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Original Article

Assessing Equity and Demand Satisfaction of an Intermittent Water Supply Using a Non-Iterative Implementation of EPANET 2.2: A Case Study of Itanagar Water Distribution Network

Bini Kiron[1], Ram Kailash Prasad[2]

[1,2]*Department of Civil Engineering, North Eastern Regional Institute of Science and Technology, Arunachal Pradesh, India.*

[1]*Corresponding Author : Itachikiron@gmail.com*

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Abstract *- Intermittent Water Supply (IWS) is a water supply system in a developing country where water is supplied intermittently for a limited duration. Factors responsible for IWS are water resource scarcity, inadequate facilities, unaccountable water losses, etc. The IWS systems, however, frequently result in variable pressure levels, water quality issues, and potential customer dissatisfaction. Furthermore, a crucial feature of the Water Distribution Network (WDN) is that it provides adequate water to consumers to meet the required demand with satisfactory performance. Thus, in this study, consumer satisfaction is assessed through demand satisfaction and the level of equity for the WDN of Itanagar (Arunachal Pradesh). This study is unique of its kind for Itanagar WDN, as no study of this kind has been undertaken on this network. This study also compares different equity formulae available in the literature. Moreover, EPANET version 2.2 was used to simulate the Itanagar WDN. The results highlight that the water supply depends on the availability of water at the Itanagar WDN source. Furthermore, it is also found that the pressure varies significantly at nodes. Consumer dissatisfaction is high due to insufficient access to drinking water in Itanagar town under IWS. A huge discrepancy in the supply-demand ratio was observed in the Itanagar WDN, where more than half of the demand nodes are facing a shortage of supply against their demand. As such, some consumers are getting more than their required share of water, and others are not getting the required demand or supply to sustain their livelihood. Consequently, the equity value is found to be approximately 0.5 under full supply conditions, as against its ideal value of 1. This signifies that there is insufficient access to drinking water in Itanagar for a supply duration of 4 hours.*

Keywords *- Intermittent water supply, Equity, Water distribution networks, Demand Satisfaction, EPANET software.*

1. Introduction

The IWS system refers to a piped system that provides water for a few hours a day or a week (Mokssit et al., 2018). Factors responsible for IWS include growth in population, scarcity of water, planning, leakage, and rapid demand growth (Erickson et al. 2017; Laspidou et al. 2017). Eventually, the Lower And Middle-Income (LMIC) countries depend on the IWS (Taylor et al. 2019; Kumpel et al. 2022). Due to inadequate resources, water availability is limited in developing countries; therefore, scarcity of water is a usual occurrence, and supply is intermittent (Chandapillai et al. 2012). Several studies have highlighted the causes and consequences of IWS around the world (Kumpel and Nelson 2014; Ghorpade et al. 2021). Furthermore, inadequate facilities and water resource availability are the main causes of the IWS system (Farmani et al., 2021). However, leakage is identified as the most common cause of IWS (Laspidou et al. 2017). In some cities throughout the world, water is delivered once per week (Taylor et al. 2019). As the water demands of short duration cannot be reachable to the consumers, these systems are categorized as highly intermittent systems (Mohan and Abhijith 2020). According to Reddy and Elango (1989), discharge is proportional to the pressure head for a highly intermittent system. Furthermore, The author and Abdelazeem and Meyer (2024) have termed the condition uncontrolled pressure dependent and unrestricted flow, respectively. Equity is defined as the measure of the dispersion of supply and demand within a WDN. More specifically, equity refers to 'delivering a fair share of water to consumers throughout a WDN' (Molden and Gates 1990). Chandapillai et al. (2012) defined simple measures of equity concerning the supply-demand ratio. Ameyaw et al. (2013) defined equity as the delivery of an adequate volume of water to consumers across the WDN. According to De Marchis et al. (2010), the increase in inequity and competition among consumers in WDN depends on factors like WDN structure, topography, private tank usage, etc. In those circumstances, consumers acquire as much water as possible, rapidly depleting the limited available water. Even when enough water is delivered to meet consumer demand, IWS results in an inequitable distribution of water, which may involve high dispersion (Fontanazza et al., 2007). Furthermore, De Marchis et al. (2011) and Chandapillai et al. (2012) demonstrate that inequity is directly proportional to water scarcity in the system. Moreover, in IWS, the issue of equity occurs frequently (Galaitsi et al. 2016). In urban India, the intermittent water situation is highly uneven and inequitable (Satpathy and Jha 2022). In Delhi and Bengaluru cities, the pipe network was inequitably distributed; fewer houses in the poorest areas had piped connections. Inequitably, wealthier areas had lower storage needs and longer supply continuity (Meyer et al., 2023). Lastly, the inequitable supply of the WDN is the outcome of an IWS nature of the system (Ghorpade et al. 2021).

