Theme: Integrated Water Resources Management

Water Scarcity and Dhaka City

A Water Stress Index approach from Dhanmondi and Mirpur

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ABSTRACT

Among the megacities around the world, Dhaka is comparatively one of the fastest expanding one from the time of the emergent of Bangladesh as an independent nation. And this growth is accelerating by urban migration as this is capital city of Bangladesh too. But this trend of being populated more and more in the course of time is hampering the basic needs demand to be fulfilled in spite of lots of development programs already either implemented or on the way of being implemented. Among these all phenomena, Water crisis has gone beyond the limit. Water crisis has two dimensional problems. They are shortage and not being enough pure to use. This paper is limited its analysis to the water problem with first dimension that means Water Shortage. The aim of water index is to show relationship between total water use and water availability. And to make this happen, two areas named Mirpur and Dhanmondi have been taken as sample. ArcGIS software have used for Data analysis purpose and then, the index has been calculated manually. And GIS Dataset has been collected from DWASA manually. This work demonstrates that households living in this two regions get 0.33 litre water against 1 litre water demanded. Water demand at summer rises higher which is impossible for DWASA to cover up with their existing water supply network.

1.Introduction:

Water has been a plentiful resource in most areas, amounting virtually to a free good but the situation is now abruptly changing to the point where, particularly in the more arid regions of the world, water scarcity has become the single greatest threat to food security, human health and natural ecosystems. Being the emancipation region of many rivers and comparatively effortlessly found water level, the water for agriculture and use other than urban household is easy accessible for the people living outside of the urban area. Water is definitely physically scarce in densely populated arid areas, Central and West Asia, and North Africa, with projected availabilities of less than 1,000 cubic meters per capita per year (Cosgrove and Rijsberman, 1998). In case of Bangladesh, water is more scare in Mirpur, Mugda, Kholgaon and Narayanganj area of DWASA jurisdiction (DWASA 2013) and Khatunganj and Chaktai area of CWASA jurisdiction (CWASA 2014) This scarcity relates to water for food production, however, and not to water for domestic purposes that are minute at this scale. In most of the rest of the world water scarcity at a national scale has as much to do with the development of the demands the availability of the supply. Accounting for water for environmental requirements shows that abstraction of water for domestic, food and industrial uses. The water scarcity indices thus far have measured water resource status based on fixed human water requirements and water availability, mostly on a national scale but have not incorporated renewable water supply and national, annual demand for water. Freshwater scarcity is commonly described as a function of available water resources and human population. These figures are generally expressed in terms of annual per capita water and mostly on a national scale. The logic behind their development is simply that if we know how much water is necessary to meet human demands, then the water that is available to each person can serve as a measure of scarcity (Rijsberman, 2006). Individual usage is the basis for the water stress index and therefore provides away of distinguishing between climate and human-induced water scarcity. In developing third world country like Bangladesh, water is an important resource both for urban utility services and increasing water demand for the world's most densely urban area for straight ahead. In this paper which partially fulfill the requirement for the Four Year Bachelor of Urban and Regional Planning program under the Department of Urban and Regional Planning, I anticipate to pronounce the presence, level and harshness of the water stress of the study area and construct and index of it using appropriate methodology and data sets.

2. Methodology of the Study

For this research, no specific questionnaire survey has conduct because of the nature of the research. Observation survey provides information about physical objects to show or portrait the current scenario of the study area. The main purpose of two surveys' is to determine the existing scenario of water supply or to measure the efficiency of water supply of the respective study areas. In this study physical observation survey will be comprised the survey of water supply pipelines to collect information regarding length, shape, thickness, materials and number of pipes in the study area, number of consumption units, number of water users from common sources, customers' satisfaction and cost for the water in respect of the income of the responded, etc.

2.1. Measuring Water Stress Index of Any Specific Area

Determination of water stress in an area will be determined by using index that is called water stress Index (WSI). The development and evaluation of WSI has been widely developed in various countries, one of which is developed by a Swedish researcher, Prof. Malin Falkenmark, in 1989.

