A Study on Urban Municipal Water Supply and Demand

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Abstract

Water is the main factor which had a biggest impact on the sustenance and flourishing of a population. Water resources are being depleted day by day, be it the surface or groundwater resources. A water supply system is mainly planned on the basis of the quantity of the consumption by the present and future population for a time period of 20-30 years (design period).In India, 82% of the population has been provided access to drinking water, but large amount of it are under-performed both in quantity and quality. Apart from the inadequacy in water, the main concern is the deterioration in the quality of water supplied. Bangalore is heading towards freshwater crisis mainly due to improper management of water resources and environmental degradation, which has led to lack of access of safe water supply. This paper is a detailed report on the municipal water supply, means of water supply used and attitude of the people toward the consumption. For this purpose Yelahanka is selected as a study area. This paper is an outcome of a study conducted on the bases of data collected from the Disaster Management Cell (Yelahanka) and Bangalore Water Supply and Sewerage Board (BWSSB). Household Survey were also conducted to known the type of responsibility a common person is feeling and the attitude of the people towards the true utilization of water resources. The data collected were analyzed using MATLAB software by a technique called Fuzzy logic and the outcome of the analysis is compiled and studied. The study is expected to reveal the present situation of water supply system with respect to estimated result of system. Evaluations of the model were done using various performance evaluation indices. The result of the developed model reveals that Fuzzy logic methods were capable for analyzing the present and future water scenarios in the urban area.

Keywords: Fuzzy Logic, MATLAB, Urban area, Water resources.

1. Introduction

Water is the main factor which had, has and will have a biggest impact on the sustenance and flourishing of a population. A water supply system is mainly planned on the bases of the quantity of the consumption by the present and future population for a time period of 20-30 years (design period).

The main sources of a water supply system are Rainfall or Ground water tapped and stored in form of reservoirs and tube wells. The runoff of rainfall is also some time directly tapped in provide water for an area. The important factors which plays major role are the Quantity and Quality of the water available for both domestic and commercial use.

This water supply system is usually influenced by the amount of water consumed by population, which is mainly characterized by the climatic conditions. A higher temperature usually results in higher water consumption and vice-versa for lower temperature. Even low rainfall can create a high pressure; a burden on water supply system. And even the attitude of the people towards the available water resources plays a major role in the consumption and utilization of the water.

Now as we consider ground water as another main source for water, the availability of this resource depend upon the geological features of the locality. The main factors which are responsible for using

ground water as a water resources are Quantity, Quality, physical and chemical characteristics, the Depth at which it is tapped and cost of installation of a bore well .The availability of the ground water usually depends on climatic conditions, rainfall and drainage of the soil in the basin.

As the Ground Water also continues to deplete with rapid use of ground water, we are burdened with responsibility of preserving the natural resources and to maintain the balance between demand and supply. The ground water can even be replenished or recharged by adopting certain techniques like Rain Water Harvesting and other ground recharging methods.

This research is a detailed report on the municipal water supply and means of water supply used and attitude of the people toward the usage of these water resources.

2. Literature Review:-

There are many approaches to forecast the urban water demand. Totoshiyaka Chiba and Yoji Shimizu proposed the simple forecasting model of wide spread damage to the water supply network by linear multiple regression model supply interruption rate. The other object of this study is to discuss the applicability of fuzzy theories to the forecasting model of the supply interruption rate. They require a long computational time due to a network inter-linkage analysis and also so far developed are very complicated. The forecasting model for the damage restoration considered in this paper is a simple model and in this study, the water supply network of Fukuyama city is used for numerical examples.

Vujca Y et al describes that the urban water supply systems with protection and prevention of contamination is a complex process and as Complicated as adding slow acting disinfectants in the treated water to protect is from contamination. By using the concept of the multiple barrier system is the corner stone of the Environmental Engineering approach to producing safe drinking water. Many measures are undertaken to eliminate, prevent and/or destroy pathogenic organisms. This strategy is the reason why the preferred source of the water is one where man's access is restricted through the unit process treating the water to remove the pathogenic organisms as well.

