International Journal of Advanced Technology in Civil Engineering

Volume 2 | Issue 2 Article 11

April 2013

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D.T MESHRAM
N.R Centre on Pomegranate, Shelgi, Solapur, India., DTMESHRAM@gmail.com

S.D. GORANTIWAR
N.R Centre on Pomegranate, Shelgi, Solapur, India., S.D.GORANTIWAR@gmail.com

A.D. KULKARNI
S.T.B. College of Engineering Tuljapur, Maharashtra India ., A.D.KULKARNI@gmail.com

P.A. HANGARGEKAR
S.T.B. College of Engineering Tuljapur, Maharashtra India ., P.A.HANGARGEKAR@gmail.com

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D.T MESHRAM, S.D. GORANTIWAR, A.D.KULKARNI, P.A.HANGARGEKAR

N.R Centre on Pomegranate, Shelgi, Solapur, India.
S.T.B. College of Engineering Tuljapur, Maharashtra India .

Abstract-The study was carried out to select the best forecasting model for the estimation of pan evaporation (E_{pan}) values for Makni reservoir. SARIMA model of 1st order were selected based on observing autocorrelation (ACF) and partial autocorrelation (PACF) of weekly evaporation time series. The model parameters were estimated by using maximum likelihood method with help of three diagnostic tests (i.e. standard error, ACF and PACF of residuals and AIC). The best model is selected for forecasting weekly evaporation values for the one year ahead to help decision makers to have accurate management of reservoir capacity, real time irrigation scheduling and watershed management by using lowest root mean square error (RMSE). The best stochastic model are SARIMA (1 ,0 ,0,) (1,1,1,)$_{52}$

Keywords- *Forecasting, Evaporation, Seasonal ARIMA models*

I. INTRODUCTION

Water is nature's precious gift which sustains life on earth. As all living things depend upon water, it is vital resource and it has also limited availability. To develop the availability of water in India From the last two decades much efforts and money has been spend for development of resources in form of dam, reservoir and small watershed. Still with the increasing demand from population this developed resources need to manage. In water resources system evaporation loss is major loss from resources as need of water increase loss also increase. For the planning and management of resource study of evaporation loss is important.

Several stochastic model have been developed in past (Box and Jenkines 1994) for modeling of hydrological time series mainly rainfall, runoff and evaporation. These include autoregressive (AR) models of different orders (Davis and Rapport, 1974; Salas et.al., 1980; Kamte and Dhale 1984; Gorantiwar et.al., 1995; Mutua 1998; Sing 1998; Subbaiash and Sahu, 2002), moving average (MA) models of different orders (Gupta and Kumar, 1994 and Verma, 2004); autoregressive moving average models (ARMA) models of different orders (Kartz and Skaggs, 1981) Chhajed, 2004; Katimon and Demon,2004) for annual stream flow. For monthly or intra-seasonal flow, seasonal or periodic autoregressive moving average (ARIMA) model (Bender and Simonovle,1994; Montanari et.al., 2000; Trawinski and Mackay, 2008), Thomas–Fiering models and fractionally difference ARIMA models were used. ARIMA class of models were used for forecasting of runoff / evaporation for time period ahead. For appropriate planning of the water resources we require to predict or forecast at least one year ahead of water requirement as ARIMA models show possibility to forecast the hydrological event.

In this study, the applicability of ARIMA models to forecast evaporation for Makni reservoir were investigated and finally the appropriate stochastic model was identified for generating and forecasting of evaporation for Makni Reservoir.

II. STUDY AREA AND DATA USED

The study was concerned with the forecast of evaporation by using ARIMA class of model Location of study area is reservoir from Marathawada region at place of Makani village located in (Fig.1.) Lohara Taluka, Osmanabad district which has latitude $17^{0}37'$ and $18^{0}42'$ and east longitude $75^{0}16'$ and $76^{0}42'$ and falls in. This is major water supply resource for Osmanabad and Latur districts. This study deals with stochastic model for evaporation by using SARIMA model for weekly E_{pan} data for the period of 1998-2012 with total time series readings of 728.

