated using last five years (2009-2013) rainfall data. A coefficient of modification (C_{MR}) representing the rainfall impact on the scale of one, has been derived from the average rainfall data (Table S1). Similarly, the influence of groundwater depletion on the scale of one has been assessed by deriving a coefficient of modification (C_{MGD}) from historically measured groundwater data (Table S2). Thereafter, the integrated coefficient of modification (C_M) has been developed by the multiplication of the coefficients i.e., C_{MR} and C_{MGD}, representing the combined effect of rainfall and groundwater depletion. The C_M has been calculated using Eq. (3).

$$C_M = C_{MR} \times C_{MGD} \quad (3)$$

The S_i values have been multiplied to the C_M to get the modified sub-sub index values (S_{Si}). The respective weight of i^{th} sub-indicator (SIW_i), where, $\Sigma^n_{i=1} SIW_i = 1$, and $0 \le SIW_i \le 1$, calculated from AHP, have been multiplied with S_{Si} to calculate the modified sub-index (S_{im}) value at sub-indicator level using equations (4) to (9), as presented below:

$$S_{si} = 1 - [(X_i - X_{\min})/(X_{\max} - X_{\min})] \times C_M \quad (4)$$

$$S_{im} = SIW_i \times [1 - \{(X_i - X_{\min})/(X_{\max} - X_{\min})\} \times C_M] \quad (5)$$

$$S_{im} = SIW_i \times [(X_i - X_{\min})/(X_{\max} - X_{\min})] \quad (6)$$

$$S_{si} = [(X_i - X_{\min})/(X_{\max} - X_{\min})] \times C_M \quad (7)$$

$$S_{im} = SIW_i \times [\{(X_i - X_{\min})/(X_{\max} - X_{\min})\} \times C_M] \quad (8)$$

$$S_{im} = SIW_i \times [1 - \{(X_i - X_{\min})/(X_{\max} - X_{\min})\}] \quad (9)$$

Table 1: Developed conceptual framework of attributes with respective weights

Sl.	*Components*	*Component weight through AHP CW_i*	*Indicators (Sub components)*	*Sub-indicators*	*Sub-indicator weight through AHP SIW_{ii}*	*Threshold*			*Data availability*
						Unit	*Max*	*Min*	
1.	Water supply	0.378	External source of water supply (Ground water)	-----	0.112	%	100 [b]	40 [a]	Water supply standards and data collected by field surveys.
			Conservation	Adopting water savings techniques	0.164	%	100 [a]	0.0 [b]	Water quantity (rain and waste) converted and reused is collected from field surveys.
				Reuse of waste water	0.469	%	100[a]	0.0 [b]	
				Rainwater harvesting	0.255	%	100[a]	0.0 [b]	
2.	Water use (Consumption)	0.422	Water demand	Toilets	0.061	Lt./cap/day	16.0[b]	10.0[a]	Institutional standards and data collected from field surveys.
				Pantry	0.040	Lt./cap/day	6.0[b]	4.0[a]	
				Air cooling (Desert coolers)	0.131	Lt./cap/day	25.0[b]	10.0[a]	
				A.C. (Cooling towers)	0.243	Lt./ min./Ton	6.5	0.0	
				Maintenance of complex (Floor Cleansing etc.)	0.098	Lt./sq.mt./ day	0.40[b]	0.20[a]	
				Landscape Irrigation	0.263	Lt./sq. mt. area/day	10.0[b]	2.4[a]	
				Water losses (leakage & misuse)	0.164	%	13.0[b]	8.0[a]	

3.	Financial aspect	0.20	Annual budget for water consumption	Price to pay to municipality for supply water (metered usage)	Not to be considered for Sub- Index value	Rs.	Yearly fixed charges from local body. *		No appropriate records are found in office.
				Electricity charges for pumping etc.	Not to be considered for Sub- Index value	Rs.	No separate record is found.		
			Annual maintenance of infrastructure	Motors, supply pipelines and plumbing items etc.	0.430	Rs./sq. mt./ year	250.0^b	110.0^a	Yearly running expenditure data is collected from office records.
				STP/WWTP	0.253	Rs./year	1.0 lac	0.0	
			Action for awareness to the employees	Activities for promotion of awareness for water savings	0.317	Rs./year	1.0^a lac	0.0^b lac	Yearly expenditure data is collected from office records.

Note: a: Preferable, b: not preferable, c: > 0 preferable, < 0 not preferable
*Since most of the sample buildings are using municipal water supply facility partially/fully, the management of the office pays a fixed amount to the municipal body every year. Presently, in U.P., there is no arrangement of having water meters in the premises, to record the water consumption per month/per year. Thus, the municipal body has fixed the per year water charges rate for the buildings as per their rules.

Table 2: Method of calculating modified sub-index (S_{im}) values at sub-indicator level

Sl	*Component*	CW_i	*Sub-indicator*	SIW_i	S_i	$S_{im} = SIW_i \times S_i$
1.	Water supply	0.378	External source of water supply (Ground water)	0.112	eq. (4)*	eq. (5)*
			Adopting water savings techniques	0.164	eq. (2)	eq. (6)
			Reuse of waste water	0.469	eq. (7)*	eq. (8)*
			Rainwater harvesting	0.255	eq. (2)	eq. (6)
2.	Water use (Consumption)	0.422	Toilets	0.061	eq. (1)	eq. (9)
			Pantry	0.040	eq. (1)	eq. ((9)
			Air cooling (Desert coolers)	0.131	eq. (1)	eq. ((9)
			A.C. (Cooling towers)	0.243	eq. (1)	eq. ((9)
			Maintenance of complex (Floor cleaning etc.)	0.098	eq. (1)	eq. ((9)
			Landscape irrigation	0.026	eq. (1)	eq. ((9)
			Water losses (Leakage & misuse)	0.164	eq. (1)	eq. ((9)
3.	Financial aspect	0.141	Motors, supply pipelines & plumbing items etc.	0.430	eq. (1)	eq. (10)
			STP/WWTP	0.253	eq. (1)	eq. ((9)
			Activities for promotion of awareness for water savings	0.317	eq. (1)	eq. ((9)

*The S_i values have been designated as S_{Si} because of the inclusion of the integrated coefficient of modification (C_M) in the calculation, therefore the S_{Si} values have been calculated using Equations (4) and (7). Similarly, the S_{im} values have been obtained using equations (5) and (8) for respective sub-indicators.

