Evaluation of the Accuracy of Some of Geostatistical Methods

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Abstract: Desertification has been one of the major worldwide problems in recent decades. This factor reduces soil potential and thus decreases the biomass. Desertification has various factors; soil salinity is one of these factors. Determination of soil salinity changes is very important in the world because the amount and intensity of desert development can be investigated by studying the salinity changes. The geostatistical methods are among the studied methods in order to prepare soil salinity map. In this study, preparing the salinity map was carried out by taking the random samples from the region. To proper sampling of studied area, at the first 150 count have been read state by using electromsgnetic inductor device. The studied geostatistical methods were: Cokriging, Regression Kriging, Kriging and Inverse Distance Weighted. According to the obtained results, the lowest error rate was observed in Regression Kriging and it was more accurate than the other models.
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1. Introduction

Electromagnetic machine (EM) allows monitor soil salinity without direct contact with it and to spend less time and cost is providing compared to other desert methods (Zolfaghari, 2010).

From electromagnetic induction sensors (especially EM-38) can be used to measure the salinity of the surface layer (30-0 cm) or deeper (90-0 cm). This sensor can be used if combined with global positioning to determine soil salinity map (Walter et al, 2001: Minasny and McBratney, 2006: Daempanah et al, 2011).

Moameni (2011) a study to reduce sampling density to prepare the map soil salinity by using of Kriging, Cokriging and RK methods conducted in China Country. The results showed that the use of auxiliary data in Cokriging and regression kriging method in different sampling density were better than ordinary kriging method. In comparison with Cokriging method is reduced RK method amount square root of 5/41 to 6/23 mm siemens per centimeter; this is because in RK method can be more used auxiliary data.

In the regression models, which are considered as another estimating method, the spatial dependency of the parameters are not considered (Lopez-Granados et al., 2005). In the co-kriging method or other estimation methods such as regression - kriging, which are in fact a subset of the geostatistical methods, the spatial correlation of the objective and secondary parameters is also considered. Therefore, many sources have suggested using the Kriging methods in order to prepare the salinity maps (Bishop and McBratney, 2001).

Pozdnyakova and Renduo (1999) research can be mentioned as an example of these researches which they studied the salinity of some soils in California. In this study, isotropic variogram and the impact radius of 700 meters were concluded. Also, in the co-kriging method to modify the estimates of sodium adsorption ratio, the electrical conductivity variable was used as auxiliary data.

In Algeria, Walter et al, (2001) were prepared the salinity maps by using the kriging method. In this study, degree of the salinity was separated from low to very high. In this regard, structural ground conditions, topography changes, water quality and type of use, had a great influence on the spatial correlation which its result was the impact radius of 4000-meter.

2. Materials and Methods

The study has been done in Yazd city (figure 1).

To proper sampling of studied area, at the first 150 count have been read state by using electromsgnetic inductor device. Then the points have been covered to attached layers by using usual Kriging with local variogram. The samples were dried in open space and sieved (by 2mm sieve) before transferring to laboratory (shojaei, 2014).

Kriging: kriging is as one of geostatistical estimation method that based on moving average weighted is firm. This method can be considered the best linear unbiased estimator. From the most important feature is the possibility to achieve the error related to each estimate (Nasiri et al, 2016). This estimator for equation (2) is defined as:

Fig 1. Location of the study area

$$Z^*(x_i) = \sum_{i=1}^{n} \lambda_i \, z(x_i)$$

Where z*(xi): Expression estimated iλ: weight or quantity importance dependent on samples i and z (xi) is a variable amount measured (Tajgardan et al, 2009).

Inverse Distance Weighted method: Inverse distance was interpolation method with average weighting where data via a deflection connection a point of other points are weighted by using of networked nodes. When the network node is estimated, weights assigned points divided to small amounts so that the sum of all weights assigned points equal to 1. When adapted point on the network node, the distance be this point to the node is equal to zero, so in this case weight assigned to mentions points equal to 1 and the weight of other points of around nodes is equal to zero (Shojaei, 1393). This method is based on the assumption that with increasing distance data, impact on each other's data becomes pale. Therefore, weighting coefficient with the distance has reverse proportion. Relevant relationships are as follows:

$$\hat{Z}_J = \frac{\sum_{i=1}^{N} \frac{Z_i}{h_{ij}^{\beta}}}{\sum_{i=1}^{N} \frac{1}{h_{ij}^{\beta}}}$$

$$h_{ij} = \sqrt{d_{ij}^{2} + \sigma^2}$$

Where hij: The difference effective distance between network node (j) and point neighboring node (i), $\hat{Z}_J$: the estimated value parameter Z, Zj: the actual value of the parameter Z in the neighborhood nodes, dij: The distance between network nodes (j) and point neighboring node (i), β: potency weighted, σ: Leveler are coefficient (Zolfaghari et al, 2011: Shojaei et al., 2017).