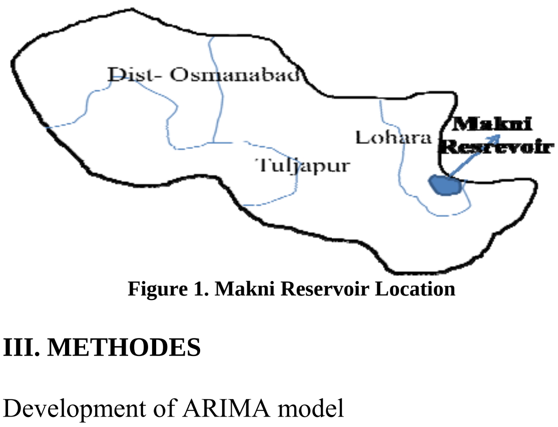

Figure 1. Makni Reservoir Location

III. METHODES

Development of ARIMA model
Seasonal autoregressive integrated moving average (SARIMA) are useful for modeling seasonal time series in which the mean and other statistical for a given season are not stationary across the year. The basic ARIMA model in its seasonal for is described

as (Hipel et.al., 1976; Box and Jenkins, 1994) a straight forward extension of the non-seasonal ARIMA models.

A. Standardization and normalization of time series variable.

The first step in time series modeling is to standardize and transform the time series. In general, standardization is performed by normalizing the series as follows.

$$Y_{i,j}=\frac{x_{i,j} - x_i}{\sigma_1} \quad (1)$$

Where, $y_{i,i}$ – stationary stochastic component in mean and variable for week i or the year j; $x_{i,j}$ – weekly evaporation in weeks of i of year j; x_i – weekly mean and, σ_1= weekly standard deviation.

B. Identification of model

An important step in modeling is identification is of tentative model type to be fitted to the data set. In present study the procedure stated by Hipel and Mecloed (1994) were adopted for identifying the possible ARIMA model. A time series with seasonal variation may be considered stationary. If the theoretical autocorrelation function (ρ_k) and theoretical partial autocorrelation function (ρ_{kk}) are zero after a lag k = 2s+2 (Where, 's' is the seasonal period; in this study, s =52). The requirement of identification procedure is as: i.e. Plot of the original series, Plot of the standardized series, ACF analysis and PACF analysis. The estimates of theoretical autocorrelation function (e_m) i.e r_m is given by eq.(2).

$$r_m=\frac{\sum_{i=1}^{n-m}(x_i-\bar{x})(x_{i+m}-\overline{x})}{\sum_{i=1}^{n}(x_i-\bar{x})^2} \quad (2)$$

Where, n – The number of observation; $\bar{x}$ - The average of the observation, r_m – Autocorrelation function at lag m.

The estimation of partial autocorrelation function (ρ_{kk}) i.e. Φ_{mm} is given by eq.2. The partial autocorrelation function varies between -1 and +1, with values nearer ± 1 Indicating stronger correlation. The partial autocorrelation function removes the effect from shorter lag autocorrelation from the correlation estimates at longer lags.

$$\Phi_{mm}=\frac{r_m - \sum_{i=1}^{m-1}(\Phi_{m-1})(r_{m-1})}{1-\sum_{i=1}^{m-1}(\Phi_{m-1})r} \quad (3)$$

Where, Φ_{mm} – Partial autocorrelation function at lag k, it is consider that (ρ_k) and (ρ_{kk}) equal to zero if (Maier and Dandy,1995)

$$(\rho_k) = 0 \text{ i.e } |r_k| \leq \frac{2}{T^{0.5}} \quad (4)$$

$$(\rho_{kk})=0 \text{ i.e.} |r_{kk}| \leq \frac{2}{T^{0.5}} \quad (5)$$

Where, r_k – simple autocorrelation at lag k; r_{kk} – sample partial autocorrelation at lag k; T - Number of observation.

If simple autocorrelation function (ACF) of analyzed series does not meet the above condition the time series need to be transformed in to stationary one using different differencing schemes. For example d = 0, D = 1, s = 52 according to expression given below

$$z_t = (1- B)^d (1-B^s)^D w_t = (1- B^s) E_{o,t}$$

where , z_t – original time series , d- order of non seasonal differencing operator, D – order of seasonal differencing operator, B – back shift operator , s- seasonal length, t- discrete time , $E_{o\ t}$ - evaporation series, k – lag at period, w_t – stationary series formed by differencing series.