Finally, the S_{im} values were calculated using equations [4-9] (Table 2). Consequently, the S_{im} values were calculated for different types of office complexes under consideration (Table S3 to S6).

Step 3: The linear aggregation method (JRC-EC, 2005b) was used to develop the composite or aggregated water sustainability index (WSI_{OC}) for the sample office complexes under consideration using equation (10), as follows.

$$WSI_{OC} = \Sigma^n_{i=1} SI \quad (10)$$

$SI_1 = [\Sigma^n_{i=1} S_{im}] \times CW_{i\_1}$: where, in case of S_{im}, i^{th} sub indicator = 1, 2 … n (n = 4) (Table S7)

$SI_2 = [\Sigma^n_{i=5} S_{im}] \times CW_{i\_2}$: where, in case of S_{im}, i^{th} sub indicator = 5, 6 … n (n = 11) (Table S7)

$SI_3 = [\Sigma^n_{i=12} S_{im}] \times CW_{i\_3}$: where, in case of S_{im}, i^{th} sub indicator = 12, 13 … n (n = 14) (Table S7)

where WSI_{OC} represents the aggregated index; $SI = \sum SI_1 + SI_2 + SI_3$; S_{im} is the modified sub-index value of i^{th} sub-indicator, from 1, 2 … n (n = 14); and CW_i is the weight of the i^{th} component, where $\Sigma^n_{i=1} CW_i = 1$, where i = 1, 2, … n (n = 3), and $0 \leq CW_i \leq 1$.

Step 4: To make the use of WSI_{OC} easier and implementable, it was required to present it in a simpler or absolute form. Therefore, it was necessary to know about the maximum index value $(WSI_{OC})_{max}$, which a sample office complex might achieve, based on taking all the S_i values of all the sub-indicators taken into consideration. The S_i for all the sub-indicators except external source of water supply (ground water) and reuse of waste water was calculated as 1 [maximum value among all the sample office complexes] (Table S3). The S_i for indicators [external source of water supply (ground water) and reuse of waste water] was calculated 0.8 for each of them (Table S3), showing the associated impacts of combined influences of climate and hydrological conditions, which has been discussed under step 2. Hence, the $(WSI_{OC})_{max}$ was computed as 0.96, which is based on the average of maximum values attained by all the three components (Table 3).

Step 5: At last, to determine the 'priority of action' in terms of efforts to make the office complexes more sustainable for water resource development in this region, a classification scheme was developed (Table 5), which is based on the absolute index values $(WSI_{OC})_{absolute}$ (Table 4). Thereafter, the performance of water management system and relative 'priority of action' for sample office complexes were determined (Table 6).

Table 3: Calculation of maximum index value $(WSI_{OC})_{max}$ based on maximum S_i values incurred from Tables S3 to S6

Sl	*Component*	CW_i	*Sub-indicator*	SIW_i	S_i	$S_{im} = SIW_i \times S_i$
1.	Water supply	0.378	External source of water supply (Ground water)	0.112	0.8*	0.0896
			Adopting water savings techniques	0.164	1	0.164
			Reuse of waste water	0.469	0.8*	0.375
			Rainwater harvesting	0.255	1	0.255
			Total	1	-	0.884
			Max. value attained by Component 1	-	-	
2.	Water use (Consumption)	0.422	Toilets	0.061	1	0.061
			Pantry	0.040	1	0.040
			Air cooling (Desert coolers)	0.131	1	0.131
			A.C. (Cooling towers)	0.243	1	0.243
			Maintenance of complex (Floor cleansing etc.)	0.098	1	0.098
			Landscape irrigation	0.263	1	0.263
			Water losses (leakage and misuse)	0.164	1	0.164
			Total	1.00	-	1.00
			Max. value attained by Component 2			
3.	Financial aspect	0.200	Motors, supply pipelines and plumbing items etc.	0.430	1	0.430
			STP/WWTP	0.253	1	0.253
			Activities for promotion of awareness for water saving	0.317	1	0.317
			Total	1.00	-	1.00
			Max. value attained by Component 3	-	-	0.2 × 1 = 0.2
			Grand Total of max. values of C1, C2, C3	-	-	0.334 + 0.422 + 0.2 = 0956 ≅ 0.96

Table 4: The classification scheme developed to determine the performance of water management system

Absolute index value interval	*Performance of water management system*	*Priority of Action*	*No. of sample buildings*
0–25	Poor	Very high	Nil
25–50	Moderate	High	18
50–75	High	Moderate	08
75–100	Very high	Low	Nil

Results and Discussion

1. External source of water supply (through bore well)
It is observed that all the sample office complex authorities are extracting ground water from 40%-100% to meet out their daily water demands, as either the municipal water supply facility is not available at some of the office complexes or the quality/quantity of municipal water is not as per the required standards (Table S3, column no. 4). Clearly, the majority of sample office complexes are extracting high amount of ground water to meet their daily water requirements; similarly many other different types of complexes are practicing the same. This community action acts as the foremost factor for decreased water table, which results in severe water scarcity in this area.

