Implementing Time Series Analysis Based Decision Support Systemfor Managing Water Resources

WissamShaya'a Abbas[a], NashaatJasim AL-Anber[b]

[a] Msc Student, Information Technology Department, Technical College of Management-Baghdad, Middle Technical University, Baghdad, Iraq. Email:dac0029@mtu.edu.iq

[b]Assistant Prof., Information Technology Department, Technical College of Management-Baghdad, Middle Technical University, Baghdad, Iraq. Email:dr.nashaat@mtu.edu.iq

Abstract: The increasing demand for water in light of limited and sometimes non-renewable resources, and the emergence of new life and industrial patterns, led to a significant escalation in water consumption, as a result of these factors, the quantity of water resources and the storage of water resources. And forecasting techniques for water imports for the purpose of determining the appropriate water stock according to the expected imports for the purpose of achieving rational planning and management for the operation of the dam and the control of water releases. One of the methods used in the first stage is the time series method, the Box-Jenkins method (ARIMA), which takes into account temporal changes in the study of phenomena. And analyzing them and identifying the most important properties in building the appropriate model for the phenomenon studied, secondly, Artificial Neural Networks (ANN) Artificial Neural Networks, which were applied in this research by the Back Propagation Network. The results of the research in the first stage showed that the Artificial Neural Network (ANN) method is the best because it has the least sum of squared errors (MSE). Artificial Neural Network (ANN) algorithm and Support Vector Machine classifier, which were used to classify the output of tank water release. Efficiency through the results reached by the researcher in order to obtain the highest Accuracy)) to reach the best decision to release water and according to the need (few, medium, high). And forecasting the time series. This system can be used by the concerned authorities in the Ministry of Water Resources, as well as the decision-making process by the supporters of the project. A decision to release water for the purpose of using it for water consumption needs such as (irrigation, agriculture, industry and electricity).

Keywords: Time Series Analysis, Artificial Neural Networks, Auto-Regressive Integrated Moving Average, Support Vector Machine, Naïve Bayes algorithm.

1. Introduction

The increasing demand for water in light of limited and sometimes non-renewable resources, and the emergence of new lifestyles and industrial patterns, has led to a significant escalation in water consumption. As a result of these factors, water resources have undergone quantitative and qualitative changes that have affected water courses and storage in dams, lakes and aquifers. , which negatively affected the security of the water supply. The dam (reservoir) is one of the defense mechanisms for floods and drought disasters. During a flood, the opening of the drain gate of the dam shall be sufficient to ensure that the capacity limits of the reservoir are not exceeded on the one hand, and that large discharges do not occur to the riverbed on the other. While the tank during drought needs to retain and release water sufficiently to achieve its purposes. Modeling the tank water release is vital to support the tank operator in making a quick and accurate decision when dealing with both disasters.

The working system of a dam can be divided into four components: upstream, reservoir catchments, stream gate, and estuary. The upstream consists of one or several rivers that carry water to the reservoir. The water in the watershed is stored in the reservoir before being released through the estuary gate into the riverbed. This type of system is designed to ensure that water does not flow from upstream directly to downstream during heavy rains.[1]

Decision support systems are one of the most important information systems that rely on information technology, which has developed a lot during the past decades as a natural evolution of the way computers are used. This system simply focuses on providing appropriate support to improve the quality of decisions, as it works to achieve this requirement by integrating data, models and programs into an effective decision-making system.[2]

The Intelligent Decision Support System (IDSS) is one of the most important potential solutions to support the decision maker in the event of an emergency, as the Intelligent Decision Support (IDSS) model is considered through the use of artificial intelligence methods, machine learning and other prediction techniques from modern technologies, and it has many applications, Especially in water management environments that require a quick and accurate decision to reduce flood risk during heavy rains and contain water during low rainfall in lakes and reservoirs, so the decision to release water is a timely and critical task.[3] In this paper, data mining techniques will be used to obtain an intelligent decision support model, which consists of two stages: the first is assessment and prediction of the situation, and the second is the quantification of water release. In the first stage, time series models are applied according to the theory discovered by Boxes and Jenkins. and Jenkins) in 1970, which are called automatic regression integrated moving averages (ARIMA) and artificial neural networks (ANN), and the second to extract predictions of water levels entering the reservoir. Where the classification techniques are represented by the Naïve Bayes classifier, the support vector machine classifier, and the artificial neural network classifier for control and selection of the appropriate launch policy.