Tabesh M used an integrated fuzzy hierarchical risk assessment model for water supply systems (IFHRA WSS) to assess hazards in a complex UWSS using a systematic approach incorporating both water quantity and quality issues. For breaking down the UWSS infrastructures to their interrelated elements to reduce the overall complexity of the system, this model uses a hierarchical frame work. It also considers uncertainties using fuzzy logic approach. The results of the proposed model can help the decision makers to plan for effective risk mitigation measures. The water supply system is composed of components and sub components. These components exposed to natural, human related and operational threats mainly because most of them are spatially diverse and accessible. These threats can affect quality and quantity in different elements of UWSS. These effects can be quantified taking into account three parameters: probability of hazards, Consequences of hazards and vulnerabilities of the facilities against these hazards which can be evaluated through risk assessment approaches.

- Taikan oki water use in urban areas is directly related to economic development, social prosperity and environmental conservation water supply in urban areas has increased rapidly due to urbanization or urban population growth. Supply of sufficient water has become a big problem for urban water management. A long planning, big investment and construction period is required for surface water development for urban water use ground water becomes the major water source. After an overview of urban development and urban water use in the world, a global perspective of ground water in urban water use is presented and some suggestions for ground water use in future urban water management are presented.

Arun N.Tiwari.describes the impact of urbanization on the ground water regime in a fast growing city in central India. After china, India is the most populous country in the world. All its development sectors are in growing state, putting unwanted stress on the natural resources urban. Urban areas are fast getting densely due to Pukka house and tall buildings around urban areas agricultural lands are rapidly vanishing civic administrators and city planners are making all attempts to provide basic amenities to the growing urban population and plan the newly added areas in a systematic manner. The impact of urbanization on ground water regime within a specified urban area depends both on its geographical location and the economic status of city or even the country.

3. STUDY AREA

4Th ward of Yelahanka city Bangalore is selected as study area. The current water supply system of the city includes BWSSB supply and also ground water developments. They are utilizing most of the water from their own sources in addition to municipal supply. The average water demand of city is 18 MLD for daily and 530 MLD for monthly. Here apart from the residential, water is utilized for other purpose such as gardening vehicle washing etc. When as demand is more supply is become irregular and ground water become depleting hence necessary to search for a new source. Therefore water planners should give more attention to demand management as the new resources are getting more expensive. So this study area is employed for forecasting the future water consumption in our research work. Predictions are carried out using monthly water consumption record for a period of fourteen years.

Figure 1: Map of Yelahanka

Yelahanka city is located at 13^{0}06'30" to 77^{0}34'15" in which is a suburb of Bangalore in the state of Karnataka. It is located near the fast developing northern section of Greater Bangalore, about 14 kilometres from downtown Bangalore. State Highway 9, Bangalore-Hindupur passes through Yelahanka bisecting the suburb into Old Town and New Town. Yelahanka is at a height of about 915m above mean sea level. Due to its higher altitude from mean sea level, it is lush green and has pleasant weather year round. The summer season lasts from March to mid-May, with a temperature in the range 20^0-35^0. At the end of May, the monsoon season starts and last until the end of October. There are about 1250 mm of rainfall annually. Yelahanka is served by both South west as well as South east monsoon. Winters are mild and last from November to February, with a temperature in the range 14^0-24^0.

4. METHODOLOGY

Fuzzy logic Fuzzy logic is capable of modelling vagueness, handling uncertainty, and supporting human type reasoning. They estimate a function without any mathematical model and learn from experience with sample data. Fuzzy logic starts with the concept of a fuzzy set. A fuzzy set is a set without a crisp; clearly defined boundary. Fuzzy set theory provides a systematic calculus to deal with such information linguistically and it performs numerical computations by using linguistic labels

stipulated by membership functions. Moreover, a selection of fuzzy if then rules forms the key components of a fuzzy inference system that can be effectively model human expertise in a specific application. Although the fuzzy inference system has a structured knowledge representation in the form of fuzzy if-then rules. A fuzzy inference system (FIS) is an inference mechanism establishing a relationship between a series of input and output sets. The inference system uses fuzzy sets theory, fuzzy logic principles when establishing such a relationship. Fuzzy inference system (FIS) is a rule based system consisting of three conceptual components. These are: (1) a rule base containing fuzzy if– then rules, (2) defining the membership functions(MF) and (3) an inference system, combining the fuzzy rules and producing the system results. Reports were found using different fuzzy inference system such as Mamdan fuzzy inference system and Sugeno Fuzzy inference system in urban water demand prediction. The general structure of the Mamdani fuzzy inference system is shown in figure2.

