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Prediction of Evaporation Loss in Reservoir with Fuzzy Logic Approach

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ABSTRACT

The quantification of evaporation losses is essentially carried out for systematic planning and management of irrigation system for draught prone area. Direct and indirect methods are popularly adopted for measurement of evaporation. In case of minor irrigation projects, it is challenging and unaffordable to setup, operate and maintain meteorological monitoring systems. Forecasting tools will be helpful in such minor irrigation projects. A fuzzy computing technique will be one of the significant tools to forecast the evaporative losses.

In the present paper a fuzzy approach for forecasting evaporation losses of Makani Reservoir, Osmanabad (MS); India has been carried out. The parameters; temperature, wind speed, and humidity are considered. Linguistic variables are utilized to define input variables and output ranges. An evaporation loss is forecasted by taking into consideration a database for the year 2004 to 2014. A rule base system is adopted for greater precision. The validation is carried out for the next successive years.

Key words: Evaporation losses, Fuzzy, Linguistic variables, Rule base

INTRODUCTION

Evaporation is most importantloss in water bodies, as water resources are scarce [1].In arid and semiarid area where water is stored in reservoir or lakes is open to atmosphere, also In region where flat terrain, suitable reservoir site is limited, and reservoir may be small or large sizes, considerable water is lost in evaporation in such Project evaporation loss is crucial .In irrigation project for and management authority to understand quantity of evaporative loss from their water body will effortless for decision making process on other hand for developing project decide reservoir capacity it is essential to understand evaporative loss [3-4, 7].Evaporation depends on meteorological factors such as relative humidity, temperature, atmospheric pressure, wind speed, and solar radiation [5-6]. In hydrological practice, there are several direct and indirect methods to estimate evaporative loss. In case of direct method class, a pan is being used and coefficients are multiplied for calculation of evaporation. But for many times it is difficult to install system due to topography, environmental condition and also it is laborious method. System needs indirect method which will fit relation between parameters and develop model to estimate loss [11-12]. This study investigates evaporative loss by fuzzy logic approach [2].

FUZZY LOGIC SYSTEM

Fuzzy set theory allows partial membership by generalizing the classical set theory to some extent. The fuzzy sets could be defined by redefining and expanding the usual characteristics of classical sets [13]. A classical set might be expressed as $A = \{x \mid x > 6\}$; whereas Fuzzy SetA in X is defined as a set of ordered pairs.

$A = \{x, \mu A(x) \mid x\ X\}$ where $\mu A(x)$ is the membership function of x in A. The membership function converts each element of X to a membership value between 0 and 1.

Fuzzy mechanism replaces the decisions by fuzzy sets and rules by fuzzy rules. Most of the decisions are logical decisions based on situation. Fuzzy rules also operate using a series of if - then statements.

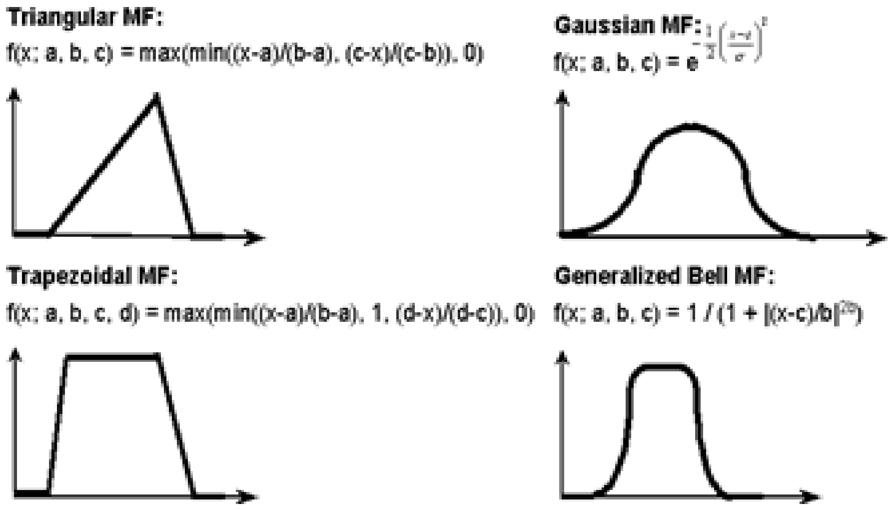

Fig.1 Membership Function

The membership function (MF) is a graphical representation of the magnitude of participation of input. MF deals with weight of input, their functional overlap and expected response in the form of output. Here the rules are being used as weighing factors which influence fuzzy output sets. After the functions will be inferred, scaled, and combined, they will be defuzzified into an output which is in crisp form. The shape of the membership function depends on the fuzzy set [9-10]. The membership function choice is the subjective aspect of fuzzy logic; it allows the desired values to be interpreted appropriately.

Linguistic variable are the variables being used in fuzzy systems where linguistic words are used, rather than numbers. The input is a noun, e.g. 'temperature', 'humidity', 'wind speed', etc. In the present study minimum, moderate, average and maximum are the variables used to define input. Fuzzy inference is the actual process of mapping. This process starts from a given input and finishes to an output using fuzzy logic. There exist two types of fuzzy inference method viz. Mamdani and Sugeno fuzzy inference system. Mamdani fuzzy inference is the most commonly seen inference method and used in this study.

