International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 09 Issue: 08 | Aug 2022 www.irjet.net p-ISSN: 2395-0072

A COMPARATIVE STUDY ON DESIGN OF OPTIMAL WATER DISTRIBUTION SYSTEMS USING WATERGEMS AND EXCEL 365 SOFTWARE FOR RURAL AREAS OF RAJASTHAN & UTTARAKHAND

Mamlook Ahmed[1], Mr. Syed Khursheed Ahmad[2]

[1]Professor, Department of Civil Engineering, Al-Falah University, Haryana, India
[2]M. Tech (Student), Department of Civil Engineering, Al- Falah University, Haryana, India

---

Abstract - *Water Distribution system these days are the basic requirement of a well-planned town and cities, without a proper Distribution system we could not achieve the goal of creating the perfect infrastructure for the people. Under this dissertation we will be focusing on studying the different present aspects of the distribution system and by comparing and assessing Topography for the plain and the hilly regions of the Uttarakhand and Rajasthan with respect to the water distribution system, methods to resolve the existing issues and creating models, designs and doing qualitative analysis of the numerous proposed treatment systems and methods discussed. Based on the existing distribution system of a town we can accumulate hydraulic data, digitized maps and topographical surveys that allows you to propose a higher distribution system with remedy plants based on our assessment. We will examine the topography of the study area and primarily based totally on the present situation an offer of full-fledged distribution network can be carried out for the plain regions and Hilly Areas which is selected primarily based totally at the comparative study of various pipe materials and hydraulic modelling of the proposed distribution network in conjunction with the guidelines set by the "CPHEE Manual".*

Key Words: **WaterGems & Excel, Distribution System, Difference Between WaterGems & Excel Design Chart, Rajasthan & Uttarakhand Optimal Water Distribution Design, Hydraulic Modelling.**

1.INTRODUCTION

Water is an important nutrient and performs a key function with inside the human being. A human can live on without meals for numerous weeks however can't stay without water for more days. Water is an important requirement that's required to feature in our frame from molecular and tissues, to important organs. A water distribution machine is an important infrastructure with inside the delivery of water for home in addition to business uses. It connects client to reasserts of water, the usage of hydraulic aspect which includes pipes, valves, pumps and tanks. The number one intention of all water distribution machine engineer is the transport of water to satisfy call for on stress and quantity. This examine is primarily based totally at the want of getting a correctly deliberate and well-engineered distribution machine with inside the rural regions or the beneath Neath evolved regions of the country. As in line with the prevailing scenario occurring with inside the rural and beneath neath evolved regions of the country, we can locate that maximum of the populace there are disadvantaged of the simple sanitation facility like a right water distribution machine, sewage series machine, toilets, waste remedy and disposal facility etc. A water distribution machine is part of water deliver community with additives that bring potable water from a centralized remedy plant or wells to water purchasers which will correctly supply water to meet residential, commercial, business and firefighting requirements. These simple facilities now no longer most effective offer with higher lifestyles requirements however additionally provide the expertise of now no longer losing the surroundings and to preserve it.

The subject matter for this examines is **"A Comparative Study on Design of Optimal Water Distribution Systems Using Water GEMS and Excel 365 Software for Rural Areas of Rajasthan & Uttarakhand"**. The examiner will consciousness on the prevailing troubles confronted through the human beings residing with inside the rural and beneath neath evolved regions due to the absence or a negative functioning distribution machine and additionally information the exclusive layout standards and elements to be taken into consideration for designing a distribution machine in a simple and Hilly region. To do a majority of these calculations and observations we can be analyzing the facts that we've got received for the projected vicinity (like topography, populace etc.) and primarily based totally at the Indian requirements and the CPHEEO Manual we can be designing a full-fledged community machine primarily based totally at the call for that we can be calculating through projecting the populace of the projected vicinity and additionally relying at the cultural and social factor of the projected vicinity.