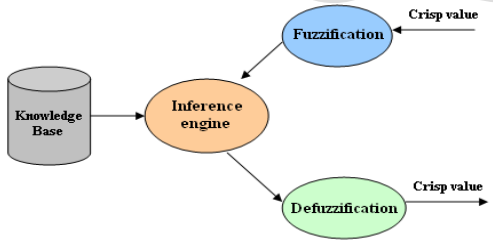

Figure 2: Structure of a fuzzy inference system

In fuzzy logic method, different models are developed using trapezoidal membership function and triangular membership function and also different rules criteria like three rules and nine rules. From the results comparison it is found that three rules triangular membership function is performed better, hence it is adopted for fuzzy modelling. It is also known that all water resources data are ambiguity in nature, exact division of fuzzy set is not possible. So assuming fifty percent as over lapping different fuzzy set are employed in the analysis.

Fuzzy Rule Based System

In the fuzzy inference method, sets of corresponding input and output measurements are provided to the fuzzy system and it learns how to transform a set of inputs to the corresponding set of outputs through a Fuzzy Associative Map (FAM) which is also called the Fuzzy Associative Memory. Fuzzy logic does not provide a rigorous way for developing or combining fuzzy rules which can be achieved through many ways. The method adopted in this paper is outlined below. First the input and output variables are divided into a number of subsets with simple triangular fuzzy membership functions.

Generally, there are m*n fuzzy rules where m and n are the numbers of subsets and input variables, respectively. In the case, say, of two inputs X1 and X2 with m subsets each, the rule base takes the form of an output Y_k (k=1, 2 . . . m2). If there are two input variables as X1 with “very small” and “small” fuzzy subsets and X2, say, “Medium” and “large” 2 subsets, then consequently there will be four rules as

R1 IF X1 is very small and X2 is medium THEN Y1

R2 IF X1 is very small and X2 is large THEN Y2

R3 IF X1 is small and X2 is medium THEN Y3

R4 IF X1 is small and X2 is large THEN Y4

$$Y = \frac{\sum_{k=1}^{4} W_k Y_k}{\sum_{k=1}^{4} W_k}$$

For each triggered rule the membership degrees for both X1 and X2 are computed and these are multiplied to give the weight W_k to be assigned to the corresponding output Y_k. Hence the weighted average of the output from four rules is a single output Y as,

Thus, once the rule base is set up, values of the output can be computed from the equation for any combination of input variables fuzzy subsets. A very common method in deciding about the fuzzy rule base is to use sample data and derive the necessary rule base by the fuzzy inference procedure. This involves computing the weight of each rule triggered,

accumulating weights and outputs for each rule and finally computing the weighted output for each rule.

5. Results of analysis

From the analysis of the acquired data we can confer that the result from the fuzzy model technique were found to promising,

Table 1: Survey details

No of houses surveyed	200
Population in the houses	972
No of intakes used (Kaveri, Bore-water, Well, Tanker)	4
Requirement of water for population surveyed in ML	393.6
Approximate water supplied in ML	258
Condition of water supplied	Deficient