Normally, the design of WDN is not to maintain constant pressure throughout the supply period (De Marchis et al. 2011), which results in lower pressure and rate of flow by the consumers located at high elevations or far away from the WDN centre, resulting in less or no supply of water during the supply period. Consequently, inequity prevails in the traditional way of IWS operation. Nonetheless, the working of the IWS system has intensified with one of the editions of the Battle of Water Networks (Sánchez-Navarro et al. 2021). Moreover, according to Gullotta et al. (2021), the Uniformity Coefficient (UC) index contributes as the latest index for global equity measurement in the IWS system, and it was used in the battle of networks on intermittent water supply as an equity index, showing that the community agrees such an index is a good one.

The geographical layout of the network determines the advantages of some nodes of the water distribution system over others because of their elevation or source closeness (Ameyaw et al., 2013). As a result, each node in the network has a varied water reception time (Mokssit et al. 2018). Moreover, Ceita et al. (2023) found that the Volumetric Coefficient (VC) can be used to calculate the level of demand satisfaction of the network, i.e., the quantity of water received in a node in relation to the others and whether the nodes' water needs are being satisfied at that time.

2. Study Area

Figure 1 shows the location of Itanagar city in Arunachal Pradesh, the Northeast State of India. The water distribution system of the study area has been found to be a dead-end or tree system. The water supply for Itanagar WDN has been implemented in two phases, Phase I and Phase II. The total water supply combining Phase I is 7 Million Litres per Day (MLD), and Phase II for the 11 MLD project is 18 MLD. This includes a 15% Unaccounted Flow of Water (UFW) for the population of 141,619 inhabitants for the design period of 2023. The net quantity of water supplied from both phases is to be 1,56,52,051 L/day (181.158 L/s or 652.17 m^3/h). The WDN of the Itanagar area has been divided into 3 zones, viz., Zone I (Mowb II Zone, nodes 1-18), Zone II (Microwave Zone, nodes 19-24), and Zone III (R.K. Mission Zone, nodes 25-42). Figure 2 shows the WDN layout of Itanagar. Three storage tanks are situated in the Mowb II area, receiving treated water supply from the two sump tanks of Clear Water Reservoirs (CWRs). The bottom elevation of all three tanks has been kept at 458.5 m. The total head of CWR nodes 49 and 50 is 294.71 m and 517 m, respectively.