2. Significanceof the Study

The importance of the research lies in optimizing the exploitation of water imports, according to accurate estimates provided by this system, which helps the decision maker, and gives an expected future picture according to the previous data from the imports, and thus the decision to release the imports is scientific according to a computerized system, and provides scientific management to control the storage in light of random environment.

3. Reviewof Related Studies

In **2018, researchers Dubolazov and Somov** studied the new method of time series data preparation and prediction mediated by artificial neural networks, where a detailed analysis of the methodology was done and the results compared with the ARIMA method.[1]**In 2018, the researcher Zaini and others undertook** a study that could lead to the application of artificial intelligence techniques to predict river flows to further improve water resource management and flood prevention. This study relates to the development of a support vector machine (SVM) model and its hybridization with improved particle swarm (PSO) to predict the short-term daily flow of the river in the upper Bertam watershed in Cameron Highland, Malaysia.[2]**In 2019, the researcher Fanoodi et al., conducted** a study aimed at predicting platelet requirements based on artificial neural networks (ANNs) and auto-regressive integrated motor system (ARIMA) models to reduce supply chain uncertainty. To this end, daily orders for eight types of platelets from 2013 to 2018 have been used in the current study. Data was collected from treatment centers and hospitals located in Zahedan, Iran. The results of this study indicated that the ANN and ARIMA models were more accurate in predicting uncertainties in demand than the basic model used at the Zahedan transfusion center.[3]**In 2020, a researcher (Mnguu) undertook** a study aimed at achieving accurate, real-time and able prediction of electricity generation. This study identifies the model of time series best suited for predicting electricity generation in Tanzania. This supports the development of the time series model for predicting electricity generation. Several time series models including SAREMA, SVM and ANN were installed on the data, and the most suitable data model turned out to be ARIMA.[4]**In 2020, Aldhyani and others** studied the development of a model using advanced artificial intelligence algorithms to measure future water quality. In this proposed methodology, advanced artificial intelligence algorithms, NARNET and LSTM models, were used to predict the WQI index. Furthermore, machine learning algorithms such as SVM, KNN and Naive Bays have been used to classify WQI data. The proposed models were evaluated and examined through some statistical criteria. For the WQI prediction, the result revealed that the NARNET model performed slightly better than the LSTM model based on the value obtained. However, the SVM algorithm achieved a higher accuracy of WQC prediction than the KNN and Naive Bays algorithms.[5]

4. Objectivesofthe Study

The objective of this research is to use water import forecasting methods and techniques to determine the appropriate water stock according to expected imports in order to achieve planning, rational management of the operation of the dam, control of water releases according to the amount of imports that contribute to the development of the agricultural and industrial sector by meeting their actual needs, and determine optimal uses of water resources through a system that supports those decisions**.**

5. Hypothesesofthe Study

- There is significant increase in classification accuracy among methods.
- There is useful information about hydrological variables that can serve the well management of dam.
- There is dynamic correspondence between input and outputs of system.

6. Populationand Sample

The data used in this research includes the daily data of water imports entering the Mosul Dam for a period of four years from the year (2015-2018), which we obtained from (Ministry of Water Resources / National Center for Water Resources Management), and these data are the data of the realized water resources that seek In achieving the consumptive needs of water.

6.1. Statistical Techniques Used in the Present Study

In order for the research to reach a successful and effective use of integrated management methods for water resources to manage the dam and water storage, which is carried out through two phases: the first is predictive, and the second is categorical, this was done through the use of the following four techniques:

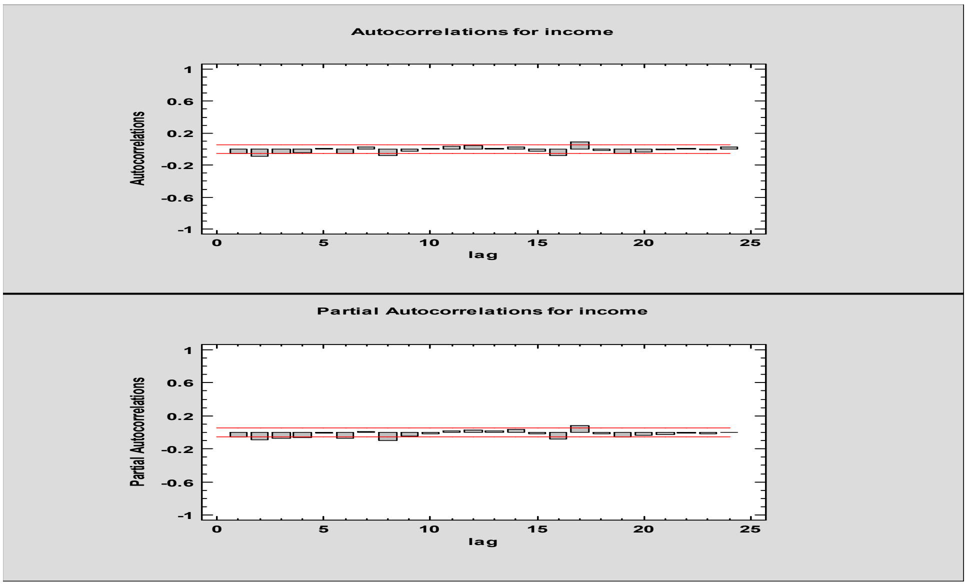
1. Auto-Regressive Integrated Moving Average ARIMA « Auto-Regressive Integrated Moving Average»
2. Artificial Neural Network (ANN) algorithm
3. Naïve Bayes algorithm
4. SVM “Support Vector Machine” algorithm