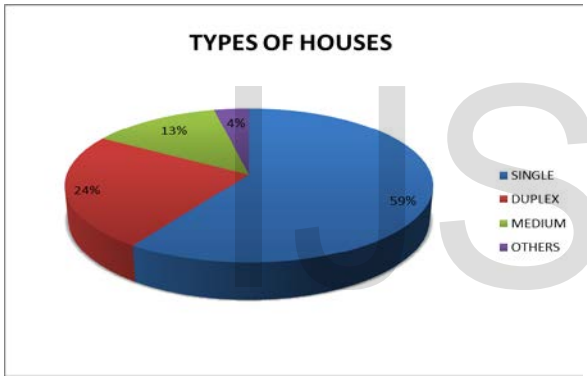

Figure 3: Types of houses

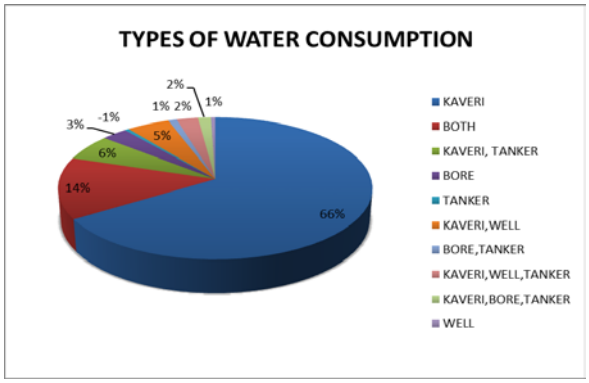

Figure 4: types of consumption

Table 2: Characatreristics of the data set

Month/year	Min temp	Max temp	Min hum	Max hum	Max win
Jan- 2013	15.6	29.3	24.6	91.6	2.0
Feb -2013	17.6	30.6	24	84.1	1.9
Mar-2013	20.3	33.1	20.1	76.3	1.9
Apr-2013	22.8	35.1	24.0	80.7	2.3
May-2013	22.2	34.2	33.1	84.9	1.9
June-2013	20.5	28.7	53.3	89.4	2.1
July-2013	20.1	27.6	56.7	89.4	2.1
Aug-2013	20.2	28.1	54.2	89.2	1.7
Sep-2013	19.8	28.0	56.4	91.4	3.7
Oct-2013	20.0	28.6	52.7	90.6	6.9
Nov-2013	18.1	28.2	44.3	91.4	5.4
Dec-2013	15.4	27.2	36.0	89.2	3.7
Jan- 2014	28.1	15.7	19	31.8	2.9
Feb -2014	30.5	17.2	81.2	26.4	1.6
Mar-2014	32.5	19.4	71.2	20.9	1.9
Apr-2014	35.2	22.4	75.9	18.3	1.8
May-2014	34.2	22.1	83.6	31.7	2.1
June-2014	32.1	21.3	86.2	41.8	2.0
July-2014	24.1	17.2	73.9	44.3	1.4
Aug-2014	29.2	20.4	89.3	51.7	1.4
Sep-2014	29.5	20.1	89.6	48.7	1.8
Oct-2014	29.0	20.0	91.1	49.7	2.8
Nov-2014	27.7	17.4	88.1	41.0	1.4
Dec-2014	27.4	17.3	87.9	43.0	1.6

