

# Comparison of different methods of application of neural network on soil profile of Khartoum state

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**Abstract:** Within the last years, four methods have been developed to predict the soil profile and its parameters in Sudan. However, a method making such predictions with the required degree of accuracy and consistency has not yet been developed. In this paper, artificial neural networks, ANNs are used in an attempt to compare between these methods by applying them on large zone contains many sites to select a unified method. A large database of actual measured is used to develop and verify the ANN model. The predicted soil profile found by utilizing ANNs is compared between them. The results indicate that ANNs are a useful technique for predicting the soil profile and its parameters when using anyone of the compared methods.

**Keywords:** Artificial Neural Network, Soil Profile, Khartoum, Prediction

## 1. Introduction

Before construction of any structure, subsoil layers, attributes and all questions concern to it have to be known. This knowledge requires drilling of number of boreholes to determine the soil profile of a given area which is costly and consumes a lot of time. In Addition to costly and consuming a lot of time in drilling number of boreholes, the engineering properties of soil exhibit varied and uncertain behavior due to the complex and imprecise physical processes associated with the information of these materials (6). The technique is known as Artificial Neural Networks (ANNs) and is well suited to model complex problems where the relationship between the model variables is unknown.

## 2. Previous Work in Predicting Soil Profile in Sudan

In Sudan there were a number of previous methods that had been adopted using the application of artificial neural networks (ANNs) to predict the soil profile. These methods were applied on two sectors: the first one around the Blue Nile River in Khartoum State, while the second one around the White Nile River. These methods were developed Multi-layer back propagation neural networks to

demonstrate the feasibility of ANNs to predict soil classification and soil parameters based on the available site data provided from borehole logs bored by Building and Road Research Institute (BRRRI) of the University of Khartoum for different purposes. The results of them indicate that Artificial Neural Networks can be considered as an effective tool to predict the soil profile in Khartoum state.

The computer software program 'Neuroshell2 version4' was used for this purpose in all previous methods.

## 3. The Historical Development of Previous Methods

The ANNS was applied to predict soil profile and soil properties in Sudan based on four different methods. The following paragraphs show the historical development of them.

In 2005, the first trial using ANNs in predicting soil profile in Sudan. Four Networks were developed to predict the soil layering for each site separately. These site located in Khartoum city (referred to as method 1).

In 2007, ANNs were used for area contain many sites in specified locations in Khartoum city through developing Seven Networks in prediction the soil Layering (referred to as method 2).

In 2009, ANNs were used also for area contain many sites

in specified locations in Khartoum city through developing ten Networks to predict the soil Layering. Some data are very far from each other's but the final outcome is good (referred to as method 3) .

In 2009, ANNs were used for area contain many sites in specified locations in Khartoum city at different depths by constructing and developing Seventeen models to predict the soil Layering. It used few data to train the network and a lot of data to validation the network (referred to as method 4).

### 3.1. Method 1

The first trial using ANNs in predicting soil profile is done for three sites each one treated separately. It used two supervised model without test data and other with calibration. It demonstrates high success, where the value of  $R^2$  is very high and considered as the highest value in the models. The reason refers to applying the network for narrow zone which has good distribution of the data.

### 3.2. Method 2

In this method ANNs were used for area contain many sites in specified locations in Khartoum city. It depends on previous method in calibration, and try and error to select the optimum hidden layer and its neurons.

### 3.3. Method 3

It followed the methodology of method 2 but add two classification models and one parameter model

### 3.4. Method 4

It differs from previous methods by used large data for production

## 4. Comparison of the Different Methods

### 4.1. Study Area

The study area in this work is located between the Blue Nile and the White Nile in Khartoum state. It lies between 446700m to 454909.7m E latitude and 1715116.838m to 1724109.318m N longitude.

### 4.2. The Assumptions to Carry Out the Comparison

The network was applied in this zone to study the comparison between previously methods and develop a unified method by taking the advantages of each and avoid the disadvantages. For this purpose the following assumptions were considered:

-Initially method 1 was assumed to apply for large zone and have the same optimal parameters of architecture (learning rate) in method 4.

-Then the comparison between methods was applied using seven classifier models and two parameter models.

Table (1) and (2) explains the type of models for comparison and its inputs and outputs.