1.1 MOTIVATION OF PRESENT STUDY

Providing sufficient water of suitable excellent and amount has been one of the maximum critical troubles in human history. People started to move water from different places to their communities. For example, the Romans built

aqueducts to supply water from distant sources to their communities. The reason of distribution machine is to supply water to customer with suitable excellent, amount and pressure. Distribution machine is used to explain together the centers used to deliver water from its supply to the factor of usage. Rapidly growing populace has brought about the want for modern techniques to manipulate a water deliver machine. There are many rural and underdeveloped regions which aren't supplied with simple services of lifestyles like water deliver, and that they have journey some distance to accumulate the ingesting water which is additionally now no longer of good enough excellent as prescribed with inside the standards. All those elements are the actual motivation in the back of our look at and the actual cause why we want a full-fledged distribution machine and that too of the appropriate nature and additionally to train the humans why we want a full-fledged distribution machine due to the fact the not unusual place humans are the final purchasers of those centers. To cater the requirement of the destiny era and populace it's miles essential to lay out a superior and reasonable distribution network.

1.2 SCOPE OF PRESENT STUDY

Water mains network demonstrating propels are essential for water industry. There must utilize demonstrating improvement to upgrade the precision of water mains model support and adjustment. This can offer a pathway to ongoing and near constant functional demonstrating support. In view of the above conversation, the extent of the review is as per the following:

- Similar Assessment of proposed network in plain region and sloping region
- Planning of format of water supply Network
- Arrangement of goal to determine existing condition
- Pressure driven Modeling of proposed network
- Evaluation of existing facility network inside the projected region
- Population estimating and request examination

1.3 OBJECTIVE OF PRESENT STUDY

- Understanding the designing situation for the Plain regions and Hilly Areas which aren't the same, there are numerous layout issues that are stored to be in thoughts even as designing a simple place distribution community and a Hilly place community.
- The important layout standards to be made for such community is to pick the pipe diameter and pipe material. Larger the diameter, higher is the provider however then again will now no longer be economical.
- Not only to layout an effective but additionally a cheap water deliver scheme.
- To layout of most suitable water distribution system the usage of water Gems
- Doing a comparative evaluation of distribution network layout in Plain Areas and Hilly Areas.

2. LITERATURE REVIEW

With the increasing population and demand of basic amenities like water supply distribution network has led many researchers and scholars to do research studies on the different aspects of the infrastructure need, different methodologies and equipment's throughout different course of time. Some of which are mentioned below that are helpful to understand the basic concept behind this thesis.

2.1 Analysis of Existing Water Distribution Network by Using Water GEMS A Case Study of Rajkot City, 2018

Rajkot has been selected as the study area in this literature review. Rajkot is located within side the center of the peninsular Saurashtra in central plains of Gujarat State of Western India at a top of 138 m above mean sea level. The Water distribution network performs important role in providing water to end user. Water GEMS is hydraulic modeling software which is used for analysis and design of water distribution network. The end result obtained confirmed that the pressure at all junction and the flows with their velocities in any respect pipes are viable sufficient to provide adequate water to the network of study place. The stop end result will assist to recognize the pipelines system of the look at place in a higher way. At the end of the analysis, it turned into located that the resulting pressure at all nodes and the flows with their velocities are enough to offer to the look at place (Virjibhai Vaghela & Bhagat, 2018).

3. METHODOLOGY

- **Village Lalpura (Block – Arthoona District-Banswara -Rajasthan.**
- We have selected Village Lalpura of Block Arthoona District Banswara Rajasthan as study area for simple location and Village Lalpura as study location for Plain location. A most beneficial and powerful design will be completed the usage of **WaterGEMS software** program together with the comparative evaluation of those regions.
- **Village Devipura (Block – Kotabagh District- Nainital Uttrakhand.**

We have selected Village Devipura of Block Kotabagh Nainital district for our study. The Nainital district

incorporates of 8 Blocks. (Betel Ghat, Bhimtal, Dhari, Haldwani, Kotabagh, OkhalkandaRamgarh & Ramnagar). Out of which a few are categorized in simple regions and more in hilly location. A most beneficial and powerful design will be completed the usage of Excel **365 software** program together with the comparative evaluation of those regions. Under the current scenario, the existing distribution system consists of PVC and AC pipes that are between 25 and 30 years old. According to the CPHEEO manual, its lifespan has expired. In addition, the existing pipes have a very small diameter and problems with leaks, so the existing network is not robust and could not meet the future water demand and the residual pressure criteria

Considering the general coverage of the project area, meeting the future water demand and the desired residual pressure, it is necessary to design a new piping network system for our project area.

