International Journal of Advances in Engineering and Management (IJAEM)
Volume 2, Issue 6, pp: 84-92 www.ijaem.net ISSN: 2395-5252

Management and Control of New Water Distribution Network by Using Geographic Information System Technology

Duni Chand [1]
1_(Student,M Tech.in Water Resources Engg.,SIRDA Institute of Engineering & Technology,Naulakha,Sundernagar (HP))

Date of Submission: 30-08-2020 Date of Acceptance: 16-09-2020

ABSTRACT: This is study of upcoming Kullu City of District Kullu in the Indian of Himachal Pradesh. This study explains the paucity of water supply system in city and planning of sufficient water supply and distribution network using GIS & Remote Sensing techniques. For this field survey has been carried out to assess the exact site conditions. An increasing demand of water due to population growth and agriculture use necessitate proper distribution network system. Application of GIS in this project will help to planning a sufficient water distribution network, carried out by developing the various thematic maps and the integrating various field and administrative information in the GIS environment. The planning and designing in respective sectors like water distribution network, Road network, and information of land use has been carried out by using Arc GIS Software. By using Remote Sensing the water quality will be monitored. For better planning of WDN, the ground water exploration can be done by using RS. The remote sensing uses electromagnetic spectrum to image the land, ocean and atmosphere by using electromagnetic radiation (EMR) at the different wavelengths (visible, red, near-infrared, thermal infrared, microwave). This study combines application of GIS & RS as a framework for managing and integrating data by the Quantum GIS i.e. (QGIS) with the mainly three hydraulic plug-in i.e. G-hydraulics, the Open layer and Qgis2threejs.Ghydraulics allows to analysis WDN with the EPANET, open layer with open street maps whereas Qgis2threejs plug-in helps in exporting terrain data, mapping canvas image and vector data to the web browser and later analyzing through hydraulic simulation in EPANET.

KEYWORDS: Components: Water Distribution Network, Arc GIS, Hydraulic Simulations, EMR, EPANET, Data Elevation model, LISS, Q-GIS etc.

I. INTRODUCTION

Water Distribution Network serves the community and also helps power the economy by delivering water from a source to its consumers. WDN is comprised of three primary components; water source, treatment and water distribution network. Water resources can be reservoirs, rivers and groundwater wells. Water treatment facilities disinfect the water to during water quality standards prior to delivering it to its consumers. The WDN is responsible for delivering water from the source or treatment facilities to its consumers at serviceable pressure and mainly consists of pipes, pumps, junction or nodes, valves, fittings and storage tanks. A large amount of money is invested around the world to provide piped water supply facilities. Even then, an enormous population of the world is suffering by inadequate water supply network. Approx. 80 to 85% of the cost of a total water supply network is contributed toward water transmission and the water distribution network. Study shown the paucity of the WDN in Kullu City of the Himachal Pradesh, existing source of water in the City is **Sarwari Khad,** but the Khad is so polluted. It needs to its treatment before using for different purpose. This process is not able to distribute the sufficient amount of water to every house in the city.