**Table 1.** The classifier models and its inputs and outputs

Model's Name	Input parameters	Output parameters
Sand\clay silt model(1)		Sand Clay\silt
Sand model(2)		Fine sand Grade of sand
Fine sand model(3)		SC, SM
Grade of sand model(4)	- E,N coordinates - Descending depth from the altitude	SW SP
Clay\ silt model(5)		Clayey layers Silty layers
Clay plasticity model(6)		CL CH
Silt plasticity model(7)		ML MH

**Table 2.** The parameter models and its inputs and outputs

Model's Name	Input parameters	Output parameters
Atterberg model(8)	- E,N coordinates - Descending depth from the altitude	L.L (%) P.I (%)
SPT model(9)	- E,N coordinates - Descending depth from the altitude	N value " blows/ft"

-For all methods selected ward nets architecture was selected number of sites for training and testing network for methods use large data are 31 sites and for those used few data are 9 sites. The production data uses the same number of sites in all methods (11 sites).

### 4.3. The results and Discussion

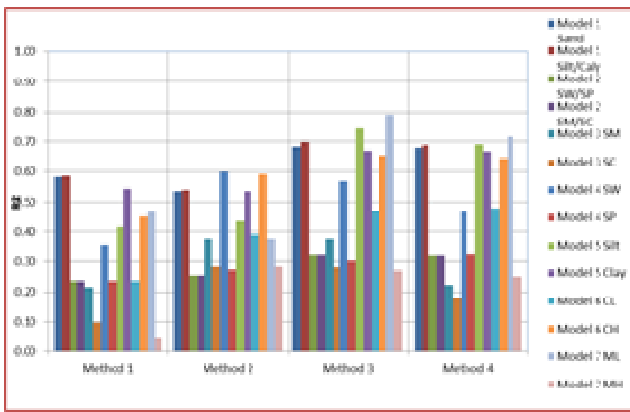
Once the training phase of the model has been successfully accomplished, the performance of the trained model has to be validated for an independent data set.

One of the most important criteria that has to be considered when assessing model performance is that good performance during training can always be attained. However, it is also important for the model to perform well for a set of data previously unseen by the model. Consequently, it is essential to check that the model performs consistently on all three data sets (i.e. training, testing and validation).

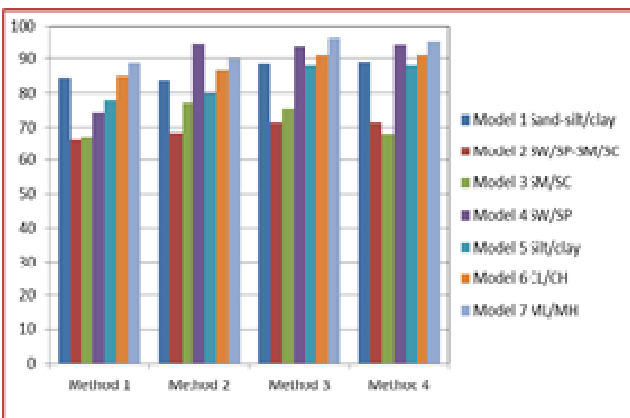
Generally in this work our estimation for classification models performance depends on  $R^2$  and percentage of success of all three data sets (i.e. training, testing and validation).

Fig (1) explains the classification models performance of training and testing data while Fig (2) explains the classification models performance of validation data.

The percentage of success was obtained after the actual soil layers type for each case study has been compared with predicted soil layers achieved by ANN.



(a)



(b)