The time series will be stationary if ACF and PACF cut off at lag at lag less than k = (2s+2) seasonal period. Thus it is necessary to test stationary status of transformed time series obtained by differencing the original time series according to different order of differencing (seasonal and non- seasonal). The differenced series that pass stationary criteria need to be consider for further analysis The following guideline were used for selecting order of AR and MA terms given by (Gorantwar, 1984).

- If autocorrelation function cuts off, fit ARIMA (0,d,q)(0,1,Q)$_{52}$ model to data.
- If the partial autocorrelation function cuts off fit ARIMA (p,d.0) (P,1,0)$_{52}$ model to data where p is lag after which partial autocorrelation function first cut off and P is lag after which seasonal PACF cut off.
- If neither the autocorrelation nor the partial autocorrelation function cut off, fit the ARIMA (p, d, q) (P, 1,Q)$_{52}$ model for grid of values of p, P , q and Q.

Thus on the basis of information obtained from ACF and PACF, several forms of ARIMA model need to identified tentatively.

C. Estimation of Parameters of model

After the identification of model the parameters of selected model were estimated. The parameters of selected model were estimated. The parameters of the identified model were estimated by the statistical analysis of data series. The most popular approach of parameter estimation is the method of maximum likelihood.

D. Diagnostic checking of the model

Once a model has been selected and parameters calculated the adequacy of model has to be checked here following three test were used.

1) Examination of standard error

A high standard error in comparison with the parameters values point out a higher uncertainty in parameter estimation which question stability of model the model is adequate if it meet following condition.

$$t = \frac{cv}{se} > 2 \quad (6)$$

Where, cv = parameter value, se – standard error

2) ACF and PACF residuals

If model is adequate at describing behaviour of a time series (evaporation) the residuals of model should not correlated i.e all ACF and PACF should lie within the following equation

Lag k = 2s + 2, where s = number of period.

3) Akaike Information Criteria (AIC)

For selection of most appropriate model for forecasting series, the adequacy of identified model was tested. The popular decision rule for diagnostic checking is Akaike Information criteria (AIC) (Akaike, 1974) and Bayesian information criteria (BIC) (Schwarz, 1978).

The AIC and BIC are calculated as

$$AIC=2k+\{\ln(\frac{2\pi v_r}{T})+1\} \quad (7)$$

Where, v_r - Residual variance, k - number of model parameters, T - total number of observation.

E. Selection of most appropriate model

The following criteria are used for selecting the most appropriate model of ARIMA amongst all the models passed the adequacy test or diagnostic checking .in present study RMSE show how close the actual values are of evaporation with predicted values of evaporation. Lower values of RMSE are better model.

The actual and forecast values are compared by RMSE

The root mean square error (RMSE) will be estimated for each model.

$$RMSE= \sqrt{\frac{(\text{Epan}_{act} - \text{Epan}_{for})^2}{N}} \quad (8)$$

Where, RMSE – Root mean square error. Epan_{act} – Actual values of reference Epan, Epan_{for} –Forecast value of reference Epan. N – Number of observation.

IV. RESUT AND DISCUSSION

A. Evaporation analysis

Weekly evaporation from Fig.2 it is shown that series is a seasonal cycle. The ACF and PACF of the original evaporation data were not stationary.

B. Fitting of ARIMA Model

The weekly evaporation data were used for generating and forecasting of development of stochastic model. Results obtained from study have discussed under following heads.

C. Identification of model

The ACF and PACF of weekly evaporation time series were estimated for different lags. These were shown with upper and lower limits. It is seen from Fig.2 that ACF lies outside limits after lag k = 2s + 2 i.e 106 Thus ARIMA model cannot be applied the original time series of evaporation. Therefore the time series were transformed by using differencing schemes d = 0, D= 1; d=1, D=1; D=0, d= 0; D=0. The ACF and PACF along with upper and lower limits were estimated by equation (4) and (5) it is observed from figure that ACF of d = 0, D = 1 and d = 1, D = 1) lie within the limits of range specified by equation (4) and (5) after lag 104, however, for d = 1, D=1) were used for developing ARIMA model for weekly evaporation time series were used for developing model.

On the basis of information obtained from ACF and PACF the orders of autoregressive (AR) and moving (MA) terms were identified as one based on this 36 forms of ARIMA models were identified and parameters computed.

D. Determination of parameters and diagnostic checking.

Following parameters of the selected models were calculated by maximum likelihood method.