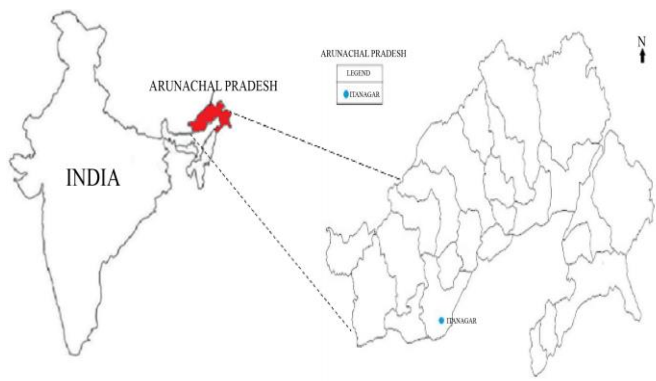

Fig. 1 The location of Itanagar city

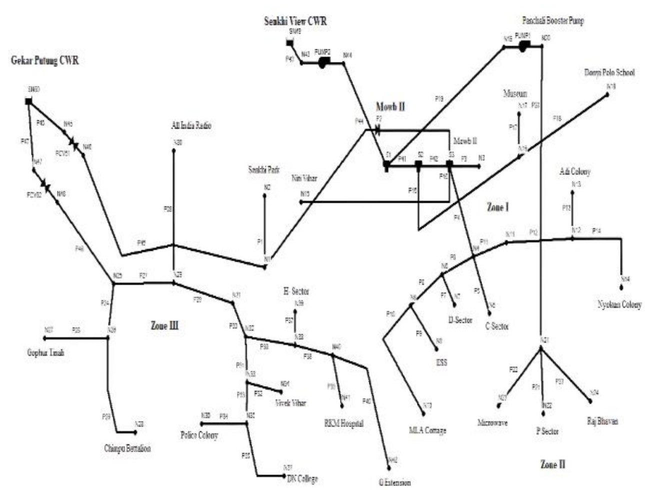

Fig. 2 Schematic of Itanagar water distribution network

A combined gravity and pumping system operates the Itanagar water supply system. Reservoir 49 has to supply 70.451 L/s (253.62 m3/h) as per design. The other details of the water distribution network of Itanagar, including nodal demands, elevation of nodes, and the length and diameters of pipes, are given by the author.

3. Methodology

3.1. Equity Measurement

Four formulas for equity measures adopted from the literature are discussed briefly.

3.1.1. Calculation of Equity

Chandapillai et al. (2012) expressed the inequity Equation (1) as the ratio of the total volume of water delivered at a node to the total demand at that node. The equity of a network is calculated using the supply-demand ratio of the network's worst node at the time when the first node's whole demand is fully supplied. It ranges from zero (minimum inequity) to one hundred percent (maximum inequity). Therefore, equity can be defined as (1-inequity).

$$Inequity = \left(1 - Min\left\{\frac{V_{avai}}{V_{des}}\right\}_j\right) \times 100\% \qquad (1)$$

Where j represents all supplying nodes; V_{avai} denotes the supplied volume at node j; and V_{des} denotes demand volume at node j.

3.1.2. Calculation of Deviation from Equity

According to Ameyaw et al. (2013), D_E refers to the difference in water supply between consumer nodes and the average supply to all nodes.

$$D_E = Min\sum_{i=1}^{n}|\%Q_{av} - \%Q_s| \qquad (2)$$

Where D_E is the deviation of equity in %; Q_s , the ratio of the actual amount of water received at a node to the amount required in %; Q_{av} is the average of $\%Q_s$ in %; and n represents the total nodes in the network.

Equation (2) shows that when, $D_E = 0\%$, all consumer's water demand is met ($Q_s = Q_{av}$). In other words, when the D_E becomes 0% ($Q_s = Q_{av}$), equity becomes 1.0, and inequity is zero. Thus, the value of inequity ranges from 0 to 100%, with a lower value indicating more equitable water delivery for a network. Thereafter, equity can be defined as (1-$\frac{D_E}{100}$).

3.1.3. Uniformity Coefficient (UC)

Gottipati and Nanduri (2014) developed the Uniformity Coefficient (UC) (Equation (3)) to assess water allocations across nodes. The Supply Ratio (SR) of a node is determined by dividing the actual water supply by the demand at the node.

The mean of SR is known as the Average Supply Ratio (ASR). The variation in the node's supply ratio from the ASR is determined at each node, and the average of these deviations is known as ADEV.

UC is calculated by:

$$\mathrm{UC} = 1 - \frac{\mathrm{ADEV}}{\mathrm{ASR}} \qquad (3)$$

When SR is one at all the nodes, then the value of UC becomes one (equitable supply). A UC value less than one indicates that the water quantity across nodes is not distributed equitably.

3.1.4. Volumetric Coefficient (VC)

Ceita et al. (2023) presented an Equation (4) called the Volumetric Coefficient (VC). The network is equitable when VC = 1, and when VC = 0, the network becomes inequitable.