Fig. 1. The classification models performance of training and testing data

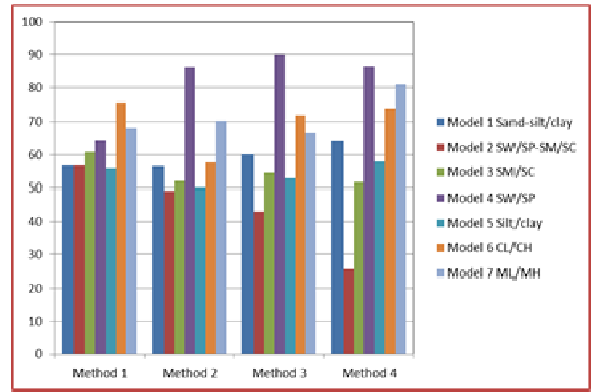
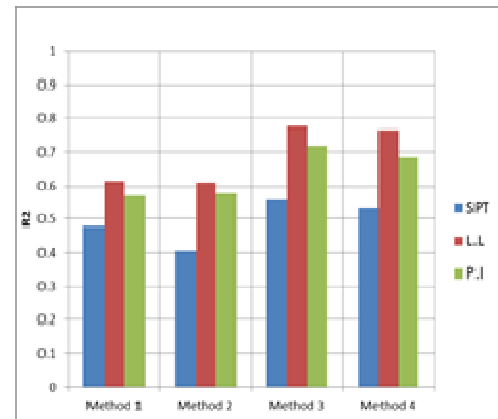


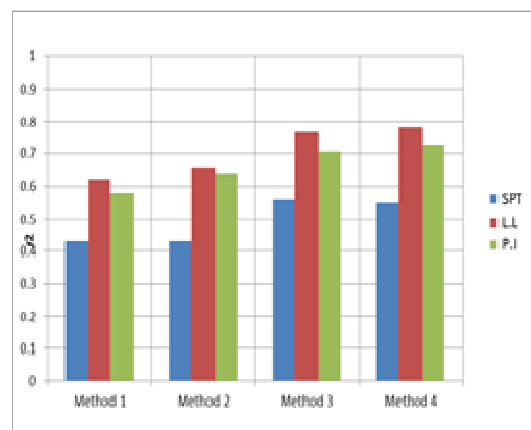
Fig. 2. The classification models performance of validation data.

Since our estimation for parameter models performance depends on  $R^2$  (training and testing) and  $r^2$  of all three data sets (i.e. training, testing and validation).

Fig (2) explains the parameter models performance of training and testing data while Fig (3) explains the parameter models performance of validation data.



(a)



(b)

Fig. 3. The parameter models performance of training and testing data

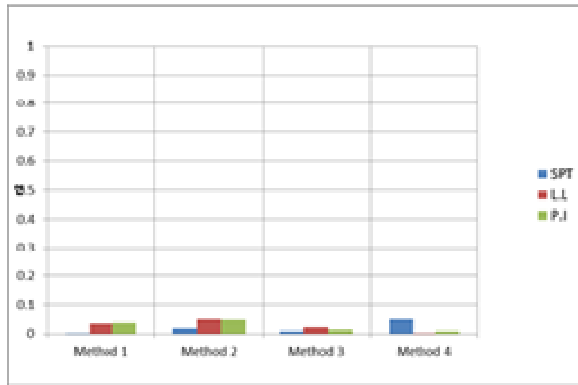


Fig. 4. The parameters models performance of validation data.

Comparisons of the results obtained from application of previous methods which presented in previous figures were shown the following:

-All methods gave reasonable results (greater than 0) and close to each other. This may be because they followed the same methodology.

-Methods which used various learning rates and momentum terms (Method 1&4) other than default value of program sometimes give performance better than methods used the default value in most of models and visa verse.

-Ward nets architecture with two hidden layers give proper results in case of classifier and parameters models.

-The number of hidden nodes on ANN has little impact on the predictive ability of the ANN in zone 2.

-Increasing training time leads to reach to highest value of  $R^2$  in training and testing data and the same time lead to bad value of  $R^2$  in production data.

-The degree of success which mentioned in method 4 sometimes didn't give the real percent in case shortage availability of specify layer in their actual profile. Example of that: model 7 was found that MH layer few in its actual profile this lead to low value of  $R^2$  (0.03) in training and testing data at the same time gave high percent of success in its training data.

## 5. Conclusion

All methods gave reasonable results (greater than 0) and close to each other. This may be because they follow the same methodology approximately.

-Decreasing training time was suggested and leads to reliable results.

-In classification models, it was suggest that in case the two outputs have value of (0) together the corresponding was excluded to improve the results of networks.

-The advantages of using neural networks to predict soil profiles is that neural networks are able to automatically create an internal distributed model of the problem during training, that make them a powerful and practical tool for soil classification prediction.

-Results obtained from the models show that ANNs with proper training is a good tool in prediction

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