2. Reuse of waste water
In this study, it has been found that thirteen (13) out of twenty six (26) samples are not reusing the waste water (Table S3, column no. 12), and draining it into public sewer. Moreover, only six and seven sample office complexes are reusing ~25-50% and 50-100% of the waste water in their secondary uses, respectively. The office management authorities are aware about

Table 5: Performance and recommendations based on absolute index value of all the sample office complexes (U.P., India)

Sl.	*City/ District*	*Type of building*	*Aggregated index value (out of value 1) (WSI_{OC})*	*$(WSI_{OC})_{absolute}$ with respect to $(WSI_{OC})_{max}$*	*Absolute index value*	*Performance of water management system*	*Priority of action*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
1	Agra	Pubic	0.3187	33.19	33	Moderate	High
		Private	0.4614	48.06	48	Moderate	High
2	Aligarh	Pubic	0.3637	37.88	38	Moderate	High
		Private	0.3100	32.29	32	Moderate	High
3	Allahabad	Pubic	0.4029	41.96	42	Moderate	High
		Private	0.4903	51.07	51	High	Moderate
4	Bareilly	Pubic	0.3156	32.88	33	Moderate	High
		Private	0.3397	35.39	35	Moderate	High
5	G.B.Nagar (Noida)	Pubic	0.5341	55.64	56	High	Moderate
		Private	0.6981	72.72	73	High	Moderate
6	Ghaziabad	Pubic	0.5438	56.65	57	High	Moderate
		Private	0.5403	56.28	56	High	Moderate
7	Gorakhpur	Pubic	0.3513	36.59	37	Moderate	High
		Private	0.3497	36.42	36	Moderate	High
8	Jhansi	Pubic	0.3858	40.19	40	Moderate	High
		Private	0.4315	44.95	45	Moderate	High
9	Kanpur	Pubic	0.3436	35.79	36	Moderate	High
		Private	0.7056	73.50	***74***	High	Moderate
10	Lucknow	Pubic	0.5103	53.16	53	High	Moderate
		Private	0.5722	59.60	60	High	Moderate
11	Meerut	Pubic	0.3684	38.38	39	Moderate	High
		Private	0.3980	41.46	41	Moderate	High
12	Moradabad	Pubic	0.3411	35.53	36	Moderate	High
		Private	0.3474	36.19	36	Moderate	High
13	Varanasi	Pubic	0.2924	31.19	***31***	Moderate	High
		Private	0.4409	45.93	46	Moderate	High

Note: Max. Index Value $(WSI_{OC})_{max}$ = 0.96, Refer Table 3

the importance of water consumption and its reuses; therefore these six office complexes have been retrofitted with limitations to reuse the waste water. The later seven office complexes are situated in national capital region (NCR), Kanpur and Lucknow. These have fully/partially adopted the mandates guided by the sustainable building rating systems i.e., LEED, GRIHA etc. Furthermore, it has been found in the selected samples that the institutions with having significant budgetary provisions and awareness for environmental security are coming forward to follow the water sustainability guidelines. Eight sample office complexes have not adopted any water saving techniques i.e., water saving fixtures, fittings etc. whereas, only eleven and seven sample office complexes have adopted ~20-50% and 50-100% for water savings techniques, respectively.

3. Rain water harvesting (RWH)

Out of twenty six sample office complexes, seven (five public and two private) are not conserving rain water and not adopting RWH systems (Table S4, column no. 8), which shows the ignorance of the government water resource management policy mandates. While, ten and nine sample office complexes (situated in NCR, Kanpur and Lucknow) are practicing the RWH from 35-50%

and 50-100%, respectively, for their secondary uses. The implementation of RWH is strongly recommended.

4. Toilet, Pantry, Air cooling (Desert cooler), and Maintenance of complex (Floor Cleansing etc.)

It has been found that the private office complexes situated in NCR, Kanpur and Lucknow regions are consuming less water as compared to other cities under consideration.

5. A.C. (Cooling towers)

The office complexes are having air cooling and / or window unit cooling facilities except eight office complexes of NCR, Kanpur and Lucknow, which are having central air conditioning facilities in their campuses.

6. Landscape irrigation

The water consumption in landscape irrigation (watering green areas) activities in public office complexes is quite less, which is almost half of the consumption of water used for the same activity in private office complexes. Notably, in public office complexes proper maintenance has not been done for landscapes and green areas, as compared to the private office complexes of NCR, Kanpur and Lucknow. Even the water consumption per unit green area is comparatively low as compared to the existing literatures.

7. Water Losses (Leakage and misuse)

The water losses are found almost within considerable limits in the sample office complexes as compared to the value ranging from 7.5-25% with 15% being the most common value for commercial buildings (Beecher, 2002). Private sector buildings of NCR, Kanpur and Lucknow are having minimum water losses due to their better maintenance and measures as compared to other sample office complexes of different cities.

8. Annual maintenance (Motors, supply pipelines, plumbing items etc.)

The annual maintenance cost including water supply motors, lines, drainage disposal system etc. in all the twenty six sample office complexes ranges from 110–250 Rs./m^2/year of the built up area. The public sector office complexes are spending less; therefore no proper maintenance is found in these buildings in comparison to private complexes.

9. Annual maintenance for sewage treatment plant (STP) / waste water treatment plant (WWTP)

Only seven sample office complexes of NCR, Kanpur and Lucknow are having sewage/waste water treatment facilities among the office complexes under consideration. Therefore, all the discharge (water/ sewage) is drained out in the cities' common sewer lines. The amount incurred in the operation and maintenance in this activity, as informed by the person concerned (supervisor) is an approximate value, since no separate accounting has been found in records for this purpose.

10. Promotional activities for awareness generation for water saving

Significantly, all the sample office complexes, except Aligarh (private building), Bareli (public building), Meerut (private and public) (Table S6, column no. 16), management has an annual budget to hold programmes/ seminars to make aware to the users for water savings in the premises. Though, the amount allocated by them is too less for the promotional activities, it is satisfactory that the system is quite aware of the alarming condition of water scarcity/stress issues, and thus initiated a step toward water savings by make the users aware of the fact.

It is obvious that if any of the sample office complex adopts and follows all the norms and guidelines of efficient water management than the $(WSI_{OC})_{max}$ value of 0.96 possibly can be achieved (Table 3). It is because the S_{Si} for sub-indicators i.e., external source of water supply and reuse of waste water is 0.8, as it is derived by multiplying S_i value 1 (a building consuming only 40% of the ground water through bore well and reusing 100% waste water) by the C_M (Table 3) value 0.8. The value 0.96 can be assessed as the best or ideal condition among the sample building considered in this study. Conversely, if any sample office complex does not adopt the sustainability criteria and fails to follow the normal water saving practices, then the minimum index value would be achieved as 0.0, which can be assessed as the worst condition regarding the water sustainability in that very building.