1. $\emptyset_1$ 2. θ_1 3. Φ_1 4. Θ_1 5. c

Out of the 36 possibility the ARIMA models satisfied the test for all parameters. Standard error and t values are given in Table 2.

1) ACF and PACF of residual

For model to be consider by adequate at all behaviour of time series the residuals of model should be correlated, i.e. all ACF and PACF should lie within the limits calculated by equation 4 and 5 after lag k = 2s + 2, where s = number of period such as s = 52 or s= 12 for this case s = 52 and the value of k = 106 computed. ACF and PACF residual series plot of 13 models are laid within the prescribed limits.

E. Selection of the best model

First 5 models with less AIC that satisfy standard error and ACF and PACF of residuals criteria were finally used for (Table II) generation of weekly evaporation values. For this purpose evaporation values were forecasted for one year with help of identified ARIMA models. These values were compared with actual values for one year by calculating the calculating the root means square error (RMSE) between them.

Based on RMSE values ARIMA (1,0,0,) (1,1,1,)$_{52}$ and ARIMA (1,0,1) (0,0,1)$_{52}$ are having same value Hence single model selected for forecasting. ARIMA (1,0,0) (1,1,1)$_{52}$ is selected for forecasting. The parameters of selected model is

$\emptyset_1$=0.49 , $\theta_1 = 0.00$, Φ_1 =0 .0079, Θ_1 = 0 .9772, c = 0.112.

F. Comparison of forecast and actual values

The ARIMA model that were finalized to forecast the values of evaporation for Makni Reservoir are presented in figure 6. These values were developed using the E_{pan} data from 1998 to 2011. The evaporation values were forecasted with help of best model and weekly evaporation values were calculated with help of weekly evaporation series. Forecasted values were compared with actual values of evaporation 2012.

V. CONCLUSION

The study indicates that the seasonal ARIMA model is available tool for forecasting the evaporation at Makni Reservoir located in Lohara Taluka, Osmanabad District. The system reveal that if sufficient length of data is used in model building then the frequent updating of model may not be necessary. This forecasted evaporation can be advantages management of reservoir also useful for irrigation system. ARIMA (1, 0, 0,) (1, 1, 1,) $_{52}$ gave lower RMSE value hence, it is best stochastic model for generation and forecasting weekly evaporation values for Makni reservoir. It is concluded that seasonal ARIMA model can be successfully used for forecasting.

Model	$\emptyset_1$	θ_1	Φ_1	Θ_1	C
ARIMA (0,1,1) (0,1,1)$_{52}$					
Estimate	0	0.6548	0	1	0
Standard error	0	0.0296	0	0.0375	0.0211
t-value	0	22.16	0	26.7	0
AIC	4902.87				
ARIMA (1,0,0) (1,1,1)$_{52}$					
Estimate	0.49	0	0.0079	0.9772	0.112
Standard error	0.0352	0	0.0458	0.0427	0.112
t-value	13.92	0	0.17	22.9	0.9
AIC	4817.4				
ARIMA (1,0,1) (0,0,1)$_{52}$					
Estimate	0.8973	0.1522	0	0.1282	35.14
Standard error	0.019	0.0428	0	0.0385	2.44
t-value	47.23	3.65	0	3.33	14.37
AIC	4948.89				
ARIMA (1,1,1) (0,1,1)$_{52}$					
Estimate	0.4079	0.9601	0	0.9998	0.00274
Standard error	0.039	0.0124	0	0.0371	0.00423
t-value	10.45	77.38	0	26.91	0.65
AIC	4805.5				
ARIMA (1,1,0) (0,1,1)$_{52}$					
Estimate	0.2623	0	0	0.9753	0.0006
Standard error	0.0373	0	0	0.0371	0.0509
t-value	7.04	0	0	26.3	0.01
AIC	4977.2				

TABLE I. PAREMETER ESTIMATE, STANDRAD ERROR, CURRSPONDING T VALUE AND AIC VALUES FOR ARIMA MODELS

TABLE II. ROOT MEAN SQURE ERROR VALUES OF FIRST FIVE MODELS

Sr no	*Models*	*RMSE Values*
1	ARIMA (0,1,1) (0,1,1)$_{52}$	3.75
2	ARIMA (1,0,0)(1,1,1)$_{52}$	3.23
3	ARIMA (1,0,1)(0,0,1)$_{52}$	3.23
4	ARIMA (1,1,1)(0,1,1)$_{52}$	3.26
5	ARIMA (1,1,0)(0,1,1)$_{52}$	4.08

