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Fuzzy Logic Based Model for Optimization of Tank Irrigation System

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Abstract: This study deals with a model developed based on fuzzy logic for the optimization of Tank Irrigation system. In this study, using MATLAB, reservoir operation is simulated considering the mass balance and continuity in inflows during successive months. The model developed can serve as an efficient tool for operation of the tank for effective decision making to meet irrigation requirements. This model is proved to be better than the traditional approach models surely shown to increase the actual irrigation potential and reduce the gap with the achievable irrigation potential resulting in improved water management. This fuzzy logic model is better for extraction of knowledge from historical data for deriving optimal operational policies for reservoir systems and tanks with the available data and knowledge.

Key words: Fuzzy logic, tank irrigation, MATLAB, water balance, inflows, fuzzification, defuzzification

INTRODUCTION

Tank irrigation has been in existence for centuries. However, optimization of the tank irrigation system is of recent origin. Even this has been attempted in piecemeal, optimizing every segment/aspect of the irrigation system individually. Thus, although each component may be optimal, the system as a whole may not be optimal. This study presents a methodology to optimize the design of the tank irrigation system by taking monthly inflow and initial storage and tries to predict the maximum possible release using fuzz logic. The specific objectives of the present study can be stated as follows:

- To develop a fuzzy rule based model for reservoir operation for a monthly time step.
- To compare the model releases with the actual monthly releases and improve the FIS model till the model releases are satisfactory.
- To simulate the reservoir operation using MATLAB considering mass balance of the tank system and continuity in flows during successive months.
- To compare the generated model releases with the actual releases for each month for the data period.

RELATED WORK DONE ON TANK IRRIGATION MODELS

From the past research done and literature survey, the following points were observed.

- Extensive work has been done using optimization models like LP, DP and NLP models, which are suitable when the objectives and constraints are linear in nature (Govindasamy, 1991).
- Many researchers coupled optimization models with simulation models to make flexible operational rules particularly for reservoir operation (Despic and Simonovic, 2000).
- Simulation models closely represent the realistic situations and many researchers highlighted that simulation modelling is comparatively simple and reservoir managers are willing to accept the models even though they may not guarantee an optimal solution. However, in modelling with simulation, one needs to develop computer codes, as any simulation cannot be generalized and each problem is unique in nature.
- It was noticed that previous researchers adopted multi-input and single output control variables in models, only using fuzzy logic technique (Jyothiprakash, 2000).
- To address the uncertainty in control variables like inflows, reservoir storage etc., many researchers used stochastic modelling approach for these variables (Mohan, 1994).
- It was noticed that fuzzy based models are close to realistic situations and comparatively simple to understand. It was also reported that fuzzy based models could effectively handle data with uncertainty and vagueness as well (Murugappan, 2001).

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- It was also noticed that new models need to be developed, which are acceptable to reservoir managers.
- It was emphasized that optimization tools may not be acceptable to reservoir managers, due to the complexity associated in the modelling and assumptions made in modelling to suit these optimization models, which may result in deviation from reality.
- Many researchers used the output of an optimization model as the basis for building the rule base for the fuzzy logic models (Mohan, 2003).
- The operation of tanks with hydrological characteristics different when compared to reservoir systems need to be studied in detail (Anjaneya, 2006).

The operation of tanks at present is in adhoc basis. Hence it is necessary to derive operational guidelines for these tanks, so that it will enable water managers to make optimal use of the available water.

HYDRAULIC PARTICULARS OF VEERANAM TANK

Study area:

Full Tank Level (F.T.L.)	:	47.50 ft (14.470 m)
Maximum Water Level (M.W.L.)	:	50.00 ft (15.240 m)
Tank Bund Level (T.B.L.)	:	54.00 ft (16.440 m)
Catchment	:	165 sq. miles (or) 427.35 sq.km.
Capacity at F.T.L.	:	1465 Mcft (or) 41.46 Mcum
Waterspread at F.T.L.	:	15 sq. miles (or) 38.85 sq.km.
Maximum width	:	5.63 km
Circumference	:	40.225 km
Length of main bund	:	15.30 km
Width of main bund	:	8 m (ave)
Length of foreshore bund	:	10.90 km
Number of sluices	:	34 (28 in the main bund and 6 in the foreshore bund)

FUZZY LOGIC MODEL DEVELOPMENT

The concept of "Fuzzy logic" was introduced by Lotfi Zadeh (1965). Klir and Yuan described some applications of fuzzy sets and fuzzy logic to practical problems. Many researchers concluded that fuzzy logic is very effective in handling uncertain data and also data associated with certain vagueness in nature. The key ideas are that fuzzy logic allows for something to be partly this and partly that, rather than having to be either all this or all that and that degree of 'belongingness' to a set or category can be described numerically by 'membership' which is a number between 0 and 1. The modeling of tank operation with fuzzy logic for Veeranam tank system is as follows:

- Fuzzification of inputs.
- Formulation of the fuzzy rule set.
- Application of the fuzzy operator.
- Implication of rules.
- Defuzzification.