6.2. Data Analysis and Interpretation

Table.1. In order to find the best model that fits the data, the values of the two criteria (AIC, BIC) are based on the model (ARIMA (1,1.4).

INCOM	ARIMA	AIC	BIC
	(1,1,4)	0.82096	-1.179

Figure.1 After making a mixture of models extracted from calculating autocorrelation coefficients (ACF) and partial autocorrelation (PACF), we estimate each of the proposed models separately to find out the significance and non-significance of the model, and to choose the best model



Interpretation of table-1.

After comparing the above-mentioned criteria, it was found that the appropriate model for the daily water imports entering the dam after conducting 6 possibilities is the ARIMA (1,1.4) model, which achieved the lowest estimation criteria.

Table.2. Demonstrates forecasting future values using the appropriate model

Forecast	Lower 95% Limit	Upper 95% Limit
327.401	149.457	505.345
323.16	79.4755	566.845
321.339	39.082	603.595
319.346	10.3887	628.304
319.411	9.90823	648.729
319.408	29.2069	668.024
319.409	-47.486	686.303
319.409	-64.897	703.714
319.409	-81.552	720.37
319.409	-97.543	736.361
319.409	-112.94	751.76
319.409	-127.81	766.63
319.409	142.204	781.021
319.409	-156.16	794.977
319.40	-169.71	808.535

9		
319.40 9	-182.91	821.727
319.40 9	-195.76	834.581
319.40 9	208.306	847.123
319.40 9	-220.55	859.373
319.40 9	-232.53	871.351
319.40 9	-244.25	883.075
319.40 9	255.742	894.56
319.40 9	-267.00	905.819
319.40 9	-278.05	916.867
319.40 9	288.897	927.714
319.40 9	299.554	938.372
319.40 9	-310.03	948.848
319.40 9	-320.33	959.153
319.40 9	330.478	969.295
319.40 9	340.464	979.281

Interpretation of table-2. After conducting the necessary statistical diagnoses and ensuring the stability of the time series of water imports, we find the last stage of the time series analysis, which is the stage of predictions or future values of the studied phenomenon,The future values were predicted for a period of 30 days, and this prediction gives a clear indication of the extent to which this prediction is used for the water level in the reservoir.