Calculation of VC:

$$VC = 1 - \frac{1}{2}\left(\sum_{i=1}^{n}\left|\frac{Q_{act\,(i)}}{Q_{total\,avl}} - \frac{Q_{req\,(i)}}{Q_{total\,req}}\right|\right) \qquad (4)$$

Where VC indicates the level of equity and is dimensionless; Q_{req} represent the required demand at node (m^3/h or CMH); Q_{act} represent the actual supply to the node (m^3/h or CMH); $Q_{total\,avl}$ represent the total volume of available water in the network (m^3/h or CMH); $Q_{total\,req}$ represent the total demand (m^3/h or CMH), and n is the number of nodes in the network.

3.2. Comparison of the Equity Formulae

Chandapillai et al. (2012) only check the supply state of the very worst node in WDN, which might lead to erroneous conclusions. Ameyaw et al. (2013), D_E have no definite limits; additionally, Ceita et al. (2023) found that D_E gives an undesired equity, i.e., even when there is no supply in the network, the D_E value shows zero percent, i.e., maximum equity. This indicates that each node is equally unsupplied, which may lead to erroneous calculations and conclusions. Additionally, Ceita et al. (2023) analyze the equity for the filling and emptying phases; these conditions are not included in the present study. Furthermore, according to Gullotta et al. (2021), the UC index contributes as the latest index for global equity measurement in the IWS system, showing that the community agrees such an index is a good one. Therefore, the UC index by Gottipati and Nanduri (2014) is considered the best choice for presenting equity for the present study.

3.3. Network System Layout

In Itanagar WDN, all the distribution nodes are like small reservoirs, which act as surge tanks to dissipate the kinetic energy from the flow. Since the flow begins with the maximum feasible flow and decreases as the available pressure decreases (Mahmoud et al. 2017), therefore, Artificial Reservoirs (ARs) and Check Valves (CVs) are added in order to represent the actual working scenario of the Itanagar water supply as uncontrolled pressure dependent or unrestricted flow. The AR is added to allow for unrestricted/uncontrolled flow to the consumers. A check valve prevents flow reversal when the available head at nodes falls below the minimum head.

The algorithm for the simulation of the IWS system consists of 5 steps, as previously explained by the author.

In Itanagar city, the duration of supply of water is generally 4 hours a day. Therefore, for the simulation of the Itanagar WDN under IWS, the source of supply of water is converted from reservoirs to overhead tanks in order to depict the demand of water from m^3/h into the required volume (m^3) of water for that specific supply duration of water. The overhead tank is taken as cylindrical with varying diameters and a fixed height (h) of 10 meters. Furthermore, the V_{req} (Volume required) of the overhead tank is equal to the total demand of the WDN multiplied by the supply duration, and the diameter (d) of the tanks is calculated using Equation (5).

$$d = \sqrt{\frac{4V_{req}}{\pi h}} \tag{5}$$

The calculated diameters of the source node (SN49) and source node (SN50) are 11.36 m and 14.24 m, respectively. In the simulation, the inflow rate to the source node is assumed to be 0. Figure 3 shows the layout of Itanagar WDN for a supply duration of 4 hours.