2.2. Research Design

Mirpur and Dhanmondi area of Dhaka city has been selected as the sample area for the present study because both areas are located in an important location with respect to Dhaka city and both are the fastest growing residential area of Dhaka city accommodating and attracting people of all classes in recent years. Therefore, Mirpur, Pallabi and Kazipara areas are selected accordingly as a planned and unplanned residential area for a comprehensive and comparative study on 'Water Supply' of Mirpur area. Data sources are—

2.2.1. Primary Sources—which include key informant survey, literature survey, observation survey and data supplied by various government and NGO's.

2.2.2. Secondary Sources—which include different books, journals, articles, reports, internet and previous research works.

Table-2.1: Required data & pre-determined relevant sources

Required Data	***Variables***	***Data Source***	***Process of Data Collection***
Water Resource Data	• Ground water availability • Surface water availability • Piped water flow capacity • Number of Population • No. of Population served by Piped Water • Time of Water Supply	Primary	Field Observation/ Check List Survey

Physical Quality	Physio-chemical Parameters Odor Teste Turbidity	Primary	Data Supplied by DWASA
Water Consumption Data	Average Per Person Consumption Number of Users of Bottled Water Expense for the Water	Primary	Field Observation Survey and DWASA Data

2.3. Data Collection

An important phase of research work is data collection which required relevant data collected from different sources**.** Data collection is two types and those are—

1. Primary Data Collection
2. Secondary Data Collection

***2.3.1.* Primary Data Collection**

Water availability, water supply, number of connections, connection type, number of residential connections, number of population living in the study area, number of population served and time of water supply are identified**.**

2.3.2 Secondary Data Collection

Physio**-**Chemical Parameters along with odor, teste and turbidity, typical per capita consumption, expense for the water and number of bottled water user data are collected from secondary sources**.** Maps and literatures are also collected from secondary sources**.**

3. Review of Literatures

(Ali, 2018) conducted a study to examine the water stress in North Jakarta city and the water supply system and procedure of North Jakarta city. The town was always facing insufficiency of fresh water source to meet the clean water requirement and a very squat water provision handling which is less than half. He described a new tactical method targeting to detect water stress zones with the improvement of a water stress index(WSI) which further develops a basis in purpose of strategy and approach for the upgrading of clean water and sanitation circumstance. Yet, all together it is continuously facing flood threat, especially in the wet season, as same as Dhaka does. The calculation methodology for WSI used in this study is based on 3 (three) main components comprising of water resources, ecological system, and demand magnitude and clean water consumption. On the other hand, the urban environmental sanitation condition is also very critical, especially due to pollutant load that is always being discharged into water bodies in the form of urban waste. By using 8 (eight) supporting indicators for each respective component, the result of the study shows that the city is facing water stress in its most of the area.

(Sullivan *et al.*, 2003) in his study explore discussion of ways in which an interdisciplinary approach can be taken to produce an integrated assessment of water stress and scarcity, linking physical estimates of water availability with socioeconomic variables that reflect poverty, i.e., a Water Poverty Index. Itis known that poor households often suffer from poor water provision, and this results in a significant loss of time and effort, especially for women. By linking the physical and social sciences to address this issue, a more equitable solution for water allocation may be found. For the purpose of initiating discussion, a summary of different approaches to establishing a Water Poverty Index is discussed.

(Falkenmark, 1989) argued that water scarcity is a multipart problem once it distresses countries with a semi-arid climate, i.e. countries for which there are variations between