Figure.2. Demonstrates forecasting future values using the appropriate model

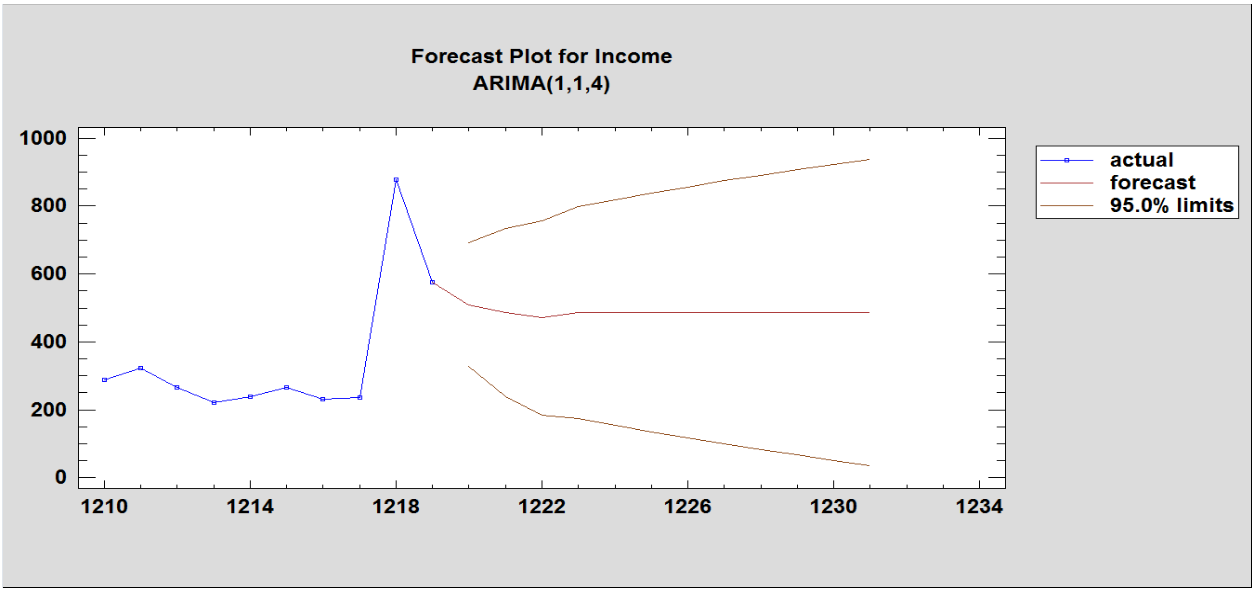


Table.3. It shows the predicted values from the artificial neural network.

income	level	day
202.491738	301.1	1
200.827485	301.1369153	2
202.8463132	301.1914945	3
213.8955603	301.2599351	4
231.0431004	301.324317	5
246.5435982	301.3694632	6
258.1365662	301.3975796	7
266.4802363	301.4154634	8
272.5337528	301.4274593	9
277.0113146	301.4358989	10
280.3901906	301.4420621	11
282.9858546	301.446693	12
285.0101942	301.4502495	13
286.6088932	301.4530276	14
287.8845824	301.4552269	15
288.911237	301.4569864	16
289.7432943	301.458406	17
290.4215573	301.4595593	18
290.9771067	301.4605015	19
291.4339521	301.4612746	20

291.8108 679	301.4619 114	21
292.1226 897	301.4624 376	22
292.3812 464	301.4628 734	23
292.5960 433	301.4632 352	24
292.7747 686	301.4635 36	25
292.9236 761	301.4637 865	26
293.0478 773	301.4639 953	27
293.1515 666	301.4641 695	28
293.2381 984	301.4643 151	29
293.3106 252	301.4644 367	30

Interpretation of table-3.

Using the trained artificial neural network, predictive values were obtained for 30 days, which turned out to follow the same path of real values, which indicates the efficiency of the prediction process.

From the application of the two techniques mentioned in the first stage, which shows the first stage, which consists of the first method, the integrated autoregressive method and the moving averages (ARIMA), as well as the second method, the artificial neural network (ANN), the results of the two methods were compared through the statistical scale (MSE) to find out the best A way to reach predictions of water levels entering the tank that can be used as inputs in the second stage. The results of the comparison show that the best method is the Artificial Neural Network (ANN), which represents the least average squared error, as its mean squared error is equal to (MSE=0.38) and the integrated autoregressive and moving median (ARIMA) method, where the mean of the error squares is equal to (MSE = 0.40), through the implementation stages and steps of the artificial neural network (ANN) method for the time series of daily water imports evident through Applied to these data, results were obtained that show that the artificial neural network (ANN) is better than the method of (ARIMA).

Where these predictions are an important step for the researcher, where indicators have been adopted to move to the second stage to model the artificial neural network for the time series of water levels to reach the best output, which is the levels of water entering the tank, where these levels obtained from the predictions obtained from the best method are used. In the first stage, the Artificial Neural Network (ANN), which is the input to the second stage of the system.

Table.4. Explain the results using the three methods.

header	ANN	SVM	NB
TP	678	791	602
TN	232	282	269

FP	159	131	161
FN	150	15	187

To illustrate the confusion matrix for a classifier with three aqueous release classes (low, medium, and high) as it is often used to describe the performance of a classification model (or "classifier") on a set of test data for which true values are known, three methods have been applied which are the Naïve Bayes Classifier), the Artificial Neural Network algorithm classifier, the Support Vector Machine classifier, and the extraction of results

Table.5. Compare results and know the efficiency of these methods on the statistical scale.

header	ANN	SVM	NB
Accurac y	0.74651	0.88023	0.71452
Fscore	0.81441	0.91551	0.77577

