

PREDICTION OF RUNOFF USING ARTIFICIAL NEURAL NETWORKS, MLR REGRESSION AND ARIMA MODEL (A CASE STUDY: BARED RIVER, LEBANON)

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Introduction

- ❖ Climate change is an important factor for strategic water resource management in arid and semi-arid countries.
- ❖ Recent studies have shown the adverse effects of climate change on water resources.
- ❖ Thus, investigating the impact of climate change on the hydrologic cycle is essential for hydrology development.
- ❖ Several studies have concluded that climate change is the main indicator related to the changes in runoff in the basin or catchment area

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- ❖ Accordingly, the prediction of the quantity of water available in a basin over a longer period is considered an essential topic for scientists and engineers for centuries.
- ❖ Additionally, the analysis of runoff is very important for predicting floods and droughts.
- ❖ Moreover, runoff modeling is a versatile tool for designing and operating the various components of water resources projects and water resource planning and management. It also helps to reduce the influence of drought and water resources issues.

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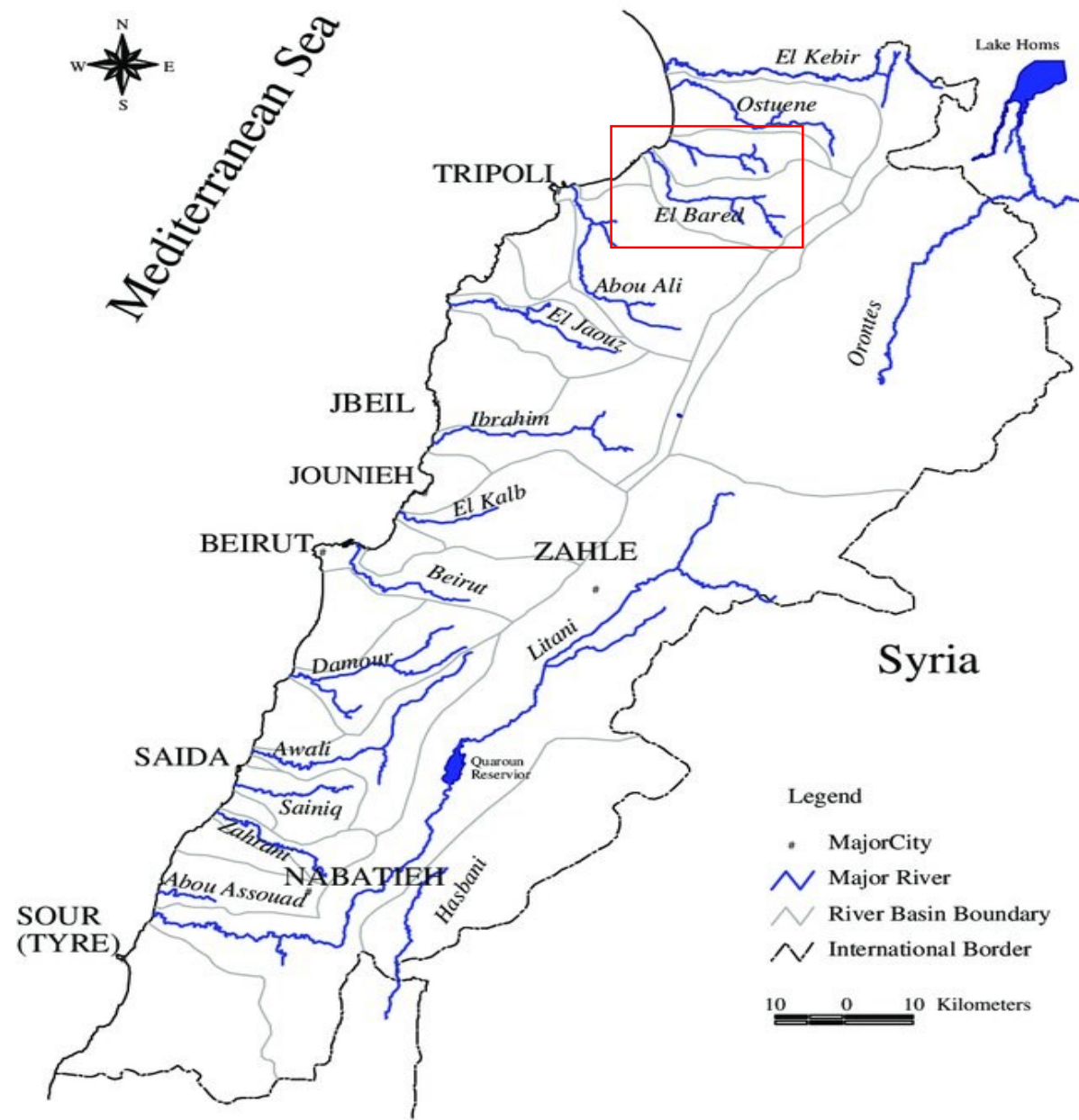
- ❖ Recently, several empirical models of runoff series such as machine learning models and mathematical modeling are developed to construct a long-term runoff forecasting model