The fuzzy logic model was constructed using MATLAB fuzzy tool box of the recent version MATLAB 7.3.0 (Rel. 2006 b).

RESULTS

Fuzzy logic based tank operation tool has been developed in the study. For demonstrating the model application, Veeranam tank of Cuddalore district, Tamilnadu was chosen. The reason for selecting this system for study was it is a major tank sufficiently large catering to the irrigation demand of many villages downstream of the tank. The releases obtained from the FIS fuzzy logic model for the months were compared with the actual historical releases, which show a close trend for many months.

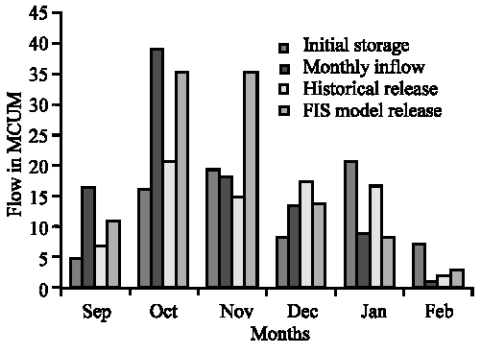

Fig. 1: Comparison 1988-89

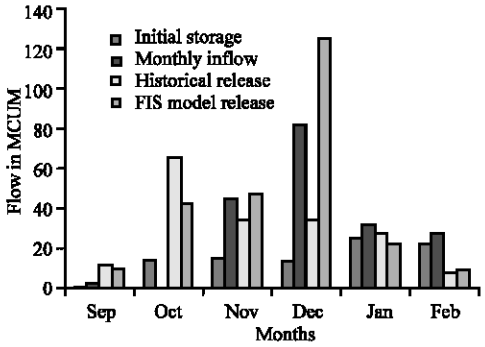

Fig. 2: Comparison 1989-90

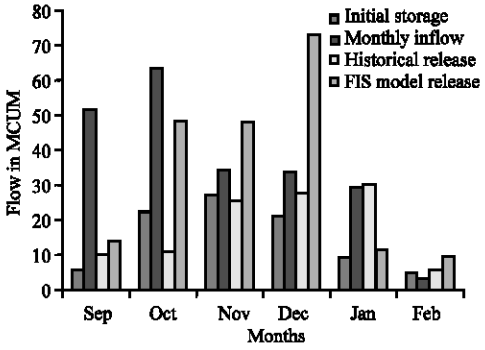

Fig. 3: Comparison 1990-91

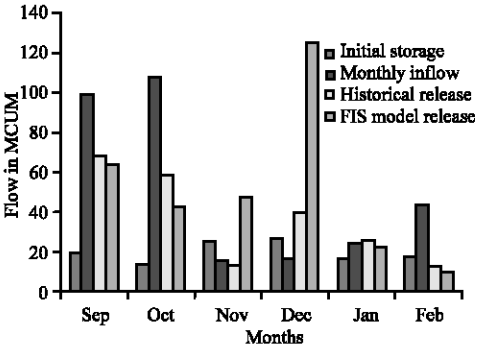

Fig. 4: Comparison 1991-92

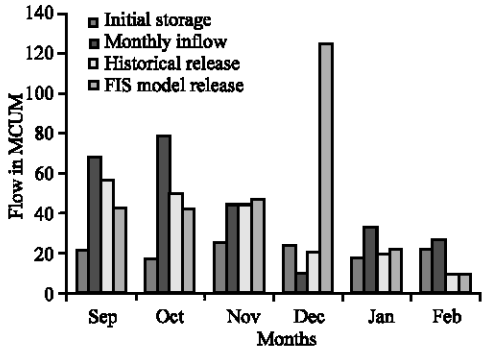

Fig. 5: Comparison 1992-93

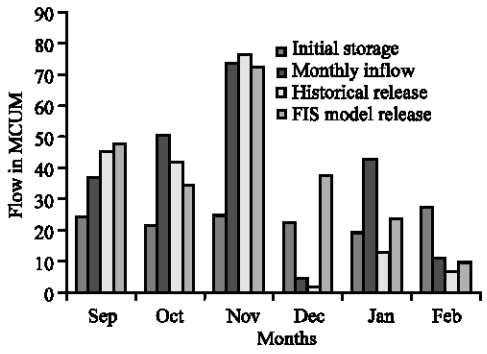

Fig. 6: Comparison 1993-94

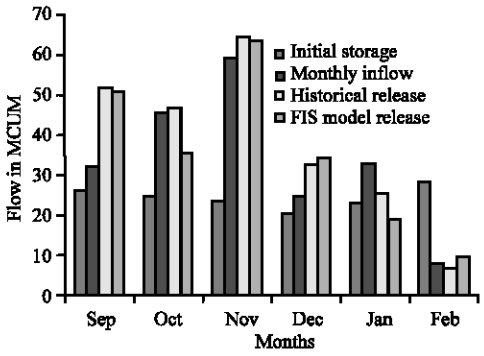

Fig. 7: Comparison 1994-95

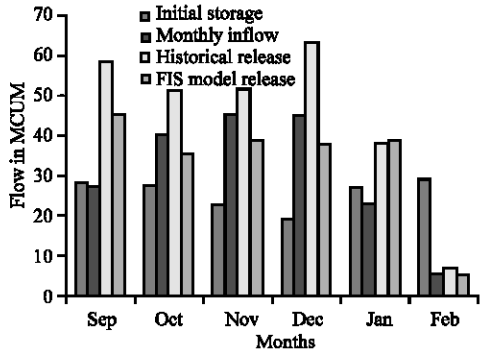

Fig. 8: Comparison 1995-96

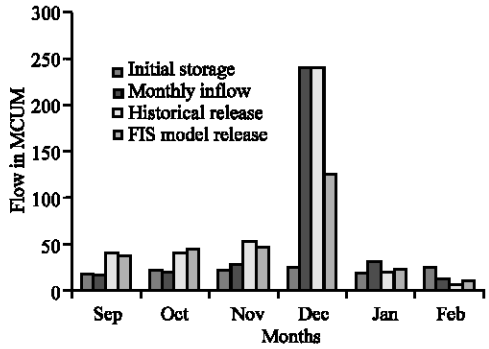

Fig. 9: Comparison 1996-97

The releases of each month for the considered years from 1988-89 to 1996-1997 as obtained from the MATLAB simulation model were compared with historical releases as shown in the Fig. 1-9 for the years from 1988-89 to 1996-97. The simulation model gives satisfactory results which will help to design an optimal operation policy. The developed fuzzy model is a simple operating model wherein the operator needs to input the value of initial storage and inflow to get release. This model describes the complete operation of the system through simple rules and can be used for day-to-day operation of the system.

CONCLUSION

The fuzzy simulation model developed in this study can serve as an efficient tool for operation of the tank, for effective decision making to meet irrigation requirements. By using the simulation model the surplus conditions can be avoided by controlling the release thereby saving water for future use.

A sophisticated tool like fuzzy logic modeling can surely result in better operational strategies of the tank and evolve better water management policies.