METHODOLOGY

The study has been carried out for the reservoir located in Marathawada region at place Makni village located in LoharaTaluka; District Osmanabad; MS, India (17°59′N 076°21′E). This is major water resource for Osmanabad and Latur district. The data acquired from meteorological station situated at sitefor the year 2004 to 2014. Ten years' data has taken for model development and calibration whereas two years' data is used for validation of model. The evaporation loss has been measured by standard method using Class a Pan Evaporimeter conforming IS:5973-1970 made up of 1mm copper sheet tinned insideand painted white outside, covered with wire mesh. Daily air temperature data was obtained from thermometers housed in a Stevenson Screen conforming to IS: 5948-1970. Thermohydrograph and dry and wet bulb thermometers located in Stevenson Screen were used to provide relative humidity values. The mean relative humidity data was obtained by averaging the maximum and minimum values. Wind speed is measured by cup cone anemometer conforming to I.S.:5912-1970.

Fuzzy approach to forecast evaporation loss: The crisp data acquired is summarized in Table 1. This data indicates minimum and maximum values obtained for entire year with reference to temperature, humidity and wind speed. The values indicate tremendous variation anddue to which fuzzy logic approach will be more effective to forecast the evaporative losses.

Table- 1 Parameter Data of Study Area from 2004-2014

Year	**2004-05**		**2005-06**		**2006-07**		**2007-08**		**2008-09**		**2009-10**		**2010-11**		**2011-12**		**2012-13**		**2013-14**	
Parameter	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
T	26	43	24	42	28	41	23	45	26	42	22	43	25	42	25	42	26	44	22	45
H	10	60	12	72	18	65	12	68	12	70	10	12	05	65	08	62	12	60	10	65
W	3	12	5	14	7	16	6	15	5	16	3	18	4	18	5	20	4	20	6	18

T- Temperature, H – Humidity, W- Wind

Table- 2 Crisp Data with Linguistic Variable Indicating Range

Parameter	Minimum	Moderate	Average	Maximum
Temperature	25-34	30-38	34-40	38-45
Humidity	60-80	35-64	15-40	0-20
Wind speed	0-5	4-8	7-12	11-20

