How much the Remote Sensing Indices can Improve Suspended Sediment Predictions?

Ali Fathzadeh[*]
Associate Professor, Faculty of Agriculture and Natural Resources, Ardakan University
Maryam Asadi
MSc student of watershed management, Faculty of Agriculture and Natural Resources, Ardakan University
Ruhollah Taghizadeh-Mehrjardi
Assistant Professor, Faculty of Agriculture and Natural Resources, Ardakan University

Received: 11/08/2016 Accepted: 27/10/2016

Extended Abstract

Introduction

In the recent decades, the prediction of suspended sediment load was highly regarded by water resources management and engineering researches, particularly in flood prone areas. Nowadays, the methods and artificial intelligence techniques to predict hydrologic properties have become very popular. In recent studies, we have used various parameters such as the spectral reflection bands of satellite images, land use and geology maps and climatic data. Landsat satellite images have good spatial resolution. Da Silvia (2015) also used spectral calibration of multispectral satellite images to assess suspended sediment concentration. Their results showed that the concentration of suspended sediment has been strongly influenced by seasonal rainfall. The yellow river sediment using Landsat satellite images were evaluated by Zhang et al (2014). The results showed that, using the modified algorithm and recovery appropriate climate models, TM / ETM + can be used to quantify the concentration of suspended sediment at the mouth of the Yellow River. In this study, they have investigated mining indices of satellite images and watershed geomorphometry parameters derived from the characteristics of the basin surface to evaluate and compare the performance of these parameters in prediction of the suspended sediment. In this study, the methods such as artificial neural networks, linear regression, K nearest neighbor, Gaussian processes, support vector machine and evolutionary support vector machine have been selected with the purpose to check the role of these parameters in prediction of suspended sediment load. The purpose of the detecting the impact of these parameters is to improve the assessment models.

* E-mail: fatzade@ardakan.ac.ir Tel: +989133526878

Materials and Methods

1- Study Areas

There were 68 catchment areas located in the provinces of Gilan and Lorestan from Iran. (Figure 1)

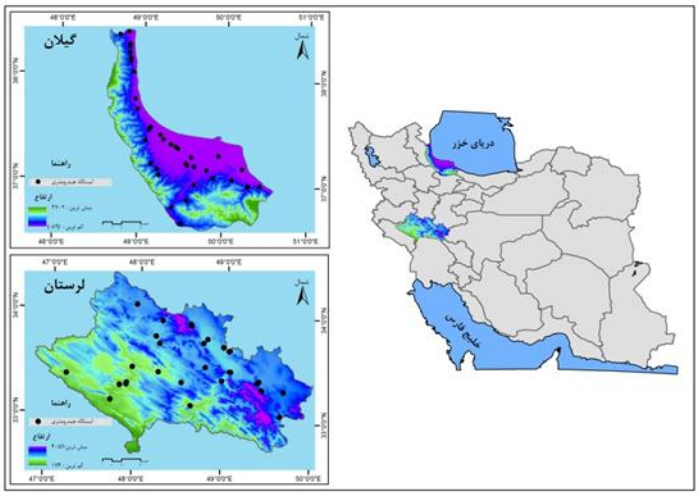

Figure 1. The location and studied stations

2- Data processing

Data mining geomorphometry

After determining the study area, geomorphometry parameters were extracted. Geomorphometry parameters was extracted from 30-meter area digital elevation model (Table 1)

Table1. Geomorphometry parameters extracted from DEM

Analytical Hillshading	MRRTF[1]
Aspect	MRVBF[2]
Catchment Area	Plan Curvature
Channel Network Base Level	Profile Curvature
Convergence Index	Relative Slope Position
Cross-Sectional Curvature	Slope
Discharge	Strahler Order
Drainage Density	Stream Power Index
Flow Accumulation	Suspension Load
Flow Directions	Tangential Curvature
General Curvature	Topographic Wetness Index
Longitudinal Curvature	Vertical Distance to Channel Network
LS Factor	Watershed Basins

1. Multi resolution ridge top flatness index
2. Multi resolution index off valley bottom flatness

3- The modeling process

In this study, we have used the input parameters in the prediction of suspended sediment load of data mining models such as linear regression, Gaussian processes, neural networks, k-nearest neighbor, support vector machine and evolutionary support vector machine.

- Linear regression

Linear regression to model the value of a quantitative dependent variable is based on a linear relationship with one or more independent variables.

- Artificial Neural Network

Artificial neural networks including computational models can be used even if the relationship between inputs and outputs of a physical system is complex and nonlinear, with a network of interconnected nodes that all are joined together.

- K-Nearest Neighbor

K-Nearest Neighbor algorithm including the selection of a specific number of vector data is randomly selected from the set for the simulation period.