The census data was collected from District Census Manual, Dehradun District from 1971 to 2011. The census population of the villages is given below:

Note: - The census population data has been collected from the District Census Handbook, District Banswara & Nainital from year 1971 to 2011. The Graphical representation of the population data has been depicted in the form of Bar chart for both the villages below:

Table -1: Census Population

Sr. No.	Town	Census Population				
		1971	1981	1991	2001	2011
1	Lalpura	356	401	550	718	941
2	Devipura	70	83	100	112	101

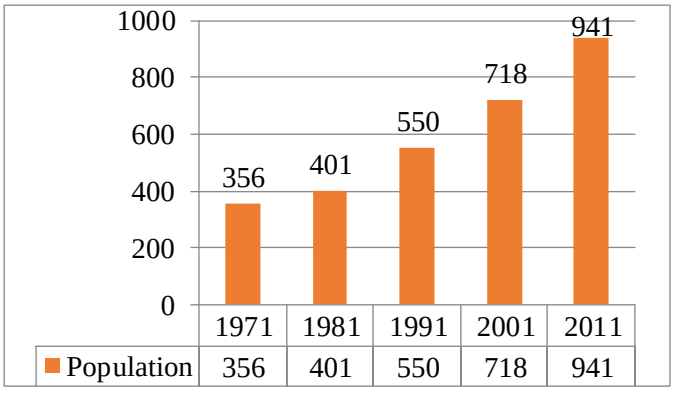

Chart -1: Lalpura census Population

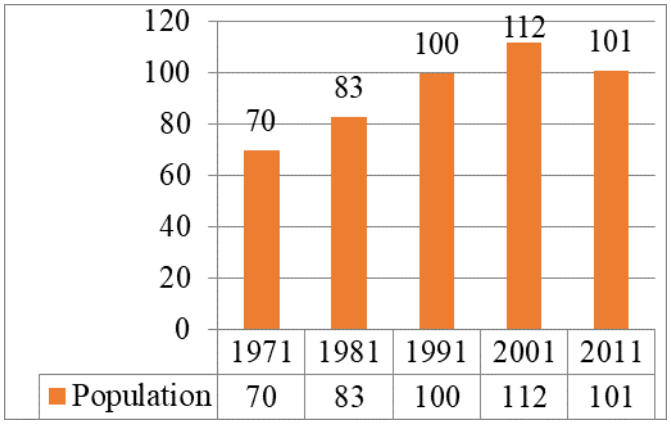

Chart -2: Devipura Census Population

We will use different technical formulas for the population forecast. The projected population is used to calculate the base year, intermediate year, and planning year water requirements that are used to design our optimized distribution network. After analyzing the growth pattern of the village, the appropriate method for our design area is selected.

The various Methods are as follows: -

1) Arithmetical Increase Method
2) Geometrical Increase Method
3) Incremental Increase Method
4) Graphical Method

Taking a gander at the development pattern of the village and per the CPHEEO Manual, **Geometrical Increase method** is the most ideal for the population projection of these village.