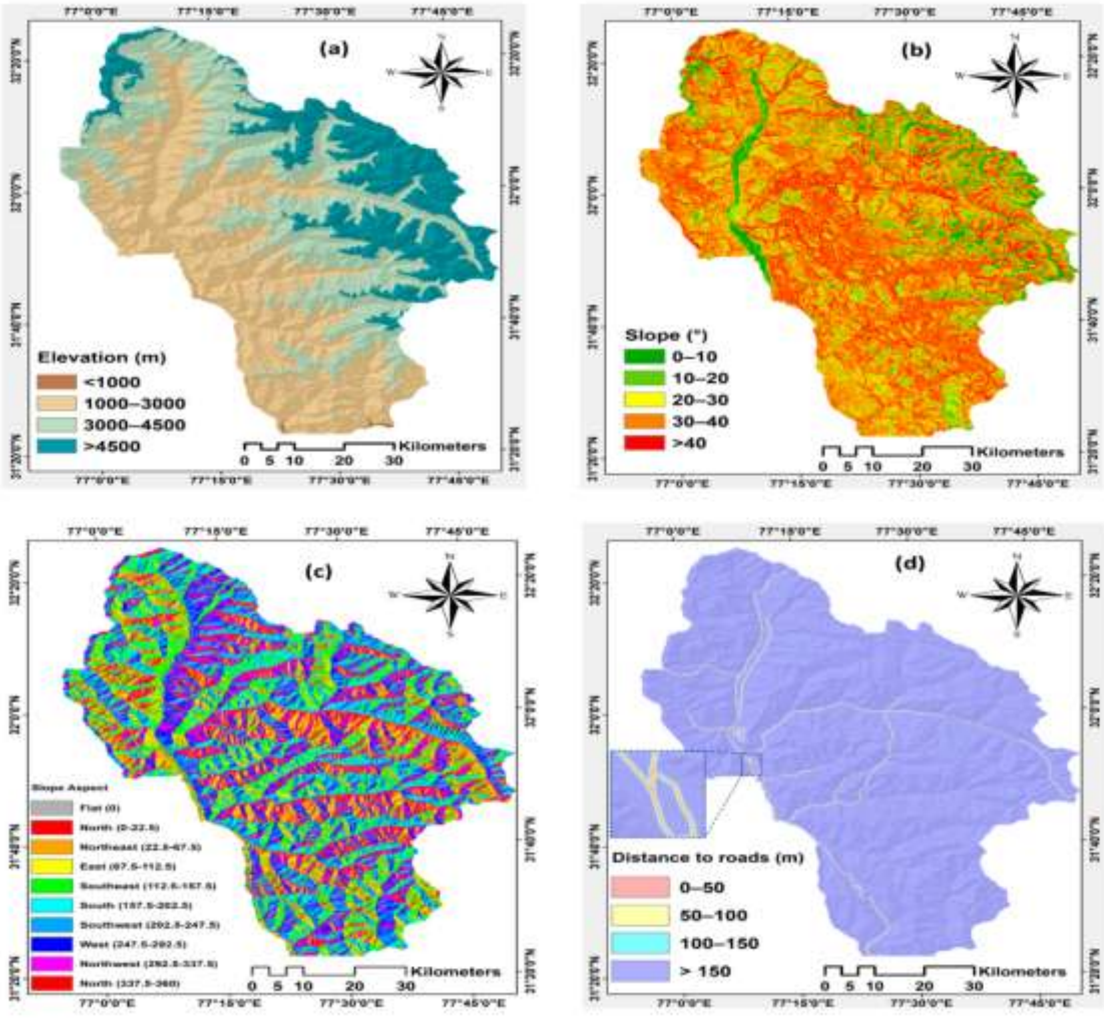
II. GENERAL INFORMATION

Kullu is the upcoming city in the Indian State of Himachal Pradesh. This is located at the Bank of Beas River. The city lies in northern part Himachal between latitude 31.5800º North and longitude 77.1000º east, and is famous for tourism. The density of population is 2,766 persons per square kilometres. **The total area of study contains Kullu town, which is prime study area having area of 1,171 kilometres square.**

Year	Population	Males	Females	Numbers of Household	Population Growth
2001	18,306	10,470	7,836	4,196	1.25%
2011	18,536	9,608	8,928	4,656	1.01%

(Table No. 1: Demographic Details of Kullu City)

III. SLOPE MAP OF KULLU CITY

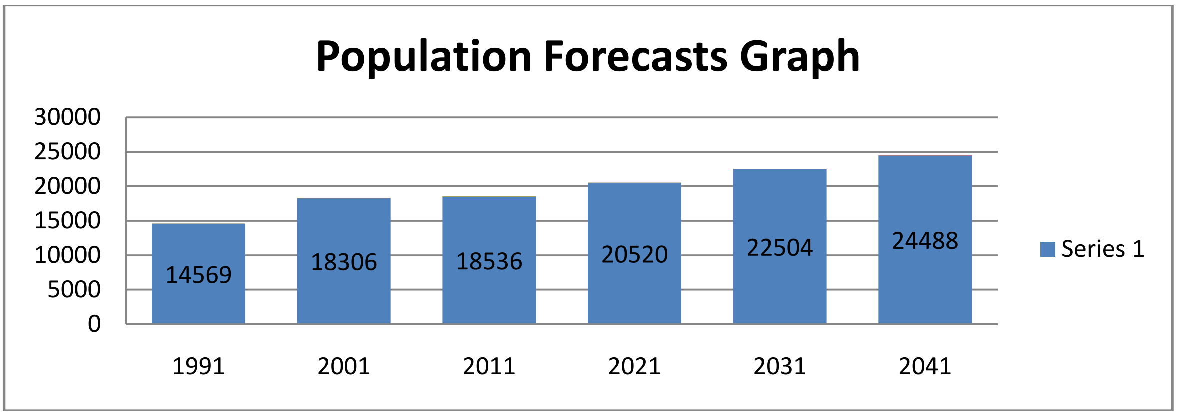


(Figure No. 1: The Slope Map of Kullu City)

