RT&A, Special Issue № 4 (70)
Volume 17, November 2022

THE PROBABILITY-STATISTICAL STUDY OF THE AMELIORATIVE CONDITION OF LANDS

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Abstract

Article devoted is comparative study of satellite imegary and collected field-research data on the research area with different natural and economic conditions. Probability - statistically evaluations were performed for the purpose of land reclamation research which of based on indicators of salinity, humus and values of NDVI, which is around the point of the where the soil sample was taken. The study was carried out to know the land reclamation condition by using GIS technology and Regression analysis. We discuss how data can be organized so that important features can be grasped quickly and effectively. During carrying out of reclamative researches and processing of the collected data necessary to solve various problems, which are applied information technology and a geographic information system (GIS), accoding to directions on the study.

Keywords: probablity-statistical, vegetasion index, amelaration candition of lands, dry residue, humus

I. Introduction

Development of innovative technologies and use of geographic information systems accoding to wide perspectives are opening up and increasing the efficiency of scientific research; effective solution of many practical problems in a short period of time during monitoring; in the assessment of natural resources, in environmental protection, in the study of land reclamation, with using aerospace data. The basic problems in the land reclamination for saline land which can be solved using aerospace data are systematizing. Application of such progressive methods to more prompt and accurate, as well as from economic view is considered more efficient research.

Soil salinity is an increasing problem on Earth that affects the development of plants, with negative effects for agriculture. Identification of salinized soils, monitoring and mapping is a very difficult; because salinization is a dynamic process, drawing up maps characterizing land reclamation conditions based on the processing of satellite images it has special importance for the evaluation and clarification of the current situation.

The analysis of multi-temporal multi-spectral satellite images that illustrate the seasonal dynamics of land surfaces is very reliable.

II. Research area and Methods

Research works were carried out for the purpose of comparative study of actual and satellite images; for analysis of information capability of aerospace Earth monitoring data; for digital image processing; for more accurate processing of resolutions of space images, in Shirvan Experimental Amelioration Station (SEAS) and Zardob Experimental Plot (Zardob EP), which are considered as key objects (Fig 1). For this purpose, used various open internet (earthexplorer.usgs.gov etc.) databases. Used a GPS (global positioning system) receiver to record locations and reserch points [3].

The study site SEAS is located in Shirvan plane in the center of Azerbaijan, between latitudes 40°30′45″ N and longitudes 47°39′08″ E (40.5033^{0}N47.6985^{0}E) and it covers an area of 206.5 ha (Fig. 1). The area has an arid climate with an average annual precipitation of 320 mm and annual evaporation from the water surface 162.95 mm yr−1[1].

The study site Zardob Experimental Plot is located in Shirvan plane the center the of Azerbaiyan, between latitudes 40° 13′ 6″ North and longitudes 47° 42′ 30″ East (40.1936^{0}N 47.6180^{0}E) and it covers an area of 638.3 ha (Fig. 1). The area has an arid climate with an average annual precipitation of 350 mm and annual evaporation from the water surface 150 mm yr−1 . July is the hottest month in SEAS and Zardob Experimental Plot, averaging 26°-27°[1].

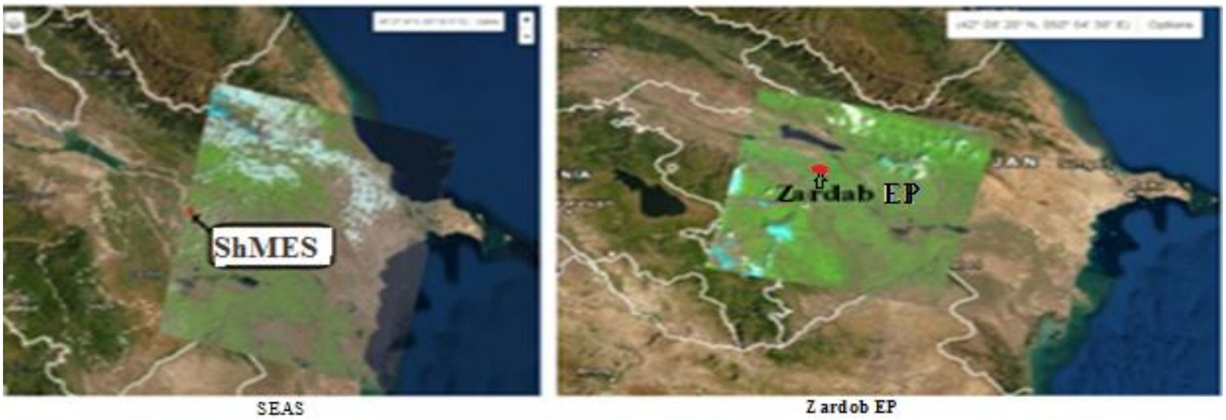

Figure 1: *Location map of the study area*

Depending on the salinity of soils such plants as garasoran, shahsevdi gishotu, are widely spread in these regions.

Various research points were identified and research was carried out, for perform a comparative study of the results of chemical laboratory analysis of soil samples and the results of the satellite images in the territory of SEAS and Zardob EP.