Aim of the Study

- ❖ In this study, four empirical models, namely, Feed-Forward Neural Network (FFNN) and Cascade Feed-forward Neural Network (CFNN), Autoregressive integrated moving average (ARIMA), and Multiple Linear Regression (MLR) are developed to predict the runoff at Bared river, Lebanon.
- ❖ For this aim, the monthly global meteorological data including maximum temperature, minimum temperature, wind speed, solar radiation, rainfall, and soil moisture are utilized as input variables for the models.

Study Area

- ❖ Bared river, the third largest river in the Akkar district of North Lebanon, has a very important strategic position.
- ❖ It is fed by the springs in the mountains. Recently, the heavy rainfall with snow has led to an extreme flood, which caused flooded some streets up to the windows of the houses especially houses built near the river.



Data

- ❖ Due to the limitation of available the actual data of climate parameters, global meteorological data are utilized to understand the influence of geographical coordinates on the prediction of precipitation and predict monthly precipitation using various empirical techniques.
- ❖ In this study, global meteorological data were obtained from TerraClimate. TerraClimate dataset offers global monthly meteorological data with high-spatial resolution ($1/24^\circ$, $\sim 4\text{-km}$) monthly climate as well as provides the data since the year 1958 to date.

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- ❖ The main reasons to utilize TerraClimate were the availability of consistent long-term
 - ❖ monthly maximum temperature (T_{max}),
 - ❖ minimum temperature (T_{min}),
 - ❖ solar radiation (SR),
 - ❖ wind speed (WS),
 - ❖ soil moisture (SM),
 - ❖ runoff (Q) and
 - ❖ rainfall (R)

Machine Learning Models (MLMs)

- ❖ MLMs are utilized as a tool to describe a complex system .
- ❖ Wide ranges of ML models are utilized to solve complex problems in a variety of fields.
- ❖ In this study, FFNN and CFNN are developed to determine the runoff.
- ❖ FFNN and CFNN are the most popular artificial neural network approaches for modeling nonlinear and complex processes in the real world.
- ❖ In this study, the training (70%) and testing data (30%) were used to develop and validate the models, respectively. The results of the proposed models are compared with observed data.

ARIMA model

- ❖ It is very widely used in the time series modeling. It proposed by Box, Jenkins, and Reinsel.
- ❖ The model involves of the autoregressive (AR) and the moving average (MA) models.
- ❖ ARIMA model is very popular and accurate than the other time series models, which is defined by three terms (p , d , and q).
- ❖ Box–Jenkins algorithms are utilized to finalize the value of p , d , and q .

MLR model

- ❖ The MLR is a mathematical a statistical model for establishing the relationship between independent and dependent variables.

$$Q = f(Tmax, Tmin, SM, R, WS, SR)$$

- ❖ In this study, MLR can be expressed as

$$Q = A + B(Tmax) + C(Tmin) + D(R) + E(SM) + F(WS) + G(SR)$$

where $A = -5.194$, $B = -4.254$, $C = 5.152$, $D = 0.32$, $E = 0.066$, $F = 3.401$, and $G = -0.005$