IV. POPULATION GROWTH & POPULATION FORECASTS

Year	1991	2001	2011
Population	14,569	18,306	18,536

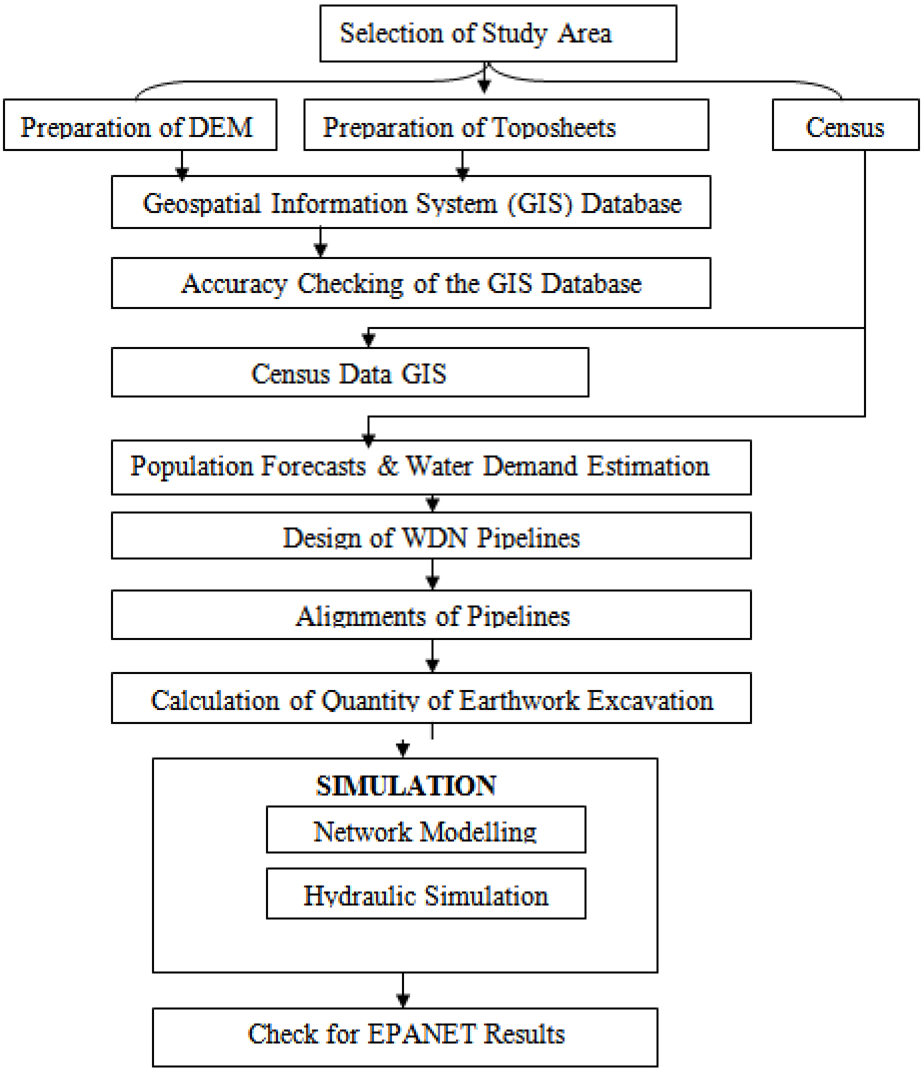
(Table No. 2: Popolation Forecast According to Census 2011)



(Figure No. 2: Population Forecasts Graph by using Arithmetic Increase Method)

V. METHODOLOGY

A) Flow Chart of GIS Technology Used for WDN:



(Figure No. 3: Flowchart for methodology of GIS for Water Distribution Network)