a dry season and a season when rain occurs. He deliberates the over-all defenselessness of the semi-arid zone in terms of four different types of water scarcity, the effects of which are being superimposed on each other: two are natural (type A, arid climate, type B, intermittent drought years) and two are man-induced (type C, desiccation of the landscape driven by land degradation, and type D, population-driven water stress). When fueled by a rapid population increase, a risk spiral develops, manifesting itself in social and economic collapse during intermittent drought years. They conclude that many countries in Africa are heading for severe water scarcity-in fact two-thirds of the African population will live in severely water-stressed countries within a few decades. This severe water stress will largely be the result of unfettered population growth.
(Ridgley and Rijsberman, 1994) Studied that it's tough to define whether water is truly scarce in the bodily sense at a global scale (a supply problem) or whether it is accessible but should be used improved manner. he reviews water scarcity indicators and global valuations based on these pointers. The most widely used indicator, the Falkenmark Indicator, is popular because it is easy to apply and understand but it does not help to explain the true nature of water scarcity. The more complex indicators are not widely applied because data are lacking to apply them and the definitions are not intuitive. Water is definitely physically scarce in densely populated arid areas, Central and West Asia, and North Africa, with projected availabilities of less than 1,000 cubic meters per capita per year. This scarcity relates to water for food production, however, and not to water for domestic purposes that are minute at this scale. In most of the rest of the world water scarcity at a national scale has as much to do with the development of the demands the availability of the supply. Accounting for water for environmental requirements shows that abstraction of water for domestic, food and industrial uses already have a major impact on ecosystems in many parts of the world, even those not considered "water scarce". Water will be a major constraint for agriculture in coming decades and particularly in Asia and Africa this will require major institutional adjustments. A "soft path" to address water scarcity, focusing on increasing overall water productivity, is recommended.

4. Water Availability:

The water availability indicator has three different determinations. They are

1. GW: Ground water availability.
2. SW: Surface water availability.
3. PW: Piped water flow capacity.

GW, ground water availability: Ground water availability designate to determine the amount of water available in the study area annually. For the study area of this thesis, the available groundwater lifetable for private use is prohibited as per government rule. So this amount is considered as zero for this calculation.
SW, surface water availability: Surface water used for household work is considered as available surface water for any area. For study area of this thesis, there was no significant area with specific surface water source. So this amount is considered as zero for this calculation.
PW, piped water flow capacity: Piped flow capacity is considered as highest capacity of water flow for the specific area. From the GIS data of DWASA authority, the total length of the water supply pipe of zone 4 and 10 is found as 403577.384-meter and for zone 3 it is 275993.207725-meter length and average diameter of 200 cm. So the total area of the pipe of the zone 4 and 10 is:

$$Total\ Water\ Avaiablity = \sum(GW + SW + PW)$$
$$Total\ Water\ Availablity = \sum\{0 + 0 + 2\pi(h/r)\}$$

$$Total\ Water\ Availablity = 2\pi(\frac{403577.384}{.002})$$
$$Total\ Water\ Availablity = 2\pi x 201788692$$
$$Total\ Water\ Availablity = \ 1267875745.7293869642796417983489\ m3/\text{yr}$$
And total area for zone 3 is
$$Total\ Water\ Avaiablity = \sum(GW + SW + PW)$$
$$Total\ Water\ Availablity = \sum\{0 + 0 + 2\pi(h/r)\}$$
$$Total\ Water\ Availablity = 2\pi(\frac{275993.207725}{.002})$$
$$Total\ Water\ Availablity = 2\pi x 137996603.862$$
$$Total\ Water\ Availablity = 867058233.83\ m3/\text{yr}$$
As The Study area consisting Dhaka Wasa Zone of 4 and 10, which themselves comprise area of Dhaka North City Corporation, zone 4, ward no 9, 13 (part), 14 (part), 15 (part).
The population of this area roughly considered as
Table 4.1: Population of the First Study Area

Serial	Ward No	Population	
1	2-8 full	7,21,587	
2	13	99,550	One third of the entire ward's population
3	14	1,00,333	
4	15	1,87,094	
	Total	11,08,564	

(Source: DNCC zone 4 office, Mirpur 10).
The water availability indicator is calculated by the total water availability devided by the population using this resource. So the calculation for zone 4 and 10 as following.
$$Water\ Availablity\ Indicator = Total\ Water\ Availablity/Population$$
$$Water\ Availablity\ Indicator = 1267875745.7293869642796417983489/11{,}08{,}564$$
$$Water\ Availablity\ Indicator = \ 1143.7100110858614967468200287479$$
$$Water\ Availablity\ Indicator \approx \ 1143.7$$
And as per study DWASA zone 3 comprising three complete ward of Dhaka South City Corporation. Which is Ward No. 14, 15 and 18, was Ward No 48, 49 and 52 of Dhaka City Corporation. The data of the population is as per BBS (2011) census.
Table 4.2: Population of the Second Study Area

Serial	Ward No	Population
1	14	2,30,554
2	15	1,89,761
3	18	2,05,834
	Total	6,26,149