The projected populations for both the villages are given below:

Table-2: Projected Population

Sr. No.	Village	Population in the Year			
		2011	2024	2039	2054
1	Lalpura	941	1268	1790	2527
2	Devipura	101	104	122	138

4. Existing Water Supply Arrangement & Necessity of the Project:

The village Lalpura of Gram Panchayat Ora, Block Arthoona , District Banswara is benefitted with Hand Pump Scheme. The existing water supply system does not fulfill requirements of JJM in providing water supply through FHTC to each HH @55 lpcd with a minimum terminal pressure of 7m. Accordingly this proposal is being prepared to provide

suitable water supply system in this village to meet above objective. Detailed Hydrogeological investigations have been carried out to identify suitable Ground Water source to provide required quantity of potable water.
There are no existing data of Devipura village of Nainital district. Because river and Gadhera source water was used.

5. Topographical Analysis

Topography can be described as the study of the different properties and types of earth's surfaces. Topography is a field of earth science and planetary technology and is concerned with local detail in general, including not only relief but also natural and man-made features and even nearby records and culture. The topography of the time comes particularly from historical Greece, which is of importance because of the special description of the place. The main goal of the topography is the approximate knowledge of the coordinate system of the project area. By coordinates we mean the exact longitude and longitude of the region and also roughly understand the positions of features that are in our project area. A topographical survey can be carried out for several reasons: the development of military plans and geological exploration have been the main motivators for initiating surveying programs, but the particular information about the characteristics of the terrain and the surface is essential for the planning and construction of major civil engineering, public works or reclamation projects. Another important component of topographical analysis is understanding G.L. (Ground Elevations). It is the most important and critical component to take care of as it determines the slope of the area, the locations of the water components like the upper tank, pump and treatment units etc. Another fundamental element for the water supply project is the source. As the source for our water supply project, we have chosen an open well/pipe well/Gadhera.

Figure -1: Lalpura Topography

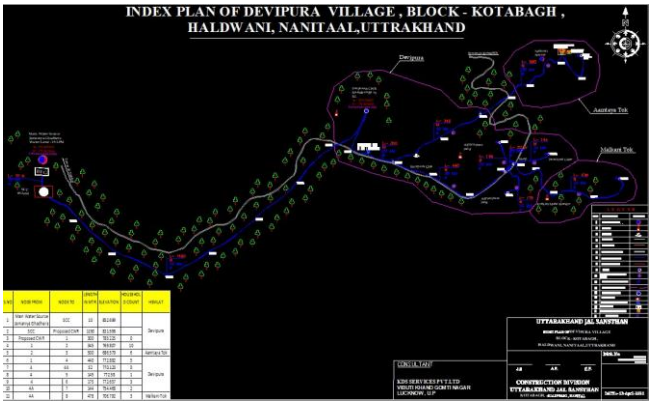

Figure -2: Devipura Topography

6. HYDRAULIC DESIGN RESULTS OF WATER NETWORK

In the water distribution design, we've got to check the numerous constraints and requirements made by the CPHEEO for water network design. The Head loss gradient has been kept much less than 4.0 m/Km. For velocity we found out that a few points we couldn't gain the minimum self-cleaning velocity. Those pipes are the end points or end pipes wherein minimal velocity became not done due to the minimum pipe diameter constrain. However, the minimal residual pressure of 7.0 m has been maintained at all of the end points as in keeping with the CPHEEO manual and Jal Jeevan mission guidelines.

6.1 Sizing Calculations

Hazen-William's formula is used for computing velocity, which is expressed as follows:

$$V = 0.849\ C\ R^{0.63} S^{0.54}$$

For circular conduits, the expression becomes

$$V = 4.567\ x\ 10^{-3}\ C\ D^{0.63} S^{0.54}$$

And

$$Q = 1.292\ x\ 10^{-5} C\ D^{2.63} S^{0.54}$$

Where,

Q = Discharge in cum/hour
D = Internal diameter of pipe in mm
V = Velocity in m/sec
R = Hydraulic radius in m
S = Slope of hydraulic gradient
C = Hazen Williams coefficient

Table 3: Hazen Williams Coefficient

1	Cast Iron & Ductile Iron	140
2	Galvanized Iron & MS ERW	100
3	Concrete pipes	140
4	PVC, GRP & HDPE Pipes	145
5	Mild Steel	140