B) Selection of Study Area

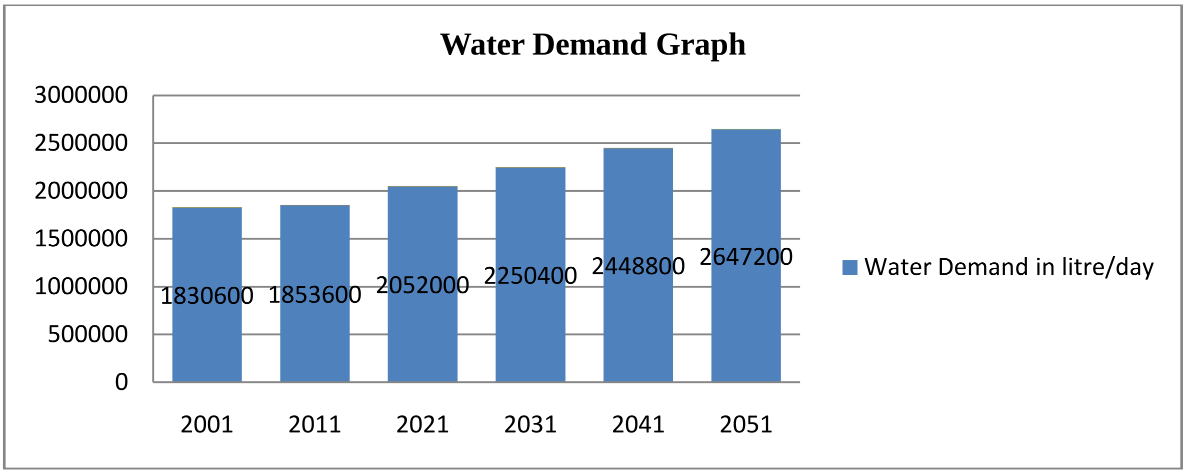
The WDN is responsible for delivering water from the source or treatment facilities to its consumers at serviceable pressure and mainly consists of pipes, pumps, junction or nodes, valves, fittings and storage tanks. A large amount of money is invested around the world to provide piped water supply facilities. Even then, an enormous population of the world is suffering by inadequate water supply network. Approx. 80 to 85% of the cost of a total water supply network is contributed toward water transmission and the water distribution network. Study shown the paucity of the WDN in Kullu City of the Himachal Pradesh, existing source of water in the City is **Sarwari Khad,** but the Khad is so polluted. It needs to its treatment before using for different purpose. This process is not able to distribute the sufficient amount of water to every house in the city. This study includes the determination of the daily water demand and population forecasting within design period of water supply system and planning of piped water network system connecting each houses of the whole part of city.

(Figure No. 4: The Location of Study Area)

C) Water Demand: The Municipal Corporation Kullu is sub-divided into 11 wards by considering the area and road network for proper planning of different facilities. For ward wise water demand is shown in Following Table.

Ward Name	Population	No. of Households	Water demand (Per person 100lpcd)
Ram Shilla	1449	341	144900
Akhara Bazaar	1788	337	178800
Beasa	1223	320	122300
Sarwari	1108	271	110800
Khori Ropa	1181	274	118100
Shisha Matti	1287	295	128700
Dhalpur	953	264	95300
Lower Dhalpur	2436	614	243600
Kahudhar	2764	674	276400
Gandhinagar	2745	807	274500
Sultanpur	1902	459	190200
Total	**18,536**	**4,656**	**1853600**

(Table No. 3: Water Demand of Kullu City)



(Figure No. 5: Water Demand Graph)

D) Planning Stage: The following Five Steps should be consider for planning purpose i.e.

a) As per the GWSSB Norms, the daily requirement of people of the Kullu City is 100 litres/person/capita/day but existing water supply system gets fail to fulfil their requirements. For that new planning of water supply system is necessary.