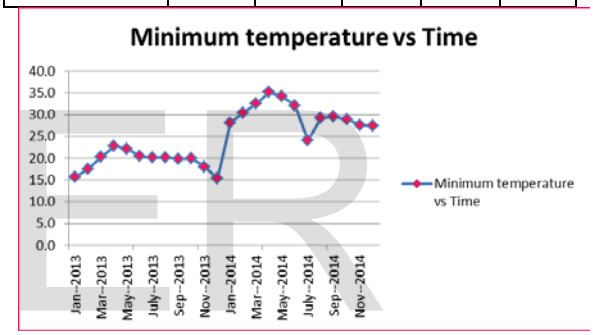

Fig 5:: Minimum tempareture vs Time

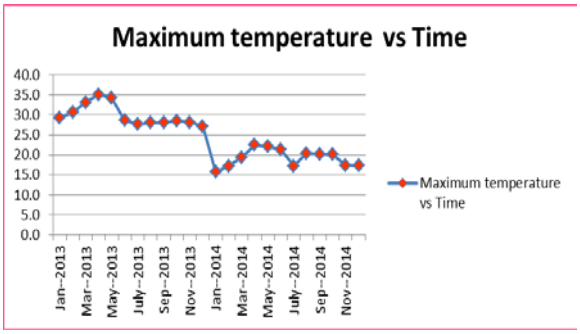

Fig 6: maximum temparature vs Time

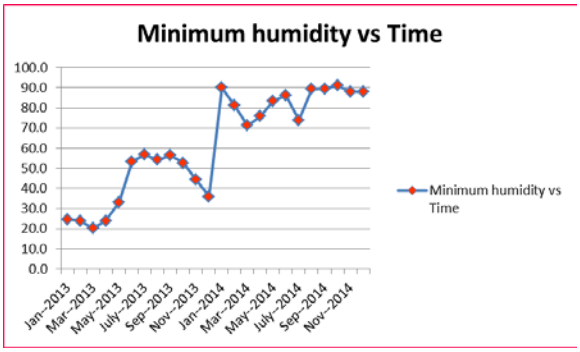

Fig 7: Minimum Humidity vs Time

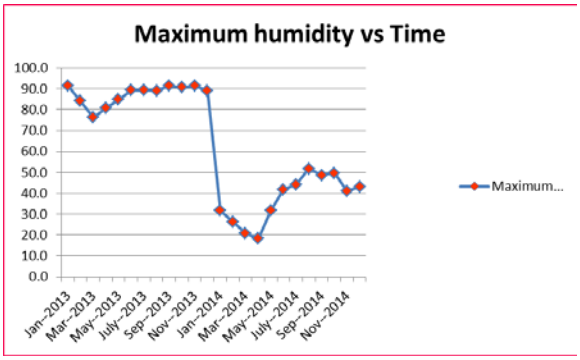

Fig 8: Maximum Humidity vs Time

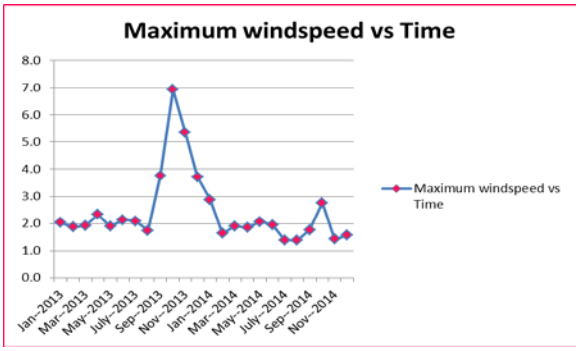

Fig 9: Maximum Windspeed vs Time

From the above graphs we can observe the variations in differrent parameters of climatic conditions.

Results from the fuzzy logic,

Prediction Error,

PE= [(y-x) / x]

If the PE value is close to 0, then the model is treated as best one.

Table 3: Input and output combination

MODEL USED	MAMDANI
RULES USED	3,4,5
INPUTS	1. RAINFALL
	2. RAINFALL & MAXI MUM TEMPERATURE
	3.RAINFALL , MAXIMUM TEMPERATURE & MINIMUM TEMPERATURE
	4.RAINFALL, MAXIMUM TEMPERATURE, MINIMUM TEMPERATURE & RELATIVE HUMIDITY
OUTPUT	WATER CONSUMPTION

Table 4: Membership functions used

MODEL TYPE	BELL			TRIANGLE		
INPUTS	3	4	5	3	4	5
1IN-1OP	0.25	0.34	0.27	0.08	0.06	0.12
2IN-1OP	0.22	0.11	0.23	0.1	0.1	0.12
3IN-1OP	0.20	0.22	0.22	0.05	0.1	0.07
4IN-1OP	0.17	0.25	0.18	0.05	0.06	0.06

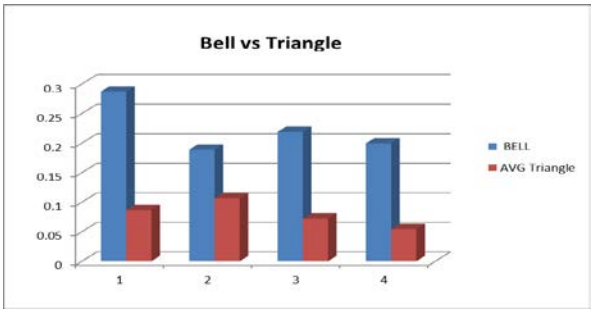

Fig 10: Results of the developed model

6. SUMMARY

In the present study, prediction error method and fuzzy model has been adopted to determine water consumption of Yelahanka city.

Here prediction error method and fuzzy models are used for comparing the values with standard values from the Bangalore water Supply and Sewerage Board [BWSSB].A house hold interview survey is done in Yelahanka city. About 200 houses with population of 974 have been surveyed and the values are analysed. The standard values of 14 years [2001-2014] are taken from the BWSSB for comparison. Using prediction error method and fuzzy method, first 13 years [2001-2013] values are analysed. Taking this analysed value as the input value, analysis is done for next year [2014] and then compared with the value given by the BWSSB. And the prediction is found to be on the positive side. From this analysis, we can conclude that, fuzzy logic method holds good for future analysis also.

7. CONCLUSIONS

In this report a sincere attempt is made to find out the influence of rainfall and temperature on municipal water consumption using prediction error method and fuzzy model. And for the analysis thirteen years of data was used as training data and one year data for testing the model. The analysis survey is carried out in Yelahanka city in individual house to obtained consumer attitude for identifying consumption

utilization of water. Since some other parameters influence the water consumption and data is less, obtained accuracy is satisfactory. But from performance evaluation obtained accuracy in fuzzy model was acceptable.

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