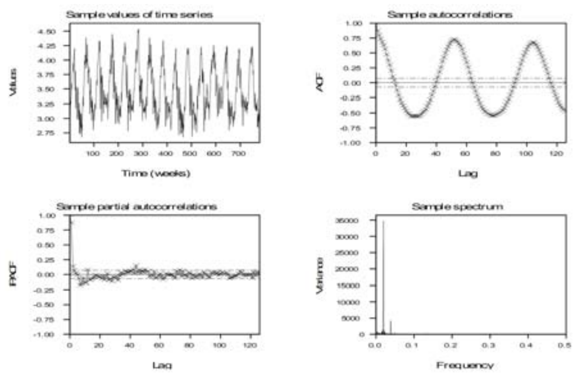

Figure 2.Evaporation time series, Autocorrelation and partial autocorrelation pattern of the differenced time series of evaporation (d=0,D=0)

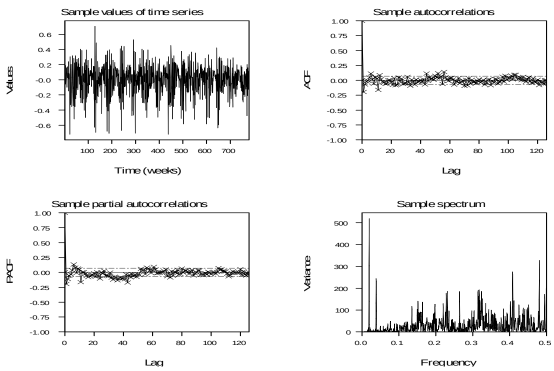

Figure 3. Autocorrelation and partial autocorrelation of differenced time series of evaporation (d=1,D=0)

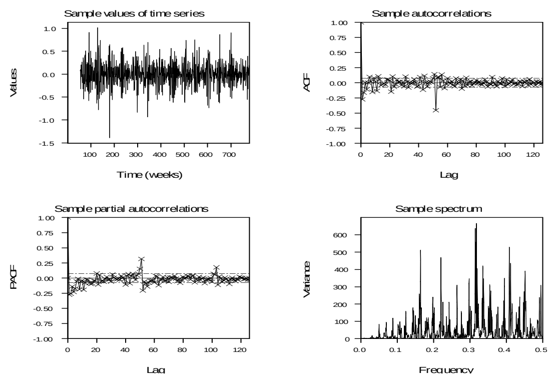

Figure 4. Autocorrelation and partial autocorrelation of differenced time series of evaporation (d=1,D=1)

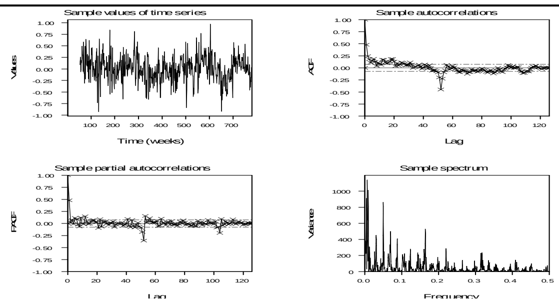

Figure 5. Autocorrelation and partial autocorrelation of differenced time series of evaporation (d=0,D=1)

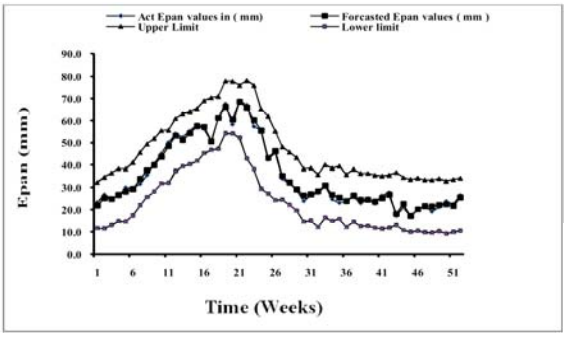

Figure 6. Comparison of Forecasting and actual values of evaporation By Using ARIMA (1,0,0)(1,1,1)$_{52}$

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