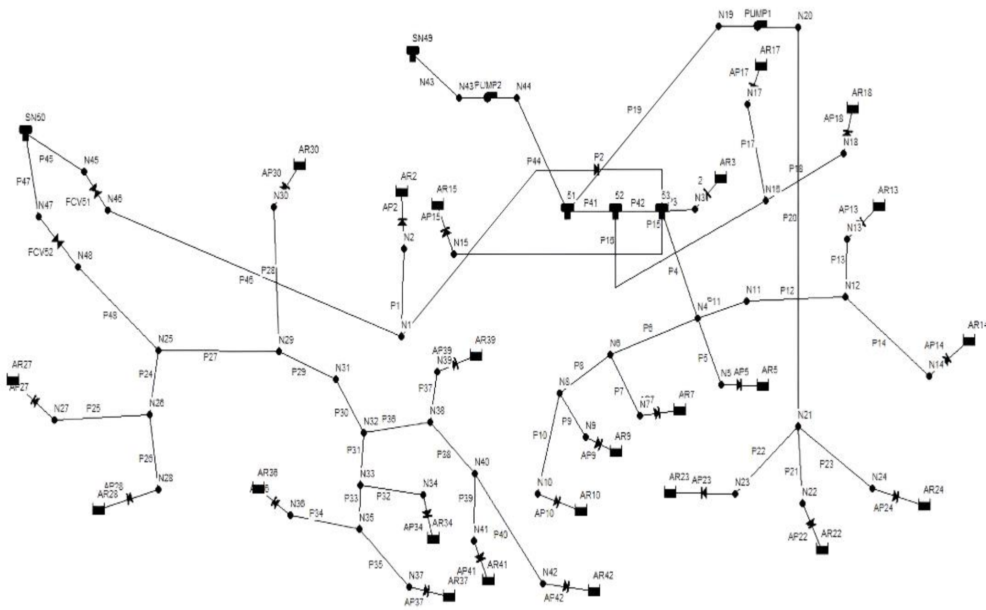

Fig. 3 Layout of Itanagar WDN for supply duration of 4 hours

4. Results and Discussions

In this study, the three supply scenarios have been analyzed. Base scenarios represent the supply condition (i.e., full supply of 100%) of the tank at which the total demand of the network is met for a supply duration of 4 hours. An increased supply condition is taken as a condition of the tank when 10% excess water (i.e., 110% supply) is available at the tank. Similarly, two decreased supply conditions of the tank are assumed to be 90% and 80% of the full supply condition.

4.1. Variation of Base Demand and Total Volume of Water Supplied (m^3) in Itanagar Water Distribution Network

Table 1 shows the volume of water diverted to the demand nodes (DN2, DN3, DN5, DN7, DN9, DN10, DN13, DN14, DN15, DN17, DN18, DN22, DN23, DN24, DN27, DN28, DN30, DN34, DN36, DN37, DN39, DN41, DN42) for full supply and different volume scenarios. It was observed that for the full supply scenario, the quantity of water supplied for four hours is 2303.00 m^3 against the required demand of 2608.69 m^3; hereby, the supplied volume is 11.32% less than the required demand. Moreover, it was observed that when the volume in the source is increased by 10%, then the observed supplied volume is 2370.61 m^3 against the required demand of 2608.69 m^3; hereby, the supplied volume is 9.13% less than the required demand. Furthermore, the supplied volume is reduced from 100% to 90% and to 80%, and then the supplied volume is observed as 2230.87 m^3 (14.48% less than the required demand) and 2158.27 m^3 (17.27% less than the required demand), respectively.

This is due to a reduction in the quantity of supplied volume from the sources. Furthermore, it was observed that the gap between demand and supply is very significant at most of the demand nodes for all the scenarios, creating inequitable distribution in the WDN. Moreover, the flow at demand nodes 3 and 42 shows a no-flow condition.

Since DN3 is the fictitious node that is used to regulate the flow in the tanks, i.e., 51, 52, and 53, DN42 has the highest elevation of all Zone III distribution nodes. As a result, no flow scenario occurs at DN3 and DN42.

Table 1. Demand and supply volume (m^3) at the nodes of Itanagar WDN for 4-hour supply duration for supply volume at tank (full condition), SUPPLY volume at increase/decrease supply condition of tank

Node	Demand	Supply Volume at Tank (Full Condition)	Supply Volume at Increase/Decrease Supply Condition of Tank		
		100%	110%	90%	80%
DN2	229.35	264.90	290.25	237.44	209.96
DN3	287.48	0.00	0.00	0.00	0.00
DN5	178.52	87.50	87.78	87.22	86.86
DN7	66.87	97.83	97.85	97.80	97.70
DN9	164.42	132.43	132.58	132.30	132.10
DN10	264.59	268.79	268.89	268.70	268.60
DN13	18.92	27.63	27.64	27.62	27.60
DN14	82.66	75.79	75.85	75.72	75.64
DN15	115.08	64.25	64.41	64.10	63.90
DN17	20.69	33.58	33.60	33.56	33.50
DN18	16.78	29.73	29.75	29.71	29.70
DN22	110.26	225.08	225.10	225.07	225.05
DN23	204.97	397.75	397.80	397.72	397.70
DN24	99.32	170.66	170.70	170.64	170.62
DN27	115.06	66.98	73.51	60.15	53.30
DN28	59.82	57.20	62.69	51.29	45.37
DN30	72.17	50.25	55.11	45.10	39.93
DN34	84.89	54.75	60.03	49.12	43.47
DN36	55.21	57.77	63.31	51.80	45.82
DN37	60.55	60.50	66.30	54.24	47.98
DN39	43.63	33.37	36.59	29.94	26.50
DN41	118.86	46.26	50.87	41.63	36.97
DN42	138.59	0.00	0.00	0.00	0.00
Total Volume	2608.69	2303.01	2370.61	2230.87	2158.27