Gaussian process

A Gaussian process is a stochastic process consisted of random values at any point in space or time domain so that each of the random variables is normally distributed.

- Support Vector Machine

Support vector machines are a class of supervised learning methods for classification and regression problems.

- Evolutionary Support Vector Machine

Evolutionary vector machine model is used as an evolutionary strategy to optimize the results. It offers an evolutionary algorithm to solve the problem of dual optimization in a support vector machine.

4- Evaluation Model

In order to evaluate the algorithms applied to the data, we used the evaluation criteria of Root Mean Squared Error (RMSE), relative error (Re), Correlation coefficient (r), and Absolute error (AE).

5- Weighting parameters

To weight input parameters of support vector machine algorithm, we determine these algorithm coefficients in a normal vector of linear support machine as the weight of characteristics.

Results and discussion

At first, the different algorithms were applied on the data of the geomorphometry parameters. The results showed that with use of geomorphometry parameters, Gaussian process model with RMSE = 10.35 and R = 0.986 is the best model to predict suspended sediment load. In the next phase models, we used the input data indices of satellite images. Then, index satellite images and geomorphometry parameters as input have been together and the models were run on them.

Also, the results showed the Gaussian process model with RMSE =5.026 and R=0.99. It has the highest accuracy for predicting suspended sediment load. (Figure 2)

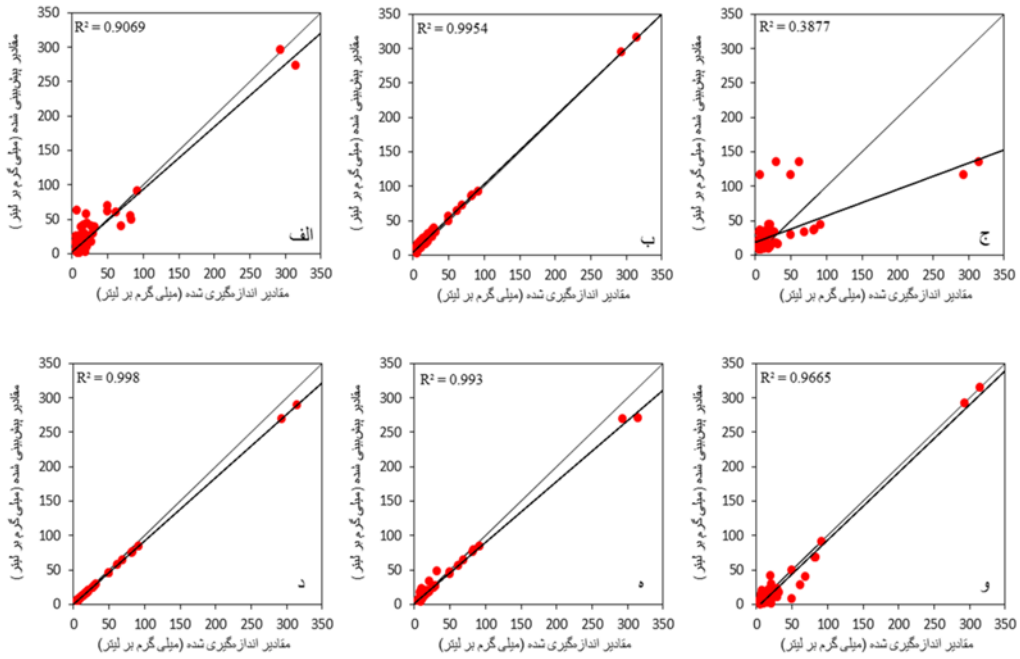

Figure 2. The scatter plot of the observed and predicted values of the models A: linear regression, B: Artificial Neural Networks, C: nearest neighbor, D: Gaussian process, E: support vector machine, F: evolutionary support vector machine, using a combination of geomorphometry parameters and indicators of satellite images.

It can be concluded that the models applied in this study compared with those with climate data as their input have more accuracy. Also, the parameters of satellite images have a greater impact on the increase in the accuracy of the models.

Conclusion

The use of satellite image indices and geomorphometry parameters as model input cause increases in the accuracy of data mining algorithms to predict suspended sediment load. The results of the study indicated that satellite imagery indices have been more effective in predicting suspended sediment load and using these indicators increase the accuracy of the models more effective than geomorphometry parameters. Therefore, with the indices of satellite images, Gaussian Process Model with RMSE =7.513 is using the geomorphometry parameters of the Gaussian process model with RMSE =10.35 as the highest accuracy. Combining geomorphometry parameters and indicators has increased the accuracy of all models and Gaussian process model with RMSE = 5.026 as the highest accuracy. The results of weighting also showed influence of satellite image indices to predict suspended sediment load.

Keywords: Data mining, Digital Elevation Model, Geomorphometry Parameters, Satellite Images.