After applying these three methods and comparing the results, and to know the efficiency of these methods according to the statistical scale to reach the best efficiency (Accuracy), it was found that the Support Machine Vector Method (SVM) is the best method in terms of efficiency (Accuracy) and based on the Intelligent Model (IDSS) using this The method: The data of the expected and predicted water levels from the first method were entered as inputs to the second best method in the second stage, represented by the (SVM) method, and were categorized, provided that (SVM) purification is the best way to reach the best classification in the decision of water releases, where these results are considered It is an indication of the use of this model in smart decisions based on the researcher's findings; To help implement a smart system to assist the competent authorities in the Ministry of Water Resources to take the optimal decision-making process for the release process, relying on the smart decision support system, which gives the best decision to release water, according to the need and classified into (low, medium, high).

Table.6. It shows the rate of water expenditures, levels, and daily forecasted releases, measured in units (m3/s) for a period of 30 days.

outcome	**income**	**level**	**day**
268.4097005	202.491738	301.1	1
287.5432464	200.827485	301.1369153	2
264.4781261	202.8463132	301.1914945	3
211.8837225	213.8955603	301.2599351	4
317.4344855	231.0431004	301.324317	5
309.1070661	246.5435982	301.3694632	6
270.5898287	258.1365662	301.3975796	7
282.3643295	266.4802363	301.4154634	8
291.8006902	272.5337528	301.4274593	9
294.5627416	277.0113146	301.4358989	10
295.1352713	280.3901906	301.4420621	11

294.9331908	282.9858546	301.446693	12
294.3960163	285.0101942	301.4502495	13
293.7172861	286.6088932	301.4530276	14
293.006102	287.8845824	301.4552269	15
292.3253836	288.911237	301.4569864	16
291.7072585	289.7432943	301.458406	17
291.1639673	290.4215573	301.4595593	18
290.6961351	290.9771067	301.4605015	19
290.298425	291.4339521	301.4612746	20
289.9630017	291.8108679	301.4619114	21
289.6814609	292.1226897	301.4624376	22
289.4457977	292.3812464	301.4628734	23
289.2488259	292.5960433	301.4632352	24
289.084302	292.7747686	301.463536	25
288.9469037	292.9236761	301.4637865	26
288.8321444	293.0478773	301.4639953	27
288.7362667	293.1515666	301.4641695	28
288.6561346	293.2381984	301.4643151	29
288.5891363	293.3106252	301.4644367	30

Interpretation of table-6.

he researcher concluded through the use of the Machine Vector Support (SVM) method and classifier and based on the use of the Intelligent Decision Support System (IDSS), where it was found that the rate of daily water releases predicted in the future for a period of (30) days, which were classified according to expected policies in a way (little). , medium, high), where we note that (16%) of the daily release predicted in the future is high, and that (17%) of the daily release predicted in the future is medium and (23%) of the daily release predicted in the future is little.

7. Recommendations

- Using the ANN model, the researcher recommends extracting future daily forecasts of water levels in the reservoir and lakes, as well as the adoption of SVM models to extract future daily forecasts of aquatic releases to help decision makers implement the intelligent decision support system (IDSS) in the Ministry of Water Resources.
- The researcher recommends that this research be approved by managers and operators of the dam to make appropriate decisions based on a computerized intelligent decision support system.
- The researcher recommends the responsible use of the SVM model and its application to help decision makers make the right decisions to release water as needed.
- The need to establish an accurate database, including temperatures, evaporation and soil absorption of water, measured by hour, for future study.
- Adopt an expansion of this prediction to take temperatures, evaporate, and absorb the soil for water, to get more precise models

8. Conclusion

The researcher was able through the research, where the results of the application of the Artificial Neural Network (ANN) showed high efficiency through the results reached by the researcher, in order to obtain the least sum of squares of errors (MSE) in extracting future predictions of water levels in the reservoir. SVM) excels in data classification, which is the best efficiency through the results reached by the researcher, in order to obtain the highest efficiency (Accuracy) to reach the optimal decision-making process for the classified water releases process (low, medium, high), and then extract future predictions for releases And that dealing with the artificial neural network (ANN) during practical application takes longer than the time of practical application when dealing with the box Jenkins method (ARIMA). The possibility of using the methodology of artificial neural networks (ANN) to design an integrated system for analysis and prediction. The application of the artificial neural network (ANN) is that it deals with a huge number of parameters and variables that the neural network can deal with and apply them. The ability of the artificial neural network (ANN) to deal with the relationships for a variety of whether it is linear or non-linear.

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