And the calculation for zone 3 as following
$$Water\ Availablity\ Indicator = Total\ Water\ Availablity/Population$$
$$Water\ Availablity\ Indicator = 867058233.83\ /3{,}26{,}149$$
$$Water\ Availablity\ Indicator = 2658.47276499$$
$$Water\ Availablity\ Indicator \approx \ 2658.5$$
The determination of score for this indicator uses Falkenmark (1998) Indicator as follows:
Table 4.3 Score for the Specific Water Availability

Serial	Water Availability	Score
1	More than 1700 m^3/capita/year	20

2	1000-1700 m^3/capita/year	15
3	500-1000 m^3/capita/year	10
4	Less than 500 m^3/capita/year	5

(Source: Ali., 2010)

The determined score for this indicator for zone 4 and 10 is 15 and for zone 3 is 20.

4.1 Piped Water Coverage Indicator

This indicator shows percentage (ratio) of piped water service coverage in a certain area. It shows the number of population receiving piped water service compared to the population that is not served by piped water system. From DNCC zone 4 office, Mirpur 10 we came to know that the population of the area comprising the zone 4 & zone 10 of DWASA is approximately 11,08,564 and for zone 3 the population is 6,26,149. And from the Data supplied by DAWSA the number of connection of household of zone 4 and zone 10 is 7766 and for zone 3 the number is 4035. The average family size in Dhaka City Corporation is 5.49 is from census of 2011 (BBS 2011). From the DWASA authority, there is 17 open water supply lines for the slum area of both zones and this is maintained under the section 18 of the Water Supply Rules 2011. This service serves for the approximate some of 1 million people in the area.

So the total number of population served by the water supply of the DWASA in zone 4 and 10 is:

$$Total\ Population\ Served = (7766 \times 5.49) + 100000$$
$$Total\ Population\ Served = 34869 + 100000$$
$$Total\ Population\ Served = 134869$$

the total number of population served by the water supply of the DWASA in zone 3 is:

$$Total\ Population\ Served = (4035 \times 5.49) + 100000$$
$$Total\ Population\ Served = 18117.15 + 100000$$
$$Total\ Population\ Served = 118117$$

To estimate the magnitude of score the following equation the equation below is used.

I_2 = 20-T

Where, T is the percentage of the people under water service coverage.

Calculation	
$T = \frac{134869x100}{1108564}$	$T = \frac{118117x100}{6,26,149}$
$T = 12.16\%$	$T = 18.86\%$

So the score for zone 4 and 10 is (20-12.16) = 7.85. And the score for zone 4 and 10 is (20-18.86) = 1.14

4.2 Water Source Continuity Indicator

Water source continuity indicator shows accessibility to the use of water sources for 24 hours a day and 7 days a week. Determination of the score refers to water flow continuity or accessibility to water sources which must be available for 24 hours a day for piped water, ground water as well as water purchased. The score limit given refers to access to water for more than 12 hours or less than 12 hours a day. The score determination for population served by piped water system is based on:

Table 4.4 Score set for Time of Water Supply

Serial	Time of Water Supply	Score
1	Access to water less than 12 hours	8
2	Access to water more than or equal to 12 hours	20

(Source: Ali., 2010)

For the population who are not piped water customers, the score is then based on the assumption that the whole population has access to continuing water supply by buying water from the vendor or utilizes ground water. The water purchased that is stored in the house and ground water is assumed can be accessed at any time by the household. In this study the score is set at 20 because water can be accessed any time after purchased and stored in the house or even groundwater that is readily available any time. Thus, the score of indicator

$$I3 = \frac{K1 + K2}{2}$$

K1 = level of water customer satisfaction toward access to piped water based on complaint reported, or based on Water Works Enterprise/Water Provider water pressure log. For this instance, the score is 8 as DWASA water supply for the both study area is less than 12 hours a day in a week is recorded in the water pressure log.

K2 = level of water customer satisfaction toward water continuity for non-customer. As said before this score is set 20.

$I_3 = (8+20)/2$

$I_3 = 14$ for both zone 4 and 10 and zone 3.