It is concluded that the traditional approaches when augmented by techniques like fuzzy logic prove to be better for extraction of knowledge from historical data for deriving optimal operational policies for reservoir systems and tanks with the available data and knowledge.

This can surely increase the actual irrigation potential and reduce the gap with the achievable irrigation potential resulting in improved water management. This model has 84% accurate when compared with actual releases.

SCOPE FOR FUTURE WORK

- The fuzzy logic model will give improved results if the actual irrigation demand based on the crop water requirement of the cultivable command area of the tank can be incorporated as an input to the FIS model.
- Among the different types of membership functions such as Triangular, Trapezoidal, Gaussian and Bell shaped, only trapezoidal membership function was adopted here in the model. Triangular and Gaussian function can be tried for the fuzzy set "medium" in the system variables.
- If the variables are categorized into more number of fuzzy sets, the rule base may prove stronger and evolve accurate results.

ACKNOWLEDGEMENT

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REFERENCES

Anjaneya Prasad, M., 2006. Development of operational rules for serial and parallel reservoir systems using fuzzy logic approach. Ph.D Thesis submitted to IIT Madras, Chennai, India.

Despic, O. and S.P. Simonovic, 2000. Aggregation operators for soft decision making in water resources. Fuzzy sets and systems, Elsevier Publishers, 115: 11-33.

Govindasamy, R., 1991. Simulation of an irrigation tank for modernization. Water Resour. Dev., 7 (2): 97-106.

Jyothi Prakash, V., 2000. Optimal conjunctive use operation in irrigation system. Ph.D Thesis submitted to IIT Madras, Chennai, India.

Mohan, S., 1994. Fuzzy linear programming model for water resources allocation. J. Ind. Water Works Assoc., pp: 155-158.

Mohan, S., 2003. Unpublished lecture notes on Water Resources Planning and Management. IIT Madras, Chennai, India.

Murugappan, A., 2001. Fuzzy optimization model for tank irrigation system operation. Ph.D Thesis submitted to Annamalai University, Annamalainagar, India.

Zadeh, L., 1965. Fuzzy Sets. Information and Control, 8: 338-353.

Zimmermann, H.J., 1991. Fuzzy set theory and its applications. Kluwer Academic Publishers, New Delhi, India.