To assess the overall status of water management system of the samples among themselves, it would be easier to use the $[(WSI_{OC})_{absolute}]$ values derived from equation (11), as mentioned below.

$$[(WSI_{OC})_{absolute}]^{avg} = \frac{(WSI_{OC})_{absolute}}{\text{number of total sample complexes}} = \frac{1162.89}{26} = 44.73 \qquad (11)$$

Sample buildings having $(WSI_{OC})_{absolute}$ below $[(WSI_{OC})_{absolute}]^{\mathbf{avg.}} = 15$

~58% of the total samples

Sample buildings having $(WSI_{OC})_{absolute}$ above $[(WSI_{OC})_{absolute}]^{\mathbf{avg.}} = 11$

~42% of the total samples

It is therefore concluded that ~58% buildings of the total sampled office complexes are not showing efficient water management practices that is not satisfactory, while remaining ~42% buildings of the total samples showing comparatively better water management practices.

There is no office complex found in the category of poor performance, eighteen office complexes are found in the category of moderate performance and need high priority of action, while only eight office complexes are found in the category of high performance and need moderate priority of action. Notably, office complexes with having possibility of low priority action are absent. Remarkably, the signs of the perfect water sustainability practices are scarce in the area under consideration. This study suggests that the incorporation of the water sustainability measures can improve the performance of the sub-indicators leading to the reduced water stress in the area.

Conclusion

Interestingly, in spite of the limited number of sample office complexes, this study provides a synoptic and explicit measure of the urban water consumption pattern in the state of U.P. India. The $(WSI_{OC})_{absolute}$ values show that the office complexes taken into consideration are not adopting appropriate water management practices. To achieve urban sustainability, the office complexes of each sector, e.g., residential, industrial, commercial etc. should be designed and constructed according to the 'Green Building Rating Systems', which lead to increased water use efficiency at a larger scale. Additionally, the water sustainability mandates should not be limited up to the urban environment, but also implementable for the agriculture sector as it demands plenty of water. The proposed WSI_{OC} lays the scientific and technical foundation for the research related to the urban water management systems in arid and semi arid urban zones. Nonetheless, a few limitations still exist in the proposed WSI_{OC}, but inclusion of diverse parameters with thorough baseline survey at a time is arduous.

The developed WSI_{OC} works as a composite index, and would facilitate better results for other geographical location provided if the selection of the attribute is re-scrutinized. Significantly, the consensus based selection of the framework attributes and application of AHP, signify the robustness of the proposed WSI_{OC}. It is suggested that a mechanism for the consistent monitoring of actual water consumption in the office complexes should be implemented, and the threshold values of water consumption in these complexes should be maintained accurately, to further establish the more simplified and explanatory index. It is suggested that the WSI_{OC} should be developed for large scale office complexes of different types in different geographical settings to establish its universal aptness.

In this study, the weights of the attributes are calculated through AHP, followed by arithmetic (linear) aggregation method to develop the index. Since in the linear aggregation method, perfect substitutability and compensability occurs, among all sub-indices. In future, the weighting methods other than AHP, i.e., MAUT, ELECTRE, PROMETHEE, and DRSA can be used in combination with geometric aggregation method having limited substitutability and compensability. A comparative study can be performed to assess the performance of different combinations of the aggregation methods with MCDMs for better acceptability of the WSI_{OC} results.

This study suggests that it should be mandatory to design and construct the large scale office complexes as per the guidelines of the sustainable building rating systems i.e., LEED, GRIHA, etc., to make office complexes more water efficient. Some incentives should be given to the managements and the staff persons, for adopting sustainable building rating systems and contributing actively for water savings in the complex respectively, so that the activities for water savings in the community can be promoted at a large scale. It is recommended that the proper allocation of the funds either form government or private organizations should be made available for conducting water saving programmes, seminars, workshops and placing relevant information i.e., slogans, hoarding etc. at different places in their campus for making the public aware and conscious to conserve water.

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Supplementary Tables

Table S1: Calculation of coefficient of modification for rainfall impact (C_{MR})

Range of rainfall (mm)	*Points scored*	*Coefficient of modification for rainfall impact (C_{MR})*
450-600	5	.33
601-750	4	.27
751-900	3	.20
901-1050	2	.13
1051-1200	1	.07
Total	15	1.00

Table S2: Calculation of coefficient of modification for ground water depletion (C_{MGD})

Range of yearly ground water depletion (mt.)	*Points scored*	*Coefficient of modification for ground water depletion (C_{MGD})*
.50-.60	5	.33
.61-.70	4	.27
.71-.80	3	.20
-81-.90	2	.13
.91-1.0	1	.07
Total	15	1.00

Table S3: Sub index value for indicators (External source of water supply (ground water) and reuse of waste water)