Table 2. Pressure at different nodes at the beginning and at the end of the 4-hour supply period for full supply condition

Node ID	Pressure (m) at 0 Hour	Pressure (m) at 4 Hours
DN2	116.09	12.00
DN5	16.10	16.23
DN7	50.17	50.27
DN9	23.42	23.55
DN10	30.39	30.45
DN13	50.00	50.12
DN14	26.87	26.99
DN15	17.39	17.51
DN17	58.93	59.13
DN18	67.97	68.16
DN22	86.57	86.62
DN23	79.39	79.43
DN24	64.82	64.87
DN27	39.47	-74.27
DN28	83.92	-3.66
DN30	50.80	-62.18
DN34	45.01	-42.62
DN36	97.97	1.07
DN37	90.30	12.00
DN39	58.46	-49.66
DN41	24.79	-83.40
DN42	-27.85	-136.11

4.2. Variations of Pressure in the Network

Table 2 shows the pressure at different nodes at the beginning and at the end of the 4-hour supply period for the full supply condition. Here, it is observed that about 8.7% of the nodes have pressure less than the minimum pressure value of 12 m at 0.00 hours of the simulation (node 3 and node 42). Furthermore, the pressure varies significantly at nodes, and 39.13% of the nodes fall below the minimum required pressure, whereas nodes 27, 28, 30, 34, 39, 41, and 42 have negative pressure at the end of 4 hours. It is further observed that the pressure at nodes of zone III decreases significantly after 1:57 hours of supply of water to its minimum value of 12 m, while the pressure at nodes of zones I and II remains almost constant till 4 hours of supply due to the elevation differences of nodes, distance of nodes from the sources, and uneven demand at the nodes.

4.3. Variation of Supply-Demand Ratio (SR)

Table 3 shows the supply-demand ratio of Itanagar WDN for 4 hours of supply duration under different supply volume scenarios. When the supply-demand ratio is 1, it represents that the supply volume equals the demand volume, i.e., customers are satisfied and vice versa. It has been observed that for the full supply scenario, the maximum volume of water supply was observed in the DN22 with a supply-demand ratio of 2.04. This is because the DN22 has the lowest elevation of any of Zone II's distribution nodes. As a result, the flow at DN22 reaches its maximum. Moreover, a minimum supply ratio was observed in DN3 and DN42, i.e., 0, because a no-flow situation occurs at DN3 and DN42.

Furthermore, it was observed that in the full supply scenario, above 10 out of 23 demand nodes (43.48%) have a supply-demand ratio greater than or equal to 1, which implies that the supply volume exceeds the required demand; this might be because of the losses in piping systems and available pressure at the nodes, and above 13 out of 23 demand nodes (56.52%) have a value less than 1, which implies that the required demand is greater than the supplied volume.

Moreover, a huge discrepancy in the supply-demand ratio (maximum '2.04' and minimum '0') was observed in the Itanagar WDN, and more than half of the demand nodes are facing a shortage of supply volume against their requirements, such as some consumers are getting more than their required share of water and others are not getting enough or no supply to sustain their livelihood which results in an inequitable distribution of water in the network.