5.2 Difference Between WaterGems, Excel Design Chart Parameters

Table-4: WaterGems Design Chart-Pipe Details

Distribution System										
Hydraulic Modelling Results for Pipe Table										
Village Name: LALPURA, Panchayat Name: ORA, Block Name: Arthoona										
Label	**Start Node**	**Stop Node**	**Material**	**Diameter (mm)**	**Flow (Absolute) (m^3/day)**	**Length (Scaled) (m)**	**Hazen-Williams C**	**Headloss (m)**	**Headloss Gradient (m/km)**	**Velocity (m/s)**
P-1	J-1	PROPOSED_OHSR_LALPURA_100KL_18m	HD/P	112.3	597.6	37	145	0.16	4.47	0.6983
P-2	J-1	J-2	HD/P	97.5	593.2	14	145	0.13	8.774	0.9196
P-3	J-2	J-3	HD/P	80.9	291.8	133	145	0.78	5.853	0.657
P-4	J-3	J-4	DI/P	100	280.5	92	140	0.19	2.067	0.4133
P-5	J-2	J-13	HD/P	80.9	277.8	324	145	1.73	5.344	0.6254
P-6	J-4	J-5	HD/P	80.9	268.8	141	145	0.71	5.027	0.6051
P-7	J-6	J-5	HD/P	80.9	259.0	54	145	0.25	4.693	0.5831
P-8	J-10	J-6	HD/P	67.3	215.1	203	145	1.65	8.157	0.6998
P-9	J-8	J-10	HD/P	67.3	167.2	555	145	2.84	5.115	0.5439
P-10	J-13	J-20	HD/P	67.3	155.1	606	145	2.70	4.449	0.5045

Table-5: WaterGems Design Chart-Junction, Pressure

Distribution System				
Hydraulic Modelling Results for Junction Table				
Village Name : LALPURA, Panchayat Name : ORA, Block Name : Arthoona				
Label	**Elevation (m)**	**Demand (m^3/day)**	**Hydraulic Grade (m)**	**Pressure (m H2O)**
J-1	189.50	4.41	208.14	18.59
J-2	188.71	23.64	208.01	19.25
J-3	186.16	11.32	207.23	21.02
J-4	184.37	11.71	207.04	22.61
J-5	181.32	9.77	206.33	24.95
J-6	179.12	28.38	206.08	26.89
J-7	171.12	36.66	200.90	29.70
J-8	171.51	38.93	201.59	30.01
J-9	171.81	34.00	202.71	30.83
J-10	173.19	42.97	204.42	31.16