			External source of water supply (ground water)								*Reuse of waste water*			
Sl.	*City/ District*	*Type of office complex*	*X_i (%)*	*(S_i)*	*Ground water depletion (mt./yr)*	*Av. rainfall (Last 5 years) (mm)*	*(C_M)*	*(S_{si})*	*SIW_i*	*S_{im}*	*X_i (%)*	*(S_i)*	*SIW_i*	*S_{im}*
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
1	Agra	Pubic	100	0	0.5	502	1	0	0.112	0	0	0	0.469	0
		Private	100	0	0.5	502	1	0	0.112	0	0	0	0.469	0
2	Aligarh	Pubic	100	0	0.5	590	1	0	0.112	0	0	0	0.469	0
		Private	100	0	0.5	590	1	0	0.112	0	0	0	0.469	0
3	Allahabad	Pubic	100	0	0.62	878	0.7	0	0.112	0	0	0	0.469	0
		Private	75	0.42	0.62	878	0.7	0.294	0.112	0.032	25	0.25	0.469	0.082
4	Bareilly	Pubic	100	0	0.6	1085	0.6	0	0.112	0	0	0	0.469	0
		Private	100	0	0.6	1085	0.6	0	0.112	0	0	0	0.469	0
5	G.B.Nagar (Noida)	Pubic	50	0.833	0.76	581	0.8	0.666	0.112	0.074	60	0.6	0.469	0.225
		Private	50	0.833	0.76	581	0.8	0.666	0.112	0.08	100	1	0.469	0.375
6	Ghaziabad	Pubic	50	0.833	0.79	456	0.8	0.666	0.112	0.074	60	0.6	0.469	0.225
		Private	50	0.833	0.79	456	0.8	0.666	0.112	0.074	60	0.6	0.469	0.225
7	Gorakhpur	Pubic	70	0.5	0.7	1166	0.5	0.25	0.112	0.028	0	0	0.469	0
		Private	60	0.67	0.7	1166	0.5	0.335	0.112	0.037	0	0	0.469	0
8	Jhansi	Pubic	70	0.5	0.85	779	0.5	0.25	0.112	0.028	30	0.3	0.469	0.07
		Private	50	0.833	0.85	779	0.5	0.417	0.112	0.046	30	0.5	0.469	0.117
9	Kanpur	Pubic	100	0	0.65	654	0.8	0	0.112	0	0	0	0.469	0
		Private	40	1	0.65	654	0.8	0.8	0.112	0.089	100	1	0.469	0.375
10	Lucknow	Pubic	50	0.833	0.7	810	0.7	0.583	0.112	0.065	80	0.8	0.469	0.263
		Private	50	0.833	0.7	810	0.7	0.583	0.112	0.065	60	0.6	0.469	0.197
11	Meerut	Pubic	100	0	0.91	560	0.6	0	0.112	0	20	0.2	0.469	0.056
		Private	100	0	0.91	560	0.6	0	0.112	0	30	0.3	0.469	0.084
12	Moradabad	Pubic	100	0	0.7	1051	0.5	0	0.112	0	0	0	0.469	0
		Private	100	0	0.7	1051	0.5	0	0.112	0	0	0	0.469	0
13	Varanasi	Pubic	100	0	0.68	804	0.7	0	0.112	0	0	0	0.469	0
		Private	100	0	0.68	804	0.7	0	0.112	0	50	0.5	0.469	0.164

Table S4: Sub index values for indicators (Water saving technique, rain wt. harvested, toilet and pantry)

Sl	City/ District	Type of office complex	Water saving technique X_i (%)	(S_i)	SIW_i	S_{im}	Qty. of rain wt. harvested X_i (%)	(S_i)	SIW_i	S_{im}	Consumption for toilet X_i (%)	(S_i)	SIW_i	S_{im}	Consumption for pantry X_i (%)	(S_i)	SIW_i	S_{im}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1	Agra	Public	0	0	0.164	0	0	0	0.255	0	13	0.5	0.061	0.031	4	1	0.04	0.04
		Private	20	0.2	0.164	0.032	100	1	0.255	0.255	11	0.83	0.061	0.051	6	0	0.04	0
2	Aligarh	Public	0	0	0.164	0	50	0.5	0.255	0.127	12	0.67	0.061	0.041	4	1	0.04	0.04
		Private	0	0	0.164	0	0	0	0.255	0	14	0.33	0.061	0.02	5	0.5	0.04	0.02
3	Allahabad	Public	25	0.25	0.164	0.041	40	0.4	0.255	0.102	12	0.67	0.061	0.041	4	1	0.04	0.04
		Private	50	0.5	0.164	0.082	100	1	0.255	0.255	13	0.5	0.061	0.031	6	0	0.04	0
4	Bareilly	Public	0	0	0.164	0	0	0	0.255	0	11	0.83	0.061	0.051	5	0.5	0.04	0.02
		Private	0	0	0.164	0	25	0.25	0.255	0.064	12	0.67	0.061	0.041	5	0.5	0.04	0.02
5	G.B.Nagar (Noida)	Public	100	1	0.164	0.164	100	1	0.255	0.255	11	0.83	0.061	0.051	4	1	0.04	0.04
		Private	100	1	0.164	0.164	100	1	0.255	0.255	10	1	0.061	0.061	6	0	0.04	0
6	Ghaziabad	Public	60	0.6	0.164	0.098	100	1	0.255	0.255	12	0.67	0.061	0.041	5	0.5	0.04	0.02
		Private	100	1	0.164	0.164	100	1	0.255	0.255	14	0.33	0.061	0.02	6	0	0.04	0
7	Gorakhpur	Public	0	0	0.164	0	40	0.4	0.255	0.102	12	0.67	0.061	0.041	4	1	0.04	0.04
		Private	0	0	0.164	0	50	0.5	0.255	0.128	14	0.33	0.061	0.02	5	0.5	0.04	0.02
8	Jhansi	Public	50	0.5	0.164	0.082	50	0.5	0.255	0.128	12	0.67	0.061	0.041	4	1	0.04	0.04
		Private	30	0.3	0.164	0.049	80	0.8	0.255	0.204	13	0.5	0.061	0.031	6	0	0.04	0
9	Kanpur	Public	25	0.25	0.164	0.041	35	0.35	0.255	0.089	11	0.83	0.061	0.051	5	0.5	0.04	0.02
		Private	100	1	0.164	0.164	100	1	0.255	0.255	10	1	0.061	0.061	5	0.5	0.04	0.02
10	Lucknow	Public	100	1	0.164	0.164	100	1	0.255	0.255	13	0.5	0.061	0.031	5	0.5	0.04	0.02
		Private	100	1	0.164	0.164	100	1	0.255	0.255	16	1	0.061	0.061	5	0.5	0.04	0.02
11	Meerut	Public	40	0.4	0.164	0.065	0	0	0.255	0	12	0.67	0.061	0.041	5	0.5	0.04	0.02
		Private	50	0.5	0.164	0.082	0	0	0.255	0	14	0.33	0.061	0.02	4	1	0.04	0.04
12	Moradabad	Public	40	0.4	0.164	0.065	0	0	0.255	0	11	0.83	0.061	0.051	4	1	0.04	0.04
		Private	50	0.5	0.164	0.082	40	0.4	0.255	0.102	15	0.17	0.061	0.01	6	0	0.04	0
13	Varanasi	Public	0	0	0.164	0	0	0	0.255	0	10	1	0.061	0.061	4	1	0.04	0.04
		Private	50	0.5	0.164	0.082	50	0.5	0.255	0.128	12	0.67	0.061	0.041	5	0.5	0.04	0.02