Table 3. Supply Demand Ratio (SR) of Itanagar WDN for 4 hours supply duration, under different supply scenarios

Node	Tank Full Supply Condition	Increase/Decrease the Supply Condition of the Tank		
	100%	110%	90%	80%
DN2	1.16	1.27	1.04	0.92
DN5	0.49	0.49	0.49	0.49
DN7	1.46	1.46	1.46	1.46
DN9	0.81	0.81	0.80	0.80
DN10	1.02	1.02	1.02	1.02
DN13	1.46	1.46	1.46	1.46
DN14	0.92	0.92	0.92	0.92
DN15	0.56	0.56	0.56	0.56
DN17	1.62	1.62	1.62	1.62
DN18	1.77	1.77	1.77	1.77
DN22	2.04	2.04	2.04	2.04
DN23	1.94	1.94	1.94	1.94
DN24	1.72	1.72	1.72	1.72
DN27	0.58	0.64	0.52	0.46
DN28	0.96	1.05	0.86	0.76
DN30	0.70	0.76	0.62	0.55
DN34	0.64	0.71	0.58	0.51
DN36	1.05	1.15	0.94	0.83
DN37	1.00	1.09	0.90	0.79
DN39	0.76	0.84	0.69	0.61
DN41	0.39	0.43	0.35	0.31
DN42	0.00	0.00	0.00	0.00

4.4. Analysis of Equity and Demand Satisfaction

In order to analyze equity, three scenarios were simulated by increasing the supply volume from 100% to 110% (Corresponding to the water depth of the tank of 11 m) and progressively reducing the water supply from 100% to 90% and 80% (Corresponding to water depth of the tank of 9 m and 8 m) of users' water demand. Figure 4 shows the equity values (D_E, UC, and VC) at different water levels of the source tank.

Here, equity by Chandapillai et al. (2012) is not included in the graph because the equity is 0 for all the water supply scenarios.

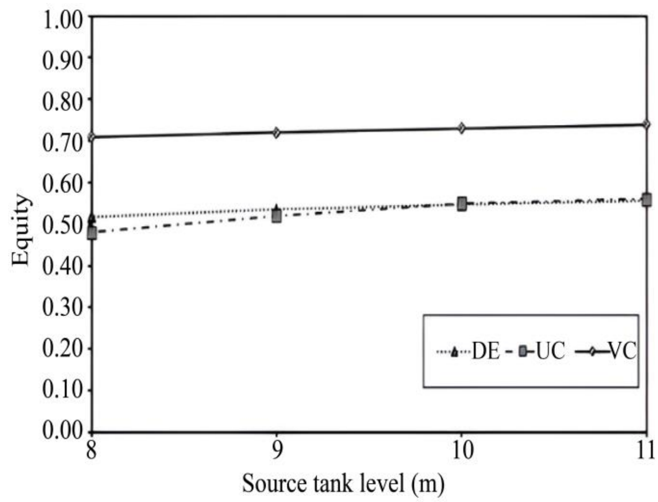

Fig. 4 Shows the equity values (D_E, UC, and VC) at different water levels of the source tank

Table 4 represents the equity of the Itanagar WDN using the Inequity Equation (Chandapillai et al. 2012) (Equation (1)), D_E (Ameyaw et al. 2013) (Equation (2)), UC (Gottipati and Nanduri 2014) (Equation (3)), and VC (Ceita et al. 2023) (Equation (4)) for different scenarios of water supply using different formulas from the literature.

It has been observed that the value of equity given by Chandapillai et al. (2012) gives a value of 0 for all the scenarios because the supply is zero (0) at DN3 and DN42. Ameyaw et al. (2013) stated that the maximum equity in the WDN is found when $D_E = 0\%$. It was found that the equity is 0.56, 0.55, 0.54, and 0.52 for source tank levels of 11 m, 10 m, 9 m, and 8 m, respectively, which implies that the equity decreases as the supplied volume decreases and vice versa.

Furthermore, the Uniformity Coefficient (UC) and Volumetric Coefficient (VC) show a lower value than 1 and decrease as the volume of supply decreases from the source, which implies that Itanagar WDN is facing an inequitable distribution of water. Hence, from the available formulas in the literature, it can be concluded that the Itanagar WDN is facing an inequitable and unsatisfactory distribution of water.