Cokriging: in Cokriging method one or more secondary variables are used as covariates to improve the estimation. Cokriging equation is as equation (1): (McKenzie and Ryan, 1997).

$$Z^*(x_i) = \sum_{\acute{e}=1}^{n} \lambda_{\acute{e}i} \,.\, x_i \sum_{k=1}^{n} \lambda_k \,.\, y(x_k) \qquad (1)$$

Where Z*(xi): is the estimated value for xi point, λ i is the weight of the variable Z, λk is the weight of the covariate y, z(xi) is observed value of the main variable and y(xk) is observed value of the covariate. To estimate by using this method and to calculate the weights, we have to calculate the mutual variogram as follows (Equation 2):

Y(zy)h = 1/2 n[z(xi + h) – z(xi)]×[y(xk – y(xk))] (2)

Where Y(zy)h is mutual variogram between Y and z, z(xi) is observed variable and y(xk) is covariate (Tajgardan et al, 2009).

Regression Kriging: Regression Kriging or Kriging after the process removal is a hybrid method consists of a Regression model and simple Kriging. In this study, for soil electrical conductivity zoning the Regression Kriging model with local variogram was used. For this purpose, first, all of the information layers converted to the cell. Then, a neuro-fuzzy relationship was created between outward electrical conductivity data and electrical conductivity data and residual values were used to provide continuous error map using local variogram (process removal). Implementation of local variogram consists of four phases: 1) Finding the nearest neighbor points to the spot where the prediction is made. 2) The creation of experimental variogram using neighbor areas. 3) Fitting the appropriate model to the experimental variogram. 4) Predicting the amount of salinity in the intended spot. Consider that in the global variogram only one variogram is calculated for the entire region. In recent years researchers have widely used the local variogram in the studies of soil digital mapping. Finally, we combined the resulting error map with the obtained map from neuro-fuzzy model (Quinlan, 2001) to obtain the final soil salinity map (Shojaei, 2014).

This method is based on the assumption that with increasing the data distance, the data effect on each other would decrease. Therefore, the weight coefficient has inverse relation with distance. The relationships are as follows:

$$\hat{Z}_J = \frac{\sum_{i=1}^{N} \frac{z_i}{h_{ij}^{\beta}}}{\sum_{i=1}^{N} \frac{1}{h_{ij}^{\beta}}} \quad (3)$$

$$h_{ij} = \sqrt{d_{ij}^{2} + \sigma^2} \quad (4)$$

Where hij is the effective distance between network node (j) and node neighboring point (i), $\hat{Z}_J$ is the estimated value of the parameter Z, Zj is the actual value of the parameter Z neighboring node, dij is the distance between network nodes (j) and node neighboring point (i), β is the given weight power, σ is leveler coefficient (Zolfaghari et al, 2011: Shojaei et al., 2017).

Assessment models

Assessment models of geostatistical models' methods.

$$RMSE = \left[\frac{\sum(X_0 - X_e)^2}{n}\right]^{1/2}$$

$$R^2 = \left[\frac{\sum((X_e - \overline{X}_e)(X_0 - \overline{X}_0))}{\sqrt{\sum((X_e - \overline{X}_e)^2(X_0 - \overline{X}_0)^2)}}\right]^2$$

$$ME = \frac{1}{n}\sum_{i=1}^{n}(X_0 - X_e)$$

3. Results and discussion

Electrical conductivity values obtained from kriging, Inverse Distance Weighted method, Co-kriging and regression kriging method shown in Table 1.

According to obtained results from electrical conductivity mean value estimate kriging model is equal to 15 dS/m. Also mean value electrical conductivity is obtained from regression kriging method equal to 15.5 dS m.

According to obtained results from electrical conductivity mean value estimate Inverse Distance Weighted model at a depth of 0-30 cm is equal to 15 dS/m. Also mean value electrical conductivity is obtained from Co-regression kriging method equal to 15.6 dS m.

Table 1. Summarize statistical of electrical conductivity values (dS/m)

mean error	**Coefficient of variation**	**SD**	**mean**	**method**
0.33	53.28	5.1	15	**kriging**
0.20	44.11	4.0	15.5	**regression kriging**
0.24	50.00	5.5	15	**Inverse Distance Weighted method**
0.32	48.23	5.7	15.6	**Co-kriging**

In this research kriging with spherical model was used. Root Square Error and mean error soil salinity arising from both kriging, Inverse Distance Weighted method, Co-kriging and regression kriging method results shown in Table 1 (Siasar and shojaei, 2017).