Table S5: Sub index value for indicators (Desert cooling, air conditioning, and maintenance of complex and landscape irrigation

			Desert cooling				Air conditioning				Maintenance of complex				Landscape irrigation			
Sl.	*City/ District*	*Type of off. Com.*	X_i (%)	(S_i)	SIW_i	S_{im}	X_i (%)	(S_i)	SIW_i	S_{im}	X_i (%)	(S_i)	SIW_i	S_{im}	X_i (%)	(S_i)	SIW_i	S_{im}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1	Agra	Pubic	25	0	0.131	0	0	1	0.243	0.243	0.2	1	0.098	0.098	3.5	0.86	0.263	0.226
		Private	22	0.5	0.131	0.065	0	1	0.243	0.243	0.3	0.5	0.098	0.049	6	0.53	0.263	0.139
2	Aligarh	Pubic	25	0	0.131	0	0	1	0.243	0.243	0.2	1	0.098	0.098	2.4	1	0.263	0.263
		Private	20	0.83	0.131	0.108	0	1	0.243	0.243	0.3	0.5	0.098	0.049	5	0.66	0.263	0.174
3	Allahabad	Pubic	24	0.17	0.131	0.022	0	1	0.243	0.243	0.2	1	0.098	0.098	2.5	0.99	0.263	0.260
		Private	21	0.67	0.131	0.087	0	1	0.243	0.243	0.35	0.25	0.098	0.025	6	0.53	0.263	0.139
4	Bareilly	Pubic	23	0.33	0.131	0.043	0	1	0.243	0.243	0.25	0.75	0.098	0.074	3	0.92	0.263	0.242
		Private	21	0.67	0.131	0.087	0	1	0.243	0.243	0.3	0.5	0.098	0.049	7	0.4	0.263	0.105
5	G.B.Nagar (Noida)	Pubic	25	0	0.131	0	6.25	0.04	0.243	0.01	0.35	0.25	0.098	0.025	4	0.79	0.263	0.208
		Private	22	0.5	0.131	0.065	4.5	0.31	0.243	0.075	0.4	0	0.098	0	8	0.26	0.263	0.068
6	Ghaziabad	Pubic	25	0	0.131	0	6.5	0	0.243	0	0.3	0.5	0.098	0.049	4	0.79	0.263	0.208
		Private	23	0.33	0.131	0.043	5.5	0.154	0.243	0.037	0.35	0.25	0.098	0.025	8	0.26	0.263	0.068
7	Gorakhpur	Pubic	22	0.5	0.131	0.065	0	1	0.243	0.243	0.3	0.5	0.098	0.049	5	0.66	0.263	0.174
		Private	20	0.83	0.131	0.108	0	1	0.243	0.243	0.4	0	0.098	0	7	0.4	0.263	0.105
8	Jhansi	Pubic	25	0	0.131	0	0	1	0.243	0.243	0.25	0.75	0.098	0.074	7	0.4	0.263	0.105
		Private	22	0.5	0.131	0.065	0	1	0.243	0.243	0.3	0.5	0.098	0.049	10	0	0.263	0.000
9	Kanpur	Pubic	24	0.17	0.131	0.022	6	0.077	0.243	0.019	0.28	0.6	0.098	0.059	3	0.92	0.263	0.242
		Private	21	0.67	0.131	0.087	5.5	0.015	0.243	0.004	0.31	0.45	0.098	0.044	8	0.26	0.263	0.068
10	Lucknow	Pubic	24	0.17	0.131	0.022	6.25	0.04	0.243	0.01	0.35	0.25	0.098	0.025	6	0.53	0.263	0.139
		Private	21	0.67	0.131	0.087	5.88	0.095	0.243	0.023	0.31	0.45	0.098	0.044	10	0	0.263	0.000
11	Meerut	Pubic	22	0.5	0.131	0.065	0	1	0.243	0.243	0.2	1	0.098	0.098	3.6	0.84	0.263	0.221
		Private	19	1	0.131	0.131	0	1	0.243	0.243	0.3	0.5	0.098	0.049	6	0.53	0.263	0.139
12	Moradabad	Pubic	24	0.17	0.131	0.022	0	1	0.243	0.243	0.25	0.75	0.098	0.074	5	0.66	0.263	0.174
		Private	21	0.67	0.131	0.087	0	1	0.243	0.243	0.35	0.25	0.098	0.025	7	0.4	0.263	0.105
13	Varanasi	Pubic	25	0	0.131	0	0	1	0.243	0.243	0.3	0.5	0.098	0.049	4	0.79	0.263	0.208
		Private	21	0.67	0.131	0.087	0	1	0.243	0.243	0.35	0.25	0.098	0.025	6	0.53	0.263	0.139

Table S6: Sub index value for indicators [Water losses, annual maintenance (motor, supp.), annual maintenance (STP/WWTP) and activities for promotion of awareness for water savings]