4.3 Non-Piped Water Quality Indicator

Non-Piped Water Quality Indicator calculation refers to the Pollution Index calculation (IP) developed by Sumitomo and Nemerow (1970). This indicator comprises of surface water and groundwater sources. The pollution causing parameters are evaluated through Nemerow's pollution index (NPI) using the average values of three monsoon season physico-chemical parameters indicated below. NPI is evaluated for all the parameters for each sample analysed, thus identifying the pollution causing parameters.

The equation used in evaluating the NPI is reproduc ed below:

NPI = Ci / Li

Where

Ci = observed concentration of i parameter

Li =permissible limit of i parameter.

In above expressions unit of Ci and Li should be identical. Each value of NPI shows the relative pollution contributed by single parameter. It has no units. Li values for different water quality para meters are indicated in Table below. NPI value exceeding 1.0 indicate the presence of impurity in water and hence require some treatment prior to use.

Table 4.5 Standard Values of water quality parameters

Serial	Parameters	Permissible Value (Li)
1	pH	8.5
2	EC	300
3	TH	300
4	Cl	250
5	Mg	30
6	F	1.5
7	Ca	75
8	TDS	500
9	NO3	45
10	SO4	200

(Source: Joarder et al.)

The level of pollution classification is based on water standard quality divided into 4 (four) classes, namely:

Table 4.6 Pollution Level as Per Standard

Serial	Level of the Pollution	Mentioned Standard of the Pollution
1	$0 \leq 1.0$	Meeting Standard Quality (Good Condition)
2	$1.0 \leq 5.0$	Slightly Polluted
3	$5.0 \leq 10.0$	Medium Pollution
4	≥ 10.0	Heavily Polluted

(Source: Sumitomo., Nemerow., 1970)

Further, the score calculation for this indicator uses the equation below.

I4 = 20 – IP

Data Collected orally from DWASA the level of pollution is none and all water supplied by DWASA is free from alien materials. Thus the score is 20 for both zone 4 and 10 and zone 3.

4.4 Piped water quality indicator

Piped water quality indicator calculation uses 3 (three) parameters, they are odor, taste, and turbidity. The piped water quality in an area refers to the condition of piped water service provided by DWASA. The score given for each parameter is:

Table 4.7 Score for the Condition of Piped Water

Serial	Condition of Supplied Water	Score
1	Good Water Quality	20
2	Normal Water Quality	15
3	Bad or Poor water quality	5

(Source: Ali., 2010)

Further, the water quality indicator I5 is equated as follows.

$$I5 = \frac{Q1 + Q2 + Q3}{3}$$

Where,

Q1 = Odor parameter score

Q2 = Taste parameter score

Q3 = Turbidity parameter score

The level of these parameters are regularly examined and quality controlled by Office of the Chief Microbiologist, DWASA. As per oral data supplied by DWASA authority the quality of supplied water is good. Hence the calculation of parameter of the score for this indicator is 20 for both zone 4 and 10 and zone 3.

4.5 The water demand indicator

The water demand indicator refers to the average consumption of clean water for each person in a day (L/capita/day). Bangladesh has one of the highest population densities in the world, with a population of 160 million living within 57,000 square miles. Of those 160 million people, 13 percent lack safe water and 39 percent lack improved sanitation. (Water.org., 2017)

Based on estimates of requirements of lactating women who engage in moderate physical activity in above-average temperatures, a minimum of 7.5 liters per capita per day will meet the requirements of most people under most conditions. This water needs to be of a quality that represents a tolerable level of risk. However, in an emergency situation, a minimum of 15 liters is required. A higher quantity of about 20 liters per capita per day should be assured to take care of basic hygiene needs and basic food hygiene. Laundry/bathing might require higher amounts unless carried out at source.

(WHO., 2017) Considering drinking water and sanitation needs only suggests the amount of clean water required to maintain adequate human health is between two and 80 liters per person per day and up to 30 Cubic Meter per person per year. (Gleick, 1996))

In case of Dhaka, the minimum requirement is set for 80 Liters per person per day.

Table 4.8 Score set for the Water Supply

Serial	Level of Water supply	Score
1	More than 80 Liters per person per day.	20
2	Less or equal to 80 Liters per person per day.	8

DWASA's supply capacity in summer season when the demand for the water is highest is 1.9 billion liters per day which is eventually 140 liters per person per day within people of its jurisdiction. Hence the score is 20 for this indicator for both zone 4 and 10 and zone 3.

