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Application of support vector machine in modeling land subsidence in parts of Aliabad plain of Qom

A. M. Rajabi*[1], Y. Abolghasemi[2], A. Edalat[3]

Abstract

Due to the enhancement of urbanization, industry, and agriculture, increasing temperature, and decreasing rainfall, the demand for water supply has increased. Excessive extraction of groundwater for consumption imposes a decline in the groundwater level and the occurrence of subsidence as a consequence. In this study, a support vector machine approach is applied to model the subsidence. Groundwater level drop, the thickness of alluvial sediments, the transmissivity of alluvial sediments, and elasticity modulus have been used as independent parameters of subsidence modeling by a support vector machine. The results indicate that the support vector machine model can model the subsidence with reasonable accuracy. To verify the performance of the support vector machine, the model's results have been evaluated with the measured values of the DInSAR method obtained from the satellite images of some parts of Aliabad Plain. In addition, to examine the impact of model input parameters on subsidence, a sensitivity analysis has been conducted, and the results illustrate that the occurrence of subsidence is distinctly dependent on the drop in the groundwater level in the region. The generalizability of the model has been investigated by using a new dataset, and the results indicate the generalizability of the subsidence support vector machine model.

Keywords: *Land subsidence, Groundwater Level Dropdown, Machine Learning, Support Vector Machine, Aliabad plain of Qom*

[1] Department of Engineering Geology, College of Science, University of Tehran, Tehran, Iran
[2] Master Student, Department of Engineering Geology, College of Science, University of Tehran, Tehran, Iran
[3] Graduated from Civil Engineering Department, University of Qom, Qom, Iran
* **Corresponding Author**

Extended Abstract:

1. Introduction

Aliabad Plain has been affected by land subsidence induced by groundwater withdrawal as a result of increasing water demand for agricultural and drinking purposes in the area. The alluvial sediments of Aliabad plain result from the operation of rivers in it and the thickness of these alluvial deposits decreases from the west to the east of the plain. In addition, the land subsidence in western parts of the region is more intensive due to excessive groundwater exploitation (Rajabi, 2018; Edalat et al., 2019). Despite the significance of land subsidence in Qom province in terms of its human losses, economic and environmental damages, a limited number of researches have been accomplished on this issue. For the first time in this area, in order to study and model the subsidence induced by groundwater reduction related to the period from 2015 to 2016, the support vector machine method has been used that according to the previous studies has not been applied.

2. Materials and methods

This study aims to develop a model for land subsidence analysis. Aliabad plain faced to lack of good geo-environmental information of the plain. As a result, in order to create a land subsidence model by the SVM method, the existing data in some parts of the plain have been used. In this regard, a geometric study area with the best distribution of piezometers, the coverage of the interferogram images, and proper hydrological and geological information has been considered. The used dataset for modeling should be the parameters with the greatest impact on the optimal output of the model to obtain a model with high generalizability. Therefore, changes in the groundwater level, elasticity modulus, sediment thickness, and aquifer sediment transmissivity have been considered as the inputs and subsidence for the output of the support vector machine model. Arc Map software version 10.2.2 has been used to manage data and create information layers from existing data. In order to prepare the dataset for land subsidence SVM modeling, raster layers of four inputs and the target parameters have been created by Arc Map.

In order to model the land subsidence, the Support Vector Regression (SVR) method has been used. To model subsidence by support vector machine, coding in the field of solving the constrained and quadratic optimization problem has been used in Matlab R2018b software. With the aim of building a suitable function that determines the best possible output value, using specific input data, support vector machine model training has been done.

3. Results and Discussion

According to obtained results (table 1), the root mean square error value of all the data in the optimal model has been obtained as 0.015, which means that the model has calculated the amount of land subsidence with an error of 1.5 cm on average at each point. The small difference between the error values in the three stages of training, testing and validation, indicates the correctness of the selected parameters and the appropriate performance of the model. In addition, the absolute average error (μ) is close to zero (0.006).

Table 1. The obtained results from the SVM model

Results	Training data	Test Data	Validation Data	All Data
R^2	0.91	0.87	0.86	0.89
R	0.96	0.94	0.93	0.95
RMSE(m)	0.014	0.016	0.017	0.015
MSE	0.0002	0.0002	0.0003	0.0002
Support Vector Number		4195		

Moreover, the results from the generalizability assessment of the SVR model including the value of regression coefficient, coefficient of determination, model error, and the average square root of the obtained error, approved that the model has provided suitable generalizability and has calculated the subsidence with unobserved information package with an average error of 1.7 cm. Furthermore, the results obtained from the sensitivity analysis of the support vector machine model indicate the support vector machine model is more sensitive to changes in groundwater rather than the other three parameters.

4. Conclusion

Aliabad Plain is one of the areas affected by land subsidence due to excessive groundwater consumption from the aquifer system. Therefore, studying and investigating the mechanism of this phenomenon is conducive to managing and preventing damages caused by the reduction of the groundwater level and land subsidence. In order to investigate and model the land subsidence of the Aliabad plain from 2015 to 2016, one of the machine learning methods called the support vector machine has been applied. The SVR model for predicting land subsidence has been developed using MATLAB R2018b software. In order to train the model, four independent variables including groundwater level dropdown, the thickness of alluvial sediments, aquifer sediment transmissivity, and elasticity modulus have been used as input parameters, and land deformation has measured as a single output parameter in the SVR model. The maximum land subsidence has occurred about 15 cm near the central parts of the plain based on the results of the support vector machine. In addition, the results of the sensitivity analysis show that the reduction of the groundwater level is one of the most significant factors affecting the SVR subsidence model. Also, according to the investigation, the support vector machine model has the ability to generalize and is able to predict land subsidence in a part of the Aliabad plain with new datasets.

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