			Water Losses				*Annual Maintenance (Motor, Supp.)*				*Annual Maintenance (STP/WWTP)*				*Activities for promotion of awareness for water savings*			
Sl	*City/ District*	*Type of office complex*	X_i (%)	(S_i)	SIW_i	S_{im}	X_i (Rs/sqmt/yr)	(S_i)	SIW_i	S_{im}	X_i (Rs/sqmt/yr)	(S_i)	SIW_i	S_{im}	X_i (Rs/sqmt/yr)	(S_i)	SIW_i	S_{im}
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**
1	Agra	Pubic	11	0.4	0.164	0.065	120	0.07	0.43	0.030	0	0	0.253	0	25,000	0.25	0.317	0.079
		Private	9	0.8	0.164	0.131	150	0.29	0.43	0.124	0	0	0.253	0	65,000	0.65	0.317	0.206
2	Aligarh	Pubic	12	0.2	0.164	0.032	110	0	0.43	0	0	0	0.253	0	20,000	0.2	0.317	0.063
		Private	10	0.6	0.164	0.098	125	0.107	0.43	0.046	0	0	0.253	0	0	0	0.317	0
3	Allahabad	Pubic	12	0.2	0.164	0.032	130	0.143	0.43	0.061	0	0	0.253	0	40,000	0.4	0.317	0.126
		Private	10	0.6	0.164	0.098	160	0.36	0.43	0.154	0	0	0.253	0	40,000	0.4	0.317	0.126
4	Bareilly	Pubic	12	0.2	0.164	0.032	140	0.21	0.43	0.090	0	0	0.253	0	0	0	0.317	0
		Private	10	0.6	0.164	0.098	160	0.36	0.43	0.154	0	0	0.253	0	20,000	0.2	0.317	0.063
5	G.B.Nagar (Noida)	Pubic	13	0	0.164	0	175	0.46	0.43	0.197	1,00,000	1	0.253	0.253	50,000	0.5	0.317	0.158
		Private	8	1	0.164	0.164	225	0.82	0.43	0.352	1,00,000	1	0.253	0.253	1,00,000	1	0.317	0.317
6	Ghaziabad	Pubic	11	0.4	0.164	0.065	170	0.43	0.43	0.184	1,00,000	1	0.253	0.253	75,000	0.75	0.317	0.237
		Private	9	0.8	0.164	0.131	180	0.5	0.43	0.215	1,00,000	1	0.253	0.253	60,000	0.6	0.317	0.190
7	Gorakhpur	Pubic	13	0	0.164	0	150	0.29	0.43	0.124	0	0	0.253	0	30,000	0.3	0.317	0.095
		Private	11	0.4	0.164	0.065	170	0.43	0.43	0.184	0	0	0.253	0	20,000	0.2	0.317	0.063
8	Jhansi	Pubic	12	0.2	0.164	0.032	155	0.32	0.43	0.137	0	0	0.253	0	25,000	0.25	0.317	0.079
		Private	10	0.6	0.164	0.098	170	0.43	0.43	0.184	0	0	0.253	0	50,000	0.5	0.317	0.158
9	Kanpur	Pubic	9	0.8	0.164	0.131	175	0.46	0.43	0.197	0	0	0.253	0	40,000	0.4	0.317	0.126
		Private	8	1	0.164	0.164	220	0.79	0.43	0.339	1,00,000	1	0.253	0.253	1,00,000	1	0.317	0.317
10	Lucknow	Pubic	12	0.2	0.164	0.032	185	0.54	0.43	0.232	75,000	0.75	0.253	0.19	40,000	0.4	0.317	0.126
		Private	11	0.4	0.164	0.065	250	1	0.43	0.43	1,00,000	1	0.253	0.253	80,000	0.8	0.317	0.253
11	Meerut	Pubic	12	0.2	0.164	0.032	140	0.21	0.43	0.090	0	0	0.253	0	0	0	0.317	0
		Private	10	0.6	0.164	0.098	160	0.36	0.43	0.154	0	0	0.253	0	0	0	0.317	0
12	Moradabad	Pubic	11	0.4	0.164	0.065	135	0.176	0.43	0.075	0	0	0.253	0	30,000	0.3	0.317	0.095
		Private	10	0.6	0.164	0.098	150	0.29	0.43	0.124	0	0	0.253	0	20,000	0.2	0.317	0.063
13	Varanasi	Pubic	12	0.2	0.164	0.032	125	0.107	0.43	0.046	0	0	0.253	0	25,000	0.25	0.317	0.079
		Private	11	0.4	0.164	0.065	135	0.176	0.43	0.075	0	0	0.253	0	35,000	0.35	0.317	0.111

Table S7: Calculation of final water sustainability index (WSI_{oc}) of sample office complexes of U.P. India