Table 4. Equity and demand satisfaction value of the Itanagar WDN for different water supply scenarios using different formulae from the literature

Source Tank Level (m) Volume of Water	Equity by (Chandapillai et al. 2012)	Equity by (Ameyaw et al. 2013)	UC by (Gottipati & Nanduri 2014)	VC by (Ceita et al. 2023)	Demand Satisfaction by (Ceita et al. 2023)
11	0.0	0.56	0.56	0.74	0.74
10	0.0	0.55	0.55	0.73	0.73
9	0.0	0.54	0.52	0.72	0.72
8	0.0	0.52	0.48	0.71	0.71

It can be noted that increasing the volume of water in the supply tank by 10 % results in a marginal increase in equity (D_E, UC, and VC); this is likely because the supply is primarily dependent on the available pressure at the node. However, in the case of Chandapillai et al. (2012), equity remains zero (0). It was observed that equity reduces when the shortage of supply increases. Moreover, D_E and UC give almost similar values; however, in comparison to D_E and UC, the VC, gives more equity values.

Furthermore, it is found that the different sizes of water distribution pipes produce different levels of equity for the WDN. Furthermore, according to Ceita et al. (2023), the Volumetric Coefficient (VC) can be used to indicate the demand satisfaction level of the WDNs. Therefore, under full supply, the Itanagar WDN has a demand satisfaction level of 0.73, compared to an ideal value of 1. As a result, it is concluded that the consumer demand of the Itanagar township demand is unsatisfied and necessitates some improvement in the WDN.

5. Conclusion

In this study, the water distribution system of Itanagar township has been analyzed with the help of EPANET 2.2 by Rossman et al. (2020). The study examines the equity and demand satisfaction of the Itanagar WDN using different formulae available from the literature, and the results were obtained in a variety of formats after running the simulation. The following are the novel insights from the study:

(1) In terms of quantity, the study shows that the supplied volume is 11.32% less than the total required demand. Moreover, variations in the supplied volume were observed for different scenarios of water supply.

(2) Moreover, it is observed that the Itanagar WDN involves serious shortcomings that contribute to pressure distribution and shortages of quantity of water. The current water supply method used by the Itanagar city water supply is experiencing a shorter supply duration and a great amount of pressure in the WDN that is below the minimum recommended limits. This indicates that there is insufficient water pressure in the distribution network to reach all parts of Itanagar Town, leading to key socio-economic issues for consumers.

(3) A huge discrepancy in the supply-demand ratio was observed in the Itanagar WDN, and more than half of the demand nodes are facing a shortage of supply volume against their demand. As such, some consumers are getting more than their required share of water, and others are not getting the required demand or supply to sustain their livelihood. Moreover, the level of demand satisfaction of the Itanagar WDN is found to be 0.73 under full supply conditions, which is against its ideal value of 1. This results in consumer dissatisfaction.

(4) Furthermore, the equity of the Itanagar WDN has been analyzed using the available formulas from the literature. It has been found that the equity is 0, 0.55, 0.55, and 0.73 using the formulas of Chandapillai et al. (2012), Ameyaw et al. (2013), Gottipati and Nanduri (2014), and Ceita et al. (2023), respectively which signifies that there is an inequitable distribution of water in Itanagar for a supply duration of 4 hours. Moreover, when supply volume increases, the equity increases marginally and decreases as the supply volume decreases.

Hence, it can be concluded that the Itanagar WDN is facing inequitable distribution of water, and the consumer's demand is not fully satisfied (unsatisfactory), which can be improved by increasing the supply volume and replacing the pipe with larger pipes (Gottipati and Nanduri 2014).

Moreover, in this study, only the hydraulic data of the Itanagar WDN and a freely accessible software toolkit were used (EPANET 2.2). Future researchers can use strategies like using semi-structured interviews to collect relevant data from the households of Itanagar township.

Data Availability Statement

Some or all data, models, or codes that support the findings of the study are available from the corresponding author upon reasonable request.

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Important Notation:

ADEV	:	Average Deviation
AR	:	Artificial reservoir
ASR	:	Average Supply Ratio
CHM	:	Cubic Meter per Hour
CV	:	Check Valve
CWR	:	Clear Water Reservoir
D_E	:	Deviation of Equity
DN	:	Demand node
IWS	:	Intermittent water supply
L/s	:	Liter per Second
MLD	:	Million Liters per Day
Q_j^{req}	:	Required demand at node j
SN	:	Source node
SR	:	Supply ratio
UC	:	Uniformity Coefficient
VC	:	Volumetric Coefficient
WDNs	:	Water Distribution Networks

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