4.6 Drinking Water Source Indicator

This indicator will measure the people trust in term of physiographical acceptance on the standard water source used for its daily consumption. This indicator is obtained from questionnaire in order to know the number of population that consumes bottled water as a source of drinking water. The score determination is carried out by using the following equation.

$$I7 = 20 - \frac{\sum respondent\ using\ bottled\ water}{\sum respondent}\ x\ 20$$

But in this cases, the number of user of bottled water is very frequent in number as the most of the domestic water consumption is from direct supply line of DWASA and in some exceptional cases the users consume water from private suppliers. I field surveyed the area to find the actual number of the bottled water supplied in the study area and found the suppliers are non-corresponding as they consider their business is illegal as per government rules and regulation. In general, 5 vendors supply bottled water in the study which visibly infested my study area to and from their service area. In addition, most clients and shops and stalls. Orally one of the vendors stated that the number of bottles consumed in Mirpur area is more than 1700. I decided to score this indicator is 20 for both zone 4 and 10 and zone 3.

4.7 Affordability indicator

Affordability indicator refers to the government regulation regarding piped water tariff setting with the limit of 4% of monthly income. This indicator describes the ability to pay for their water need of drinking water in their houses without heavy burden carrying on its income. As per Ali (2010), the score is given based on the use of income (expenditure) to meet the water demand by using the following criteria.

Table 5.9 Score for the Percentage of Monthly Expenditure for the Domestic Water Supply

Serial	Percentage of Monthly Expenditure on Water Supply	Amount	Score
1	Heavy burden when the income used to buy water	> 4,5%	2
2	Slightly burden when the income used to buy water	4 - 4,5%	5
3	Not a burden when the income used to buy water	< 4%	20

(Source: Ali., 2010)

Thus as per Water Supply Rules of 2009, any residential connection prerequisite to deposit a minimum amount of 5000/- during the time of finalization of the connection (Water Supply Rules of 2009). This deposit will be refund without any interest at the time of the termination of the connection and any failure to monthly connection fee payment will deduct from this security deposit amount. From the August 2015, DWASA authority decided to collect an increased tariff of 5% which is TK 8.09 for per 1000 liters of water they supply to any residential consumer unit. For this reason, this fall under the serial number of 3 and given score of 20 for both zone 4 and 10 and zone 3.

4.8. WSI calculation

WSI calculation is carried out by calculating the value or score of each respective indicators and each weighted component.

Table 4.10 Interpretation of the WSI

Serial	WSI	Interpretation
1	< 0.2	*No Water Stress Area*
2	0.2 ≤ 0.3	*Low Water Stress Area*
3	0.3 ≤ 0.4	*Medium Water Stress Area*
4	0.5 ≤ 0.4	*High Water Stress Area*
5	≥ 0.5	V*ery High Water Stress Area*

(Source: Ali., 2010)

This weighted component is set by Ali (2010) and furthermore this calculation will be resulted as cumulative amount of the total water supply stress of the study area.

Table 4.11 Setup of the Weighted Mean for the indicators

Serial	Component	Indicator	Indicator's Name	Weighted Mean Wi
1	Water Resource	I_1	Water Availability	1.0
2		I_2	Water Coverage	2.0
3		I_3	Water Source Continuity	1.5
4	Physical Quality	I_4	Ground Water Quality	0.75
5		I_5	Piped Water Quality	0.75
6	Water Consumption	I_6	Water Demand	0.25
7		I_7	Drinking Water Source	0.25
8		I_8	Affordability	0.5

(Source: Ali., 2010)

Further, the calculation of the index is determined by using the following equation:

$$WSI = (20 - \frac{\sum_{I=1}^{n} Wi\ Ii}{\sum_{I=1}^{n} Wi})/20$$

Table 4.12 Execution of WiIi Table

Serial	Ii (Zone 4&10)	Ii (Zone 3)	Wi	WiIi (Zone 4&10)	WiIi (Zone 3)
1	15	20	1.0	15	20
2	7.84	1.14	2.0	15.68	2.28
3	14	14	1.5	21	21
4	20	20	0.75	15	15
5	20	20	0.75	15	15
6	20	20	0.25	5	5
7	20	20	0.25	5	5
8	20	20	0.5	10	10
Total			7	101.68	93.28