Sl.	*City/District*	*Type of office complex*	*Representation of the columns is given below*																						
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
1	Agra	Public	0.000	0.000	0.000	0.000	0.000	0.378	0.000	0.031	0.040	0.000	0.243	0.098	0.226	0.066	0.704	0.422	0.297	0.030	0.000	0.079	0.109	0.200	0.022	0.3189
		Private	0.000	0.033	0.000	0.255	0.288	0.378	0.109	0.051	0.000	0.066	0.243	0.049	0.139	0.131	0.679	0.422	0.395	0.125	0.000	0.206	0.331	0.200	0.066	0.5702
2	Aligarh	Public	0.000	0.000	0.000	0.128	0.128	0.378	0.048	0.041	0.040	0.000	0.243	0.098	0.263	0.033	0.718	0.422	0.351	0.000	0.000	0.063	0.063	0.200	0.013	0.4119
		Private	0.000	0.000	0.000	0.000	0.000	0.378	0.000	0.020	0.020	0.109	0.243	0.049	0.174	0.098	0.713	0.422	0.301	0.046	0.000	0.000	0.046	0.200	0.009	0.3100
3	Allahabad	Public.	0.000	0.041	0.000	0.102	0.143	0.378	0.054	0.041	0.040	0.022	0.243	0.098	0.260	0.033	0.737	0.422	0.365	0.061	0.000	0.127	0.188	0.200	0.038	0.4570
		Private	0.033	0.082	0.082	0.255	0.452	0.378	0.171	0.031	0.000	0.088	0.243	0.025	0.139	0.098	0.624	0.422	0.434	0.155	0.000	0.127	0.282	0.200	0.056	0.6612
4	Bareilly	Public	0.000	0.000	0.000	0.000	0.000	0.378	0.000	0.051	0.020	0.043	0.243	0.074	0.242	0.033	0.705	0.422	0.298	0.090	0.000	0.000	0.090	0.200	0.018	0.3156
		Private	0.000	0.000	0.000	0.064	0.064	0.378	0.024	0.041	0.020	0.088	0.243	0.049	0.105	0.098	0.644	0.422	0.296	0.155	0.000	0.063	0.218	0.200	0.044	0.3639
5	G.B.Nagar (Noida)	Public	0.075	0.164	0.225	0.255	0.719	0.378	0.272	0.051	0.040	0.000	0.010	0.025	0.208	0.000	0.333	0.422	0.412	0.198	0.253	0.159	0.609	0.200	0.122	0.8059
		Private	0.080	0.164	0.375	0.255	0.874	0.378	0.330	0.061	0.000	0.066	0.075	0.000	0.068	0.164	0.434	0.422	0.514	0.353	0.253	0.317	0.923	0.200	0.185	1.0286
6	Ghaziabad	Public	0.075	0.099	0.225	0.255	0.653	0.378	0.247	0.041	0.020	0.000	0.000	0.049	0.208	0.066	0.383	0.422	0.409	0.185	0.253	0.238	0.676	0.200	0.135	0.7907
		Private	0.075	0.164	0.225	0.255	0.719	0.378	0.272	0.020	0.000	0.043	0.037	0.025	0.068	0.131	0.324	0.422	0.409	0.215	0.253	0.190	0.658	0.200	0.132	0.8121
7	Gorakhpur	Public	0.028	0.000	0.000	0.102	0.130	0.378	0.049	0.041	0.040	0.066	0.243	0.049	0.174	0.000	0.612	0.422	0.307	0.125	0.000	0.095	0.220	0.200	0.044	0.4005
		Private	0.038	0.000	0.000	0.128	0.166	0.378	0.063	0.020	0.020	0.109	0.243	0.000	0.105	0.066	0.563	0.422	0.300	0.185	0.000	0.063	0.248	0.200	0.050	0.4122
8	Jhansi	Public.	0.028	0.082	0.070	0.128	0.308	0.378	0.116	0.041	0.040	0.000	0.243	0.074	0.105	0.033	0.535	0.422	0.342	0.138	0.000	0.079	0.217	0.200	0.043	0.5023
		Private	0.047	0.049	0.117	0.204	0.417	0.378	0.158	0.031	0.000	0.066	0.243	0.049	0.000	0.098	0.486	0.422	0.363	0.185	0.000	0.159	0.343	0.200	0.069	0.5891
9	Kanpur	Public	0.000	0.041	0.000	0.089	0.130	0.378	0.049	0.051	0.020	0.022	0.019	0.059	0.242	0.131	0.544	0.422	0.279	0.198	0.000	0.127	0.325	0.200	0.065	0.3928
		Private	0.090	0.164	0.375	0.255	0.884	0.378	0.334	0.061	0.020	0.088	0.004	0.044	0.068	0.164	0.449	0.422	0.524	0.340	0.253	0.317	0.910	0.200	0.182	1.0398
10	Lucknow	Public	0.065	0.164	0.263	0.255	0.748	0.378	0.283	0.031	0.020	0.022	0.010	0.025	0.139	0.033	0.279	0.422	0.401	0.232	0.190	0.127	0.549	0.200	0.110	0.7929
		Private	0.065	0.164	0.197	0.255	0.682	0.378	0.258	0.061	0.020	0.088	0.023	0.044	0.000	0.066	0.301	0.422	0.385	0.430	0.253	0.254	0.937	0.200	0.187	0.8298
11	Meerut	Public.	0.000	0.066	0.056	0.000	0.122	0.378	0.046	0.041	0.020	0.066	0.243	0.098	0.221	0.033	0.721	0.422	0.350	0.090	0.000	0.000	0.090	0.200	0.018	0.4144
		Private	0.000	0.082	0.084	0.000	0.166	0.378	0.063	0.020	0.040	0.131	0.243	0.049	0.139	0.098	0.721	0.422	0.367	0.155	0.000	0.000	0.155	0.200	0.031	0.4608
12	Moradabad	Public	0.000	0.066	0.000	0.000	0.066	0.378	0.025	0.051	0.040	0.022	0.243	0.074	0.174	0.066	0.669	0.422	0.307	0.076	0.000	0.095	0.171	0.200	0.034	0.3660
		Private	0.000	0.082	0.000	0.102	0.184	0.378	0.070	0.010	0.000	0.088	0.243	0.025	0.105	0.098	0.569	0.422	0.310	0.125	0.000	0.063	0.188	0.200	0.038	0.4171
13	Varanasi	Public	0.000	0.000	0.000	0.000	0.000	0.378	0.000	0.061	0.040	0.000	0.243	0.049	0.208	0.033	0.634	0.422	0.267	0.046	0.000	0.079	0.125	0.200	0.025	0.2924
		Private	0.000	0.082	0.164	0.128	0.374	0.378	0.141	0.041	0.020	0.088	0.243	0.025	0.139	0.066	0.621	0.422	0.404	0.076	0.000	0.111	0.187	0.200	0.037	0.5823

Interpretation

Column no. 4 - S_{im}_1; Column no. 5 - S_{im}_2; Column no. 6 - S_{im}_3; Column no. 7 - S_{im}_4; Column no. 8 represents, $S^{n}_{i=1} S_{im}$; where $i = 1, 2, \dots n$ ($n = 4$); Column no. 9 - CW_i _1; Column no. 10 - *SI*_1; Column no. 11 - S_{im}_5; Column no. 12 - S_{im}_6; Column no. 13 - S_{im}_7; Column no. 14 -S_{im}_8; Column no. 15 - S_{im}_9; Column no. 16 - S_{im}_10; Column no. 17 - S_{im}_11;Column no. 18 represents, $\Sigma^{n}_{i=5} S_{im}$; where $i = 5, 6, \dots n$ ($n = 11$); Column no. 19 - CW_i_2; Column no. 20 - *SI*_2; Column no. 21 - S_{im}_12; Column no. 22 - S_{im}_13; Column no. 23 - S_{im}_14; Column no. 24 represents, $\Sigma^{n}_{i=12} S_{im}$; where $i = 12, 13, \dots n$ ($n = 14$); Column no. 25 - CW_i_3; Column no. 26 - *SI*_3;Column no. 27 represents, $\Sigma^{n}_{i=1} SI$; where $i = 1, 2, \dots n$ ($n = 3$).

Note: CW_i is the weight of the i^{th} component, where $\Sigma^{n}_{i=1} CW_i = 1$, where $i = 1, 2, \dots n$ ($n = 3$), and $0 \le CW_i \le 1$.

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