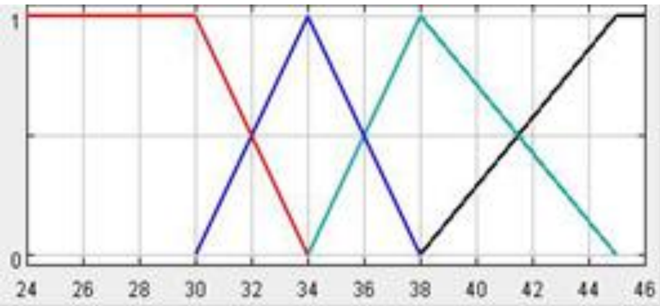

Fig. 2 Membership function for parameter Temperature

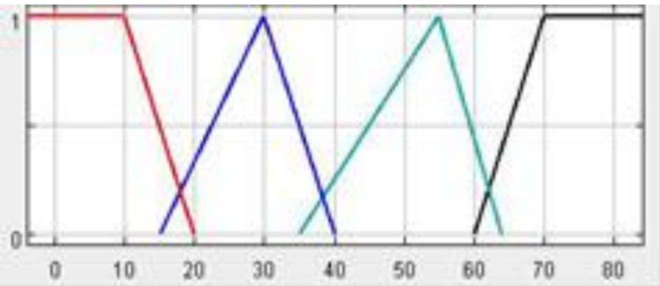

Fig. 4 Membership function for parameter Humidity

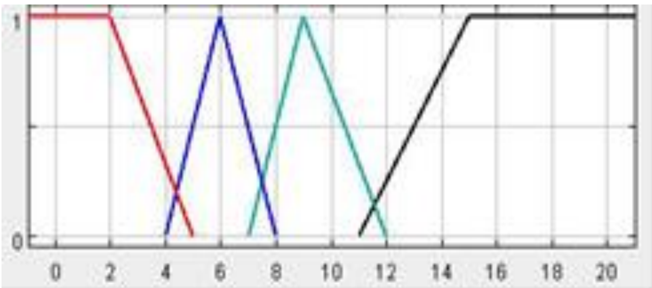

Fig. 5 Membership function for parameter Wind speed

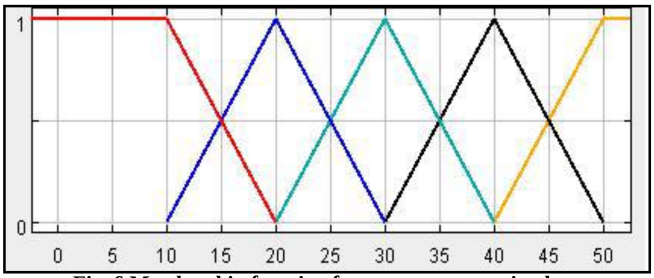

Fig. 6 Membership function for output evaporation loss

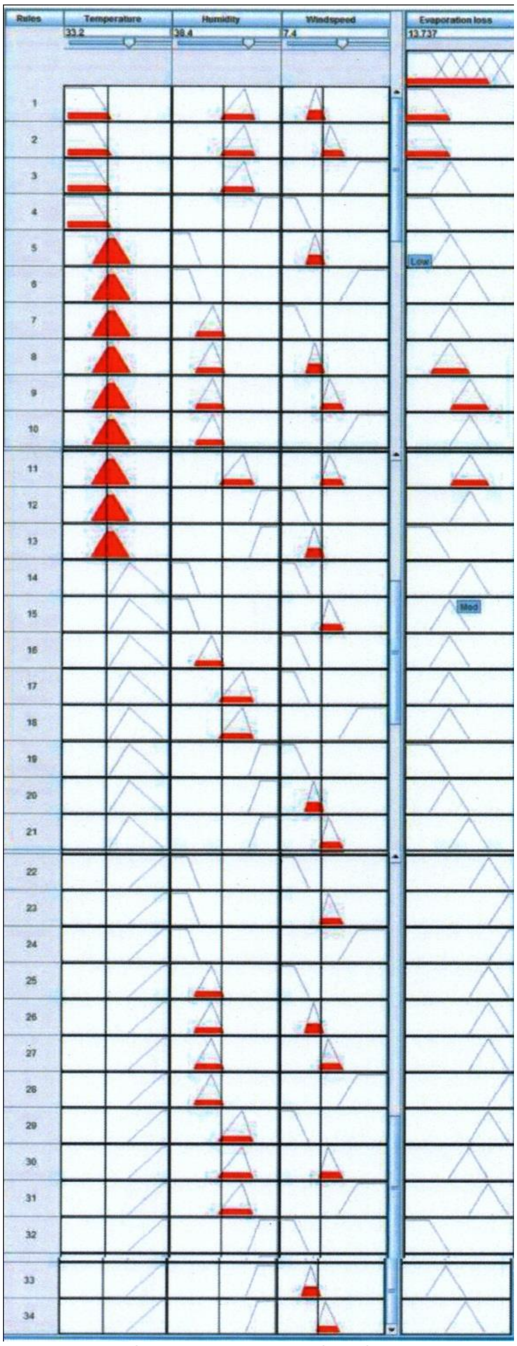

Fig. 3 Fuzzy Inference System – de-fuzzified data showing result

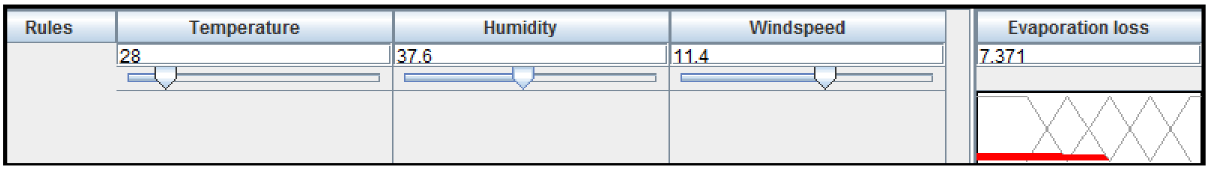

Fig.7 Output for typical minimum evaporation loss

Table- 3 Evaporation Loss Data With Linguistic Variables Indicating Range

Parameter	Extreme low	Low	Moderate	High	Extreme High
Evaporation loss	-15-20	10-30	20-40	30-50	40-56

'If –Then' rule base approach has been adopted. The model has been run to deploy the input data to get evaporation loss. Valid 34 rules are used to run the model.

A software FisPro3.5 is used to run the fuzzy model. Mamdani method for defuzzification has been implemented [8]. The input crisp data is defined with reference to linguistic variable like Minimum (Min), Moderate (Mod), Average (Avg) and Maximum (Max). The detailed is tabulated in table 2. The output, evaporation loss has been expressed by linguistic variables like extreme low (Xlow), Low (Low), Moderate (Mod), High (high) and extreme high (Xhigh). The details are tabulated in Table 3.

RESULT AND DISCUSSION

The Fuzzy rule based model is developed which gives volume of water loss by evaporation. One of the important factors in using fuzzy methodology is setting up of appropriate parameters as accuracy of model largely depends upon selection of parameters. The developed model fits relation between selected parameters. It is also found that evaporation loss varies in linear proportion with reference to temperature and wind speed. In case of humidity, the trend is shown in Fig 6. The Fig. shows that Evaporation decreases with increase in humidity the typical output for evaporation loss.

CONCLUSION

Evaporation is complex phenomenon as it depends upon meteorological factors such as Temperature, Humidity and Wind speed. Fuzzy approach is promising tool for modeling evaporation which gives reliable accuracy in estimating the loss. For smaller reservoir as it is difficult to maintain ideal instrumental setup, fuzzy approach saves the operating and running cost. The forecasting is also helpful with reference to systematic utilization of the stock water. The minimum value 7.371 for temperature 28, Humidity 37.6 and wind speed 11.4 is obtained by centroid method of defuzzification.

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