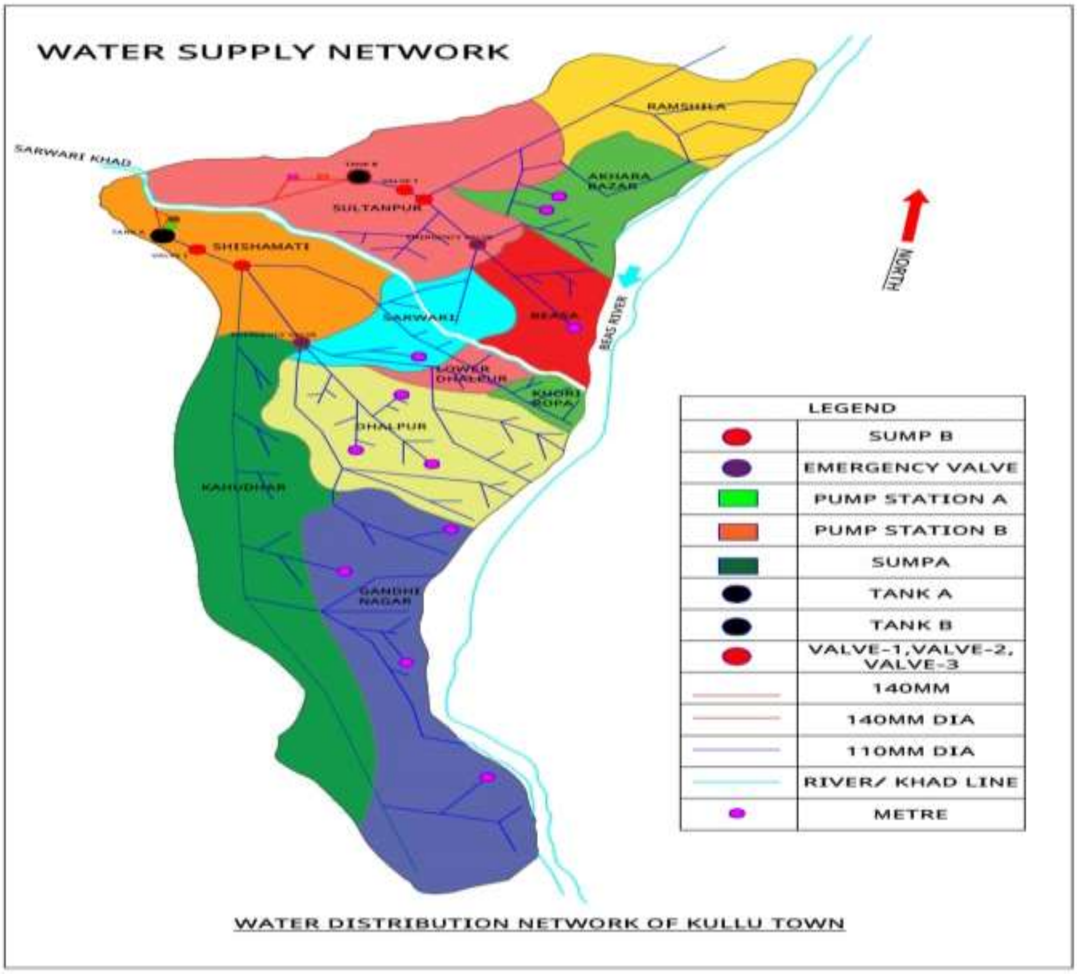
b) Suggestion of one Tank, there is already one tank is present in city, which is not in operational condition. Tank A & Tank B of 10 lakh litres capacity would be more better option and also suggest 2 sump well which is required also 10 lakh litter capacity of water.

c) From Beas River, the river will be connected to the branch pipe line and water will be supply to the ESR and SUMP well.

d) Tank A will cover 6 out of 11wards and Tank B will cover remaining 5 wards. As per CPEEHO manual and GWSSB norms, Diameter of pipe from canal to ESR will be of 140mm and ESR to home of villages OR branch pipe lines will be of 110mm.There will be ward wise valve and also one emergency valve & sensors fitting is also suggested.

e) In case due to some problem Tank A stop working then there will be a provision in a Tank B to supply water in all 11 wards, and if the Tank B stop working then Tank A will cover all 11 wards. Provision of valve will be there if one want to stop supply to any ward, and it also used for increase the supply ward as well.

E) Alignment of WDN Pipelines - New alignment of water distribution network is prepared with the help of Digital Elevation Model (DEM) map, Contour Map and Slope Map it gives the topographical data of the surface means it provides the information about hilly and flat area along the village which is helpful in alignment of the water distribution pipe lines.