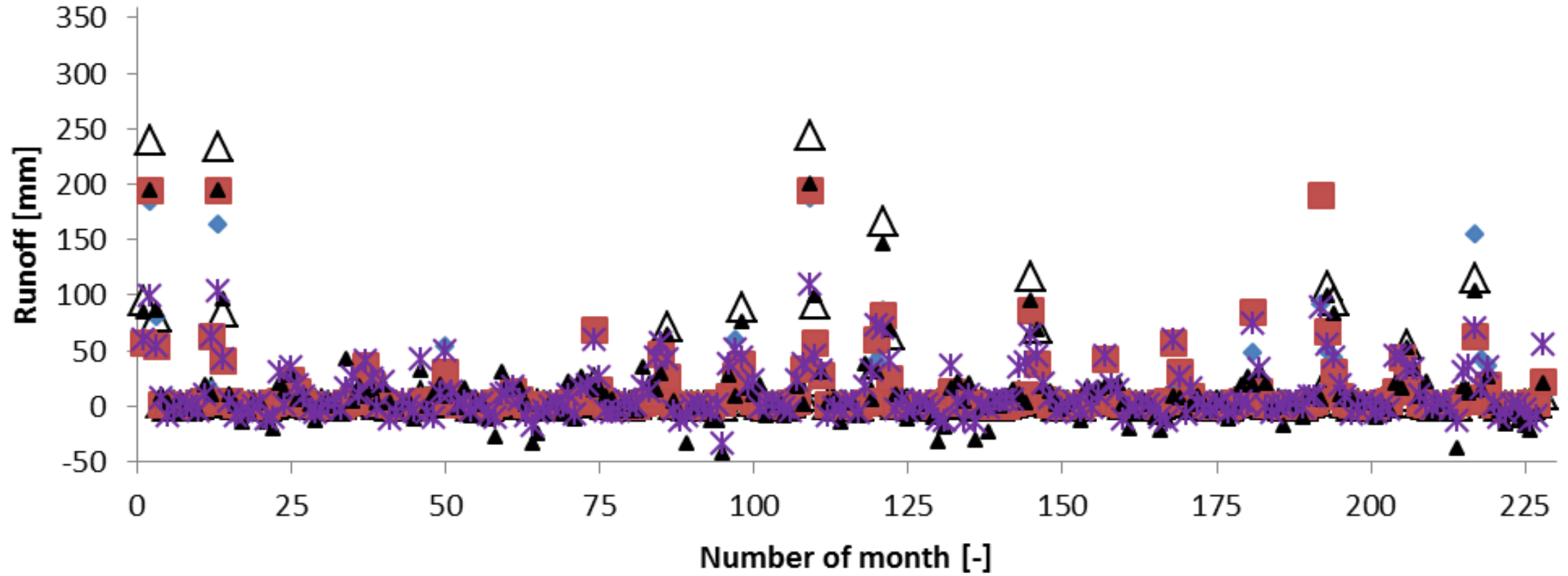
Results and Discussion

- ❖ The performance of FFNN and CFNN is compared with the ARIMA and MLR to evaluate the performance of the proposed models.
- ❖ The values of R-squared and root mean squared error (RMSE) are shown below.

Statistical indicator	FFNN	CFNN	ARIMA	MLR
R-squared	0.816	0.688	0.859	0.513
RMSE [mm]	10.25	12.70	8.56	15.91

Cont.

- ❖ It is noticed that the maximum R-squared value and minimum RMSE were obtained from the ARIMA model followed by FFNN with a value of 0.816 for R-squared and 10.25 for RMSE.
- ❖ Next figure illustrates the time series plots of the observed and predicted runoff values in the testing phase.



△ Observed ◆ FFNN ■ CFNN ▲ ARIMA ✖ MLR

Conclusions

- ❖ In this study, the ability of FFNN, CFNN, ARIMA, and MLR models for monthly runoff prediction was investigated.
- ❖ R-squared and RMSE were employed to evaluate the performance of the models.
- ❖ The results showed that ARIMA and FFNN models were suitable for estimating the monthly runoff.
- ❖ Among the developed models, the ARIMA model presented significantly better prediction performance based on the value R^2 and RMSE.

Cont.

- ❖ In future work, various models with various combinations of parameters should be investigated to identify most parameters that influenced the runoff prediction.

Thank you very much for your attention

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