Rainfall less than 60 mm per year, reduction in dry climate and vegetation due to the expansion salinity and release large part of agricultural land from reasons spread of salinity can be expressed in Yazd (Zolfaghari, 2010).

As compared other research (Figueira et al, 1999) results monitoring salinity in two pieces with different humidity soil showed that correlation between electromagnetic navigation device readings in soil with weight moisture 35% more of soil with weight moisture is 20% with increasing soil moisture measurement accuracy of these tools will also increase. After determining the main parameters and neuro-fuzzy model, the remaining amounts of training data is calculated and by using of kriging with variogram error area was convert to map of continuous variance error. In similar researches paid to Digital zoning of ability electrical conductivity appearance by using of regression kriging and local variogram in Ardekan region.

In the southern part of the study area, higher salinity values were observed. In another study, Yan et al (2007) studied the spatial variability of soil salinity in a 10-hectare farm. Due to the differences in management operations and non-uniform hilliness of the farm surface, the coefficient of variation had higher value and differences of the salinity values were apparent over short distances.

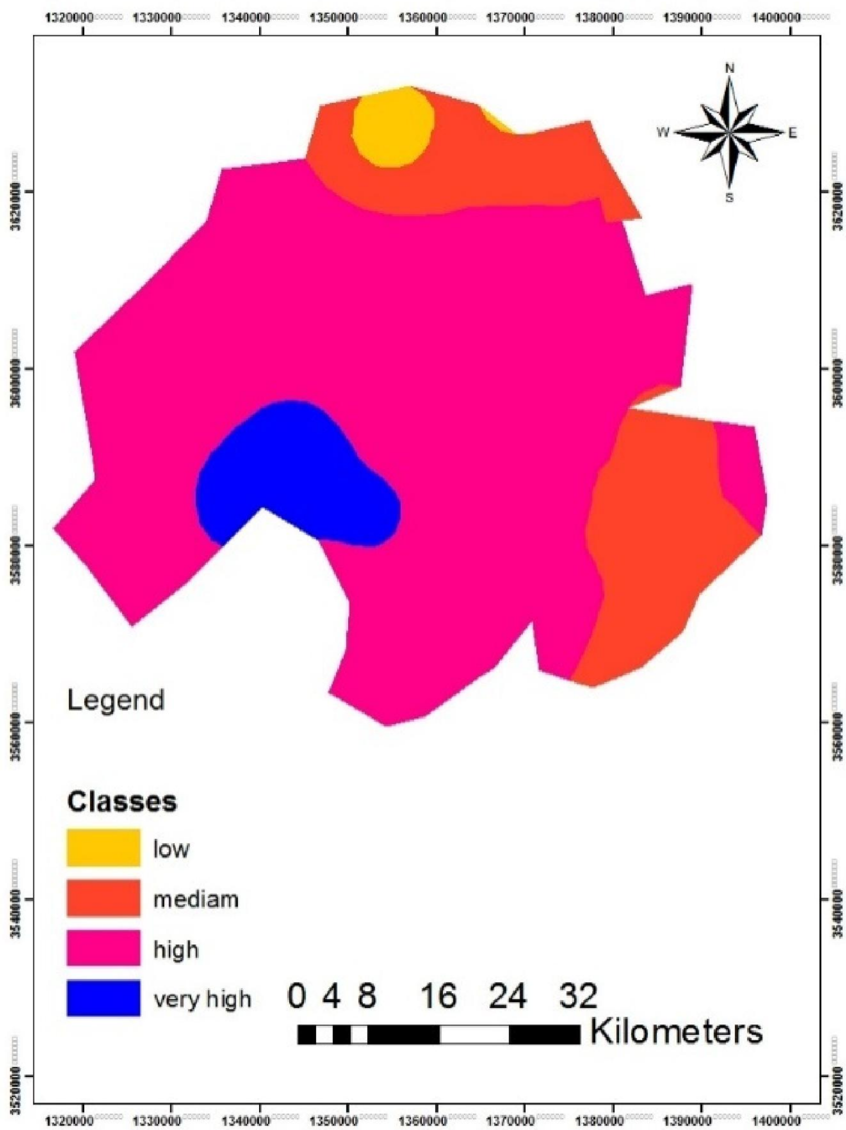

Figure 2 maps of ability the electrical conductivity by using of regression kriging mode

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