(Figure No. 6: The New Water Distribution Network for Kullu City)

F) Formula Selection Criteria for the Study Area - The hydraulic head loss by water flowing in a pipe due to friction with the pipe walls can be computed using one of three different formulas: a) Darcy-Weisbach formula b) Hazen-Williams formula and c) Chezy- Manning formula. The Hazen-Williams formula is the most commonly used head loss formula all over the world. It cannot be used for liquids other than water and was originally developed for turbulent flow only. The Darcy Weisbach formula is the most theoretically correct. It applies over all flow regimes and to all liquids. Chezy & Manning formula cannot be applied as it is for open channel

Sr. No.	Parameters for Formula Selection	Darcy-Weisbach	Hazen- Williams	Manning
1	Fluids	*All Fluids	*Only Water	*Only Water
2	Friction Factor “f” or Roughness co-eff. “C”	Tedious to Obtain “f”	*Easy to Obtain “C”	*Easy to Obtain “n”
3	Flow Type	*Any flow	*Smooth Flow	Rough Flow
4	Open/Closed	*Closed pipes	*Closed pipes	Open Channel
5	Selection of Formula0	Not Applicable	Applicable	Not Applicable

(Table No. 4: Formula Selection Criteria for the Study Area)

The water distribution network will be solved using the Hazen William's formulae as it is the best-suited method for solving the gravity based water distribution networks. Hydraulic software EPANET will be used for determining discharge, velocity, head losses, etc. for the given WDN.

Hazen William Formula:

1. Head loss (H_f) = $10.70Q^{1.852}L/D^{4.87}C^{1.852}$

2. Velocity (V) = $0.354CD^{0.63}S^{0.54}$

3. Discharge (Q) = $0.278CD^{2.630}S^{0.54}$

Where, Q=Discharge; C= Hazen William Coefficient; D = Diameter; S = Hydraulic Gradient, L= Length of the pipe; V = Velocity of flow; H_f = Head L

Each formula uses different pipe roughness coefficient that must be determined empirically. Be aware that a pipe's roughness coefficient can change considerably with age.

Sr. No.	Material Type	Roughness Co-efficient
1	#Vitrified Clay	110
2	GI pipes	120
3	Concrete pipes	130
4	Cast iron	140
5	Fibre/PVC	150

(Table No. 5: Different Roughness Co-efficient for different types of pipes)

G) Cost Estimation for Water Distribution Pipelines: From the planning of the new water distribution network of city total length of pipes planned per ward are as below:

Sr. No.	Main Pipe	Length (m)	Rate Per Metres (GI pipes 140 mm dia.)	Cost (Rs.)
1	Treatment Plant to Tank A	850	300	2,55,000
2	Ground water storage Tank to Tank B	500	300	1,50,000
Total Cost of Main Pipes				4,05,000

(Table No. 6: Estimation cost of Main Pipes for New WDN)

Ward No.	Ward Name	Length (m)	Rate per metres of GI pipes of 110 mm Diameters.	Cost (Rs.)
1	Ram Shilla	2500	162	4,05,000
2	Akhara Bazaar	2600	162	4,21,200
3	Beasa	2200	162	3,56,400
4	Sultanpur	2400	162	3,88,800
5	Sarwari	2100	162	3,40,200
6	Khori Ropa	1000	162	1,62,000
7	Shisha Matti	1200	162	1,94,400
8	Dhalpur	500	162	81,000
9	Lower Dhalpur	950	162	1,53,900
10	Kahu Dhar	1100	162	1,78,200
11	Gandhi Nagar	1400	162	2,26,800
Total Cost of Branch Pipes				**29,07,900**
The Grand Total Cost				**33,12,900**

(Table No. 7: Estimation Cost of Branch Pipes for New WDN)