The WSI calculation for DWASA zone 4 and 10 is

$\frac{\sum_{I=1}^{n} Wi\ Ii}{\sum_{I=1}^{n} Wi}$ =15.525714285714285714285714285714

WSI= (5.4742857142857142857142857142857/20)

WSI = 0.27371428571428571428571428571429

WSI ≈ 0.28
The WSI calculation for DWASA zone 3 is

$$\frac{\sum_{I=1}^{n} Wi\, Ii}{\sum_{I=1}^{n} Wi} = 13.3257142857$$

WSI= (6.6742857143/20)
WSI = 0.33371428571
WSI ≈ 0.33
From the Table Above the Water Stress Index for the Study Area, Dhaka WASA Zone 4 & 10 is 0.28 and is a low water stress area. And on the other hand, the Water Stress Index for the Study Area, Dhaka WASA Zone 3 is 0.33 and is a medium water stress area.

5. Findings of the study

The exploration of this study is mainly guided by the following research questions- present scenario of water supply of residential areas of Greater Mirpur and Dhanmondi area, the causes of growing water demand of residential areas of Greater Mirpur and Dhanmondi. The summary of the present water supply scenario, the causes and associated consequences of water scarcity of residential areas of Greater Mirpur and Dhanmondi are presented below.

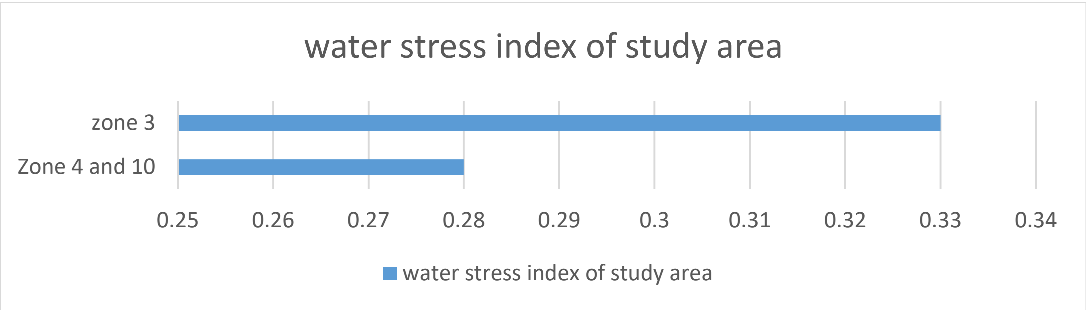

Figure 5.1: Comparative Water Stress Index of the Both Area (Source: Prepared by Author, 2017)

6. Conclusion

To alleviate the water scarcity, in 2011 the city of Dhaka announced it would amend its building code to require rooftop rainwater harvesting systems in new buildings. The measure aims to address the city's worsening water shortages and curb drops in groundwater levels. Collecting rainwater also will help avoid flooding problems in Dhaka during the monsoon season. (Wadud, 2016) Water management in Dhaka, the capital of Bangladesh and a city with 20 million inhabitants, faces numerous challenges such as flooding, poor service quality, groundwater depletion, inadequate sanitation, polluted river water, unplanned urban development, and the existence of large slums where more than one third of its population lives. The utility in charge of water and sanitation in Dhaka, DWASA, addresses these challenges with a number of measures. The utility plans to substitute surface water for groundwater through the construction of four large water treatment plants until 2020 at a cost of US$1.8bn (Saidabad Phase II and III, Padma/Pagla and Khilkhet). The treatment plants will draw water from more distant and less polluted rivers up to 160 km from the city. The four plants are expected to have a combined capacity of 1.63 million cubic meters per year, compared to a 2010 supply of 2.11 million cubic meter per year that is mainly from groundwater. As of 2011, funding had been secured for the first plant which is under construction thanks to a USD250 million contribution from Danish development assistance.The abundant water scarcity of the Dhaka City optimistically will be erased then.

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