Table-6: Excel Design Chart

DESIGN CHART OF SUPPLY MAIN AND DISTRIBUTION SYSTEM																		
Peak Factor For Supply main				1					0.74				107.9801	LPCD	Age of old pipe			0
Peak Factor For Distribution				3														
Node	Line	Length (M)	Sectional population	Total Cumulative Population	Discharge (Average) (Qt) (Litre)/ day	Dia of existing old pipe (Do)	Cr of Old pipe	Dia of New Pipe	Cr of new pipe	Peak /Design Discharge through new pipe(Qt) (Litre)/day	Velocity in new pipe (m/ sec)	Head loss M/1000 M	Total Head loss (m)	Hydraulic Level	Ground Level	Terminal Pressure at "From ".	Static head	Remark	SM/DM
			Permanent	Permanent															
1	2	3	4	5	6	7	8	7	8	9	8	10	11	12	13	14		15	
Supply Main system JAMANIYA																			
BFG_JG Outlet														854.858	855.458	-0.600		BFG_(Outlet)	SM
SCC_JG (Inlet)	BFG_JG Outlet--SCC_JG (Inlet)	10	0	136	14685	0	0.740	25	0.74	14685	0.346	13.241	0.132	854.726	852.699	2.027	2.159		SM
SCC_JG (Outlet)														854.499	852.699	1.800		SCC_(Outlet)	SM
CWR_1 (Inlet)	SCC_JG (Outlet)--CWR_1 (Inlet)	1150	0	136	14685	0	0.740	25	0.74	14685	0.346	13.241	15.227	839.272	821.56	17.713	32.940		SM
CWR_1 (Outlet)														820.959	821.56	-0.600		CWR_(Outlet)	SM
Distribution System Jamaniya																			DS
CWR_1 (Outlet)														820.959	821.559	-0.600		CWR	DS
1	CWR_1 (Outlet)--1	300	0	136	44056	0	0.74	32	0.74	44056	0.634	29.5	8.850	812.109	785.225	26.884	35.734	JP	DS
2	1--2	345	45	73	23648	0	0.74	20	0.74	23648	0.8712	91.737	31.649	780.460	769.807	10.653	51.152	HC	DS
3	2--3	500	27	27	8746	0	0.74	20	0.74	8746	0.322	15.16	7.580	772.880	686.579	86.301	134.380	HC	DS
1														812.109	785.225	26.884	35.734	JP	DS
4	1--4	440	23	63	20408	0	0.74	20	0.74	20408	0.752	70.265	30.916	781.193	772.882	26.884	39.227	JP	DS
5	4--5	145	5	5	1620	0	0.74	20	0.74	1620	0.060	0.7163	0.104	781.089	772.58	8.509	39.529	HC	DS
4														781.193	772.882	26.884	39.227	JP	DS
6	4--6	175	14	14	4535	0	0.74	20	0.74	4535	0.1671	4.618	0.808	780.385	772.657	7.728	27.109	HC	DS
4														781.193	772.882	26.884	39.227	JP	DS
4A	4--4A	52	0	9	2915	0	0.74	20	0.74	2915	0.1074	2.075	0.108	781.085	770.123	10.962	29.643	JP	DS
7	4A--7	144	9	9	2915	0	0.74	20	0.74	2915	0.1074	2.075	0.299	780.894	754.468	26.426	45.298	HC	DS
4A														781.085	770.123	10.962	29.643	JP	DS
8	4A--8	478	14	14	4535	0	0.74	20	0.74	4535	0.167	4.6177	2.207	778.878	706.792	72.086	74.293	HC	DS

6. RESULTS AND DISCUSSION

6.1 Selection of pipe material

There are exceptional pipe materials available for the piped water supply scheme. However, it is necessary to take suitable and judicious selection approximately the pipe material choice because the main project cost and its performance depends upon the pipe material. As we're discussing approximately the plain location and hilly regions topographical situations in our thesis, in order per CPHEEO manual and exceptional practical situations, For Plain regions we've got decided on HDPE pipe (Class - PE100 PN 10) for the distribution system for the lower diameter as much as 100mm that is to be laid withinside the colonies because of the reduced price and capabilities likes portability, flexibility and clean transportation additionally no heavy traffic is anticipated in colonies and for the bigger diameter 150mm and above, we've got decided on DI (Class K-7) that is to be laid on main roads and going to be handle the heavy traffic loads.

6.2 Service reservoir

Different controlling devices which are cited withinside our network like Sluice valve, scour valve, air valve and pressure release valve. However, the maximum important controlling device utilized in our assignment for the hilly regions is pressure release valve. Due to the hilly topography, the distinction among the minimum and maximum elevation is round 100m, which may be very big for any project and also inflicting the very excessive terminal pressures on the end points which want to be controlled. Hence pressure release valve is used to manipulate this pressure. They are set up on the distinctive places when the pressure of network turned into going excessive. It worked as consistent with its mechanism and helped in maintaining the nominal pressure withinside the distribution network. However, this valve isn't needed in the plain region.

6.3 Appurtenances

There are exceptional pipe materials available for the piped water supply scheme. However, it is necessary to take suitable and judicious selection approximately the pipe material choice because the main project cost and its performance depends upon the pipe material. As we're discussing approximately the plain location and hilly regions topographical situations in our thesis, in order per CPHEEO manual and exceptional practical situations, For Plain regions we've got decided on HDPE pipe (Class - PE100 PN 10) for the distribution system for the lower diameter as much as 100mm that is to be laid withinside the colonies because of the reduced price and capabilities likes portability, flexibility and clean transportation additionally no heavy traffic is anticipated in colonies and for the bigger diameter 150mm and above, we've got decided on DI (Class K-7) that is to be laid on main roads and going to be handle the heavy traffic loads.