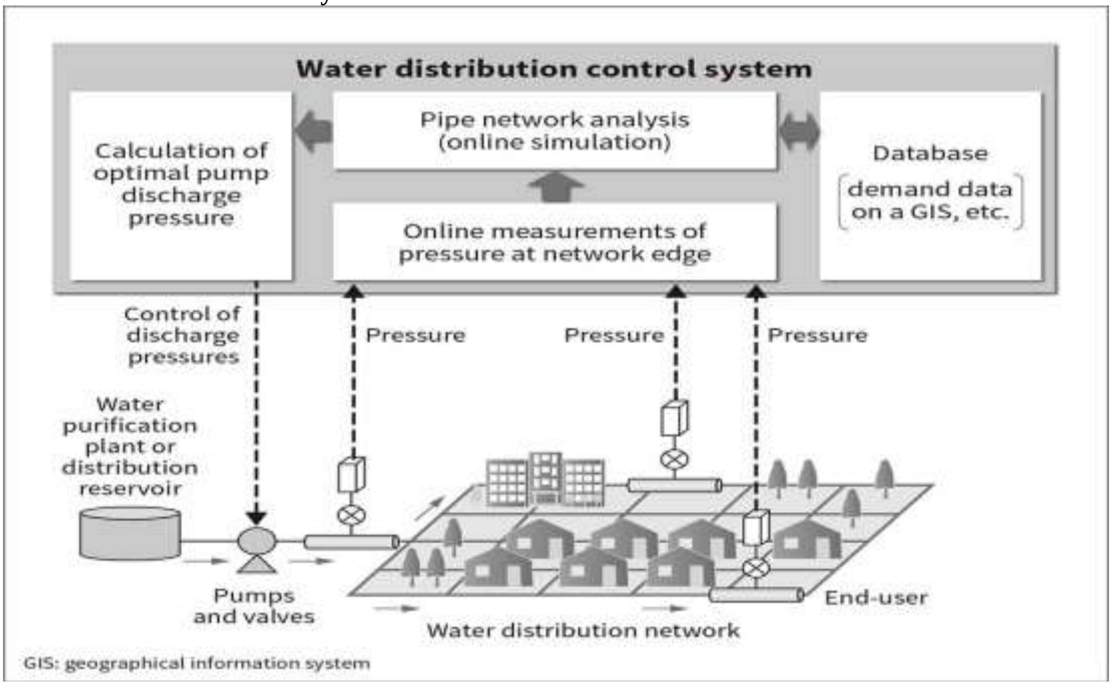
VI. MANAGEMENT & CONTROL OF WATER DISTRIBUTION NETWORK

A) Applications of GIS in WDN: Water resources management and planning is always attractive research issue for hydrologists but increasing trend to use up to 50% ground water, there is direct need to manage the ground-water reserves to maximize efficiency at the basin level. **Combination of the Remote Sensing with the Global Positioning System (GPS) and the Geographical Information System (GIS)** produces knowledge about following things i.e.

Discipline	Applications
Hydrology	Evapotranspiration, soil moisture, Snow cover, rainfall.
Environment	Water qualities, salinization, wet-lands, Forest area, and water logging.
Geography	Land cover, land use, digital elevation, land aspects and land slope.

(Table No. 7: Applications of GIS in WDN)

B) Water Distribution Control System of GIS:



(Figure No. 7: Water Distribution Control System of GIS)

VII. RESULTS & DISSCUSSIONS

A hydraulic model of the study will be set up in the EPANET. All the nodes and the pipes will be installed in the desired location depending upon the demand of the given water system. For the node's parameters, such elevation and demand will be pre-defined based on surveys and the studies conducted for the water distribution system. The steps for simulation water distribution network:

1. Set program defaults (naming convention, pipe roughness, unit system, head loss formula).
2. Draw the distribution system by inserting nodes and connecting with links.
3. Edit the properties of the objects that make up the system, e.g. pipe length, and diameters, nodal elevations.
4. Describe how the system is operated.
5. Select a set of the analysis options time step, duration.
6. Run hydraulic analysis
7. View results and change parameters and repeat as necessary.

VIII. CONCLUSIONS

It is concluded that the GIS & RS is powerful tool in developing water distribution network and facilitates to use the following process:

1. Data collection and monitoring.
2. Site selection for source of water.
3. Water quality assessment.
4. Network analysis and design of water line path.
5. Routing, optimization and visualizations.

ACKNOWLEDGEMENT

The author would like to express their sincere thanks to Jal Shakti Department of Kullu and the Census Department, & my Family and Friends for support during the study period. The author also would like to express their special thanks to HOD, Department of Civil Engineering of SIRDA Engineering & Technology, Sundernagar, Himachal Pradesh, India, for their valuable assistance and guidance.

REFERENCES

[1]. ESRI, Arc View GIS 10.7, 2019, help, Environmental System Research Institute Inc., California.
[2]. "Design of water supply networks" Prabhata K. Swami, Ashok K. Sharma.
[3]. CPHEEO Manual, 1999, (The Central Public Health and Environmental Engineering Organization)
[4]. Hazen-Williams Coefficients, Engineering Tool Box, retrieved October 2012.
[5]. Water CAD (2019)