7. CONCLUSIONS

Depending on our complete study we got here to see that there is want of getting an effectively planned and well-engineered distribution system withinside the rural areas or the below developed areas of the country. Various applicable information like existing available infrastructure, census data of last five decades, population projections, choice of pipe material, numerous designs constrain are all of the components of planning for the efficient water distribution network. These simple amenities not handiest offer with higher lifestyles requirements however additionally provide the knowledge of not wasting the environment and to preserve it. The observe has targeted on the present issues faced through the humans living withinside the rural and below developed regions due to the absence or a poor functioning distribution system and additionally know-how the exceptional design criteria and elements to be taken into consideration for designing a distribution system in a simple and Hilly region.

Referring to Chapter 5 “Results and Discussion” we've mentioned approximately the pipe material choice as in keeping with the apparent areas and hilly regions. Relevant pipe material having their personal advantages and economical as in keeping with the site situations have been decided on. The storage reservoir is also selected as in keeping with the site situations and numerous appurtenances or controlling devices had been used to make our distribution community system efficient. For us observe the CPHEEO Manual on Water supply and Treatment & Jal Jeevan mission guidelines are the maximum important record which gave us the design requirements and parameters, necessary to be observed which offers a clear idea approximately the design of numerous components which might be involved in our study during the complete process of the hydraulic design.

The main focus of our study became to evaluate the numerous design parameters withinside the plain and the hilly regions, understating the numerous demanding situations faced for the duration of the design and to resolve them following an appropriate method of hydraulic evaluation and design to offer the ones areas with higher water distribution system that may help the area to obtain balance and sustainability.

REFERENCES

1) Virjibhai Vaghela, P., & Bhagat, S. S. (2018). Analysis of Existing Water Distribution Network by Using Watergems: a Case Study of Rajkot City. 1–5. www.ijaresm.net

2) Hooda, N., & Damani, O. (2017). A System for Optimal Design of Pressure Constrained Branched Piped Water Networks. Procedia Engineering, 186, 349–356. https://doi.org/10.1016/j.proeng.2017.03.21

3) Paneria, D. B., & Bhatt, B. V. (2017). Analyzing the existing water distribution system of Surat using Bentley Water GEMS. Journal of Emerging Technologies and Innovative Research (JETIR), 4(05), 19–23.

4) Sonaje, N. P., & Joshi, M. G. (2015). A review of modeling and application of water distribution networks wdn softwares. International Journal of Technical Research and Applications, 3(5), 174–178.

5) TINA MAVI, D.R. VAIDYA (2018) Study and Design of 24/7 Water Supply Distribution System by WaterGEMS Sujal-Nirmal Abhiyaan.

6) Ashwini Patil, Aishwarya Suryavanshi1, Hemali Mahajan2, Akshay Jadhav3, Rameshwar Gore (2019) Design of Water Supply Scheme of Bhugaon Village, Mulshi, Pune.

7) Mateo Jaramillo Echeverri (2016) Manizales' Water Distribution System.

8) Vinod Kothari a, Suman Vij b, SuneshKumar Sharma c, Neha Gupta (2020) Correlation of various water quality parameters and water quality index of districts of Uttarakhand.

9) Chaudhari, A. G., Joshi, A. K., Bhosale, N. S., Dalavi, N. K., & Khode, P. S. (2017). review study: Expermental investigation by WaterGEMS software for redesign of water distribution system of Bhavani Mata ESR. Guru Gobind Singh College of Engineering and Research Center, 604–608.

10) Richárd Wéber ∗, Tamás Huzsvár , Csaba H ˝os (2020) Vulnerability analysis of water distribution networks to accidental pipe burst.