Both datas of laboratory analysis and collected as a result of visual inspection, using the appropriate formula of the Vegetation Index, systematized by using information from literature and internet resources for the purpose of organizing monitoring of lands . There are two types of Earth remote sensing techniques: aerial survey and space survey. Medium spatial resolution satellite images from the LandViewer resource have gained most popularities . Carrying out research in the research area based on the database of Landsat 8 and Sentinel-2 satellites image. In addition to the Landsat-8 RT satellite image, Sentinel-2 L2A satellite data was also used in this study to identify and compare the research areas [2,3,7].

Various multispectral images of satellite imagery data of different dates were studied for in order to study the monitoring of reclamation processes in the research area. Use Ecxel for statistical analysis for data, including the analysis of descriptive statistics characteristics of soil salinity at different soil layer and humus, NDVI and their correlation, Descriptive Statistics analysis and Correlation analysis tool, respectively [4,5,8,12].

Figure 2: *Research area in LandViewer Software*

Most commonly used vegetation index is Normalized Vegetation Difference Index (NDVI). NDVI indices were evaluated taking into account the salinity level of the soil cover in the area involved in the study, wild vegetation, the presence of garden and forest area in the fields under various cultivated crops (barley, wheat, cotton, corn, clover). Taken a photo that shows soil surface conditions and vegetation, for investiqation. Vegetation indices play an important role in evaluating the state of vegetation which of based on spectral reflectance properties. A Vegetation Index is a single value calculated by transforming the observations from multiple spectral bands.

Vegetation index means, especially during the growing season of the plant accoding to depending on other factors (land cover, meteorological conditions) the relationship between spectral reflection coefficients at different wavelengths is understood. These indices enhance the contrast between soil and vegetation but minimize the effects of illumination conditions. However, they are sensitive to optical properties of soil background. The Normalized Difference Vegetation Index is an indicator of the greenness of the biomes.

As a result, how much topsoil to the salinization process allows to determine whether it has been exposed. By using the NDVI index, type of plant, density and height of plant are important, for decoding setallite images is considered one of the main indicators in investigation of the reclamation situation. [9,10,11].

The Normalized Differential Vegetation Index (NDVI) is a standardized vegetation index which allows us to generate an image showing the relative biomass. The Normalized Difference Vegetation Index (NDVI) is a quantitative index of greenness ranging from 0-1, where 0 represents minimal or no greenness and 1 represents maximum greenness. NDVI values range from +1.0 to -1.0. High NDVI values (approximately 0.6 to 0.9) correspond to dense vegetation such as that found in temperate and tropical forests or crops at their peak growth stage. A zero means no vegetation and close to +1 (0.8 – 0.9) indicates the highest possible density of green leaves. If the NDVI is lower than 0.15, most probably all the plants died in this part of the field. Typically, these figures correspond to plowed soil without any vegetation. NDVI varies between 0.2 to 0.5, in the grasslands with sparse vegetation and the shrubby place. Various soil types reflect solar radiation differently [5,6,8,12].

It was estimated using the Normalized Difference Vegetation Index (NDVI) which is computed by the Equation

$$NDVI = \frac{\rho_{NIR} - \rho_{RED}}{\rho_{NIR} + \rho_{RED}} \quad (1)$$

Where: ρ_{NIR} is the near infrared spectral wavelength, and ρ_{RED} is the red spectral wavelength.

$$For\ Landsat\ 8\ \ NDVI = \frac{B5 - B4}{B5 + B4} \quad and\ \ For\ Sentenental\ \ NDVI = \frac{B8A - B04}{B8A + B04}$$

Satellite sensors like Landsat and Sentinel both have the necessary bands with NIR and red.

We discuss how data can be organized so that important features can be grasped quickly and effectively. The next step was to summarize the data (dry residue, humus) for evaluate soil salinity based on samples taken from different soil layers in order to study reclamation process in SEAS and Zardob Experimental Plot by mathematically and statistically methods. Statistic estimation are animportant part of research which search for better for safer and more allows to effective control the meliorative situation. Statistical measures which can be used to describe the characteristics of a set of data. In a single value that serves as a representative value of the overall data. Such measures are the mean, the mode, the median, standard error and etc. The most commonly used measure of central tendency is the mean— the arithmetic average of a group of scores. The median is the middle value. Another measure of central tendency, the median, is used in situations in which the mean might not be representative of a distribution. For example, the mode of a set of data is the value which occurs with the greatest frequency. How a set of data can be summarized by a single representative value which describes the central value of the data. The median is the middle score in a distribution after the scores have been arranged from highest to lowest or lowest to highest. The most important measures of variability are the sample variance and the sample standard deviation. The simplest measure of variation is the range—the difference between the lowest and the highest scores in a distribution. Confidence Level: The percentage of all possible samples that are expected to include the true population parameter. They are most often constructed using confidence levels of 9 5% or 99 %. Statisticians use confidence intervals to measure uncertainty in a sample variable[8,12,13].

Regression is a statistical term wherein a statistical tool is used to find relationships within a given data. The correlation coefficient ('R') is represented by a value that varies from +1 through 0 to −1. Correlation is used to denote the association betweentwo quantitative variables [13]. Positive correlation, one in which a direct relationship exists between the two variables. This means that an increase in one variable is related to an increase in the other, and a decrease in one is related to a decrease in the other, as well as the strength of that relationship (weak, moderate, strong). Negative correlation indicates that an increase in one variable is accompanied by a decrease in the other variable. 0 indicates no linear correlation between two variables.

III. Results

From 9 different points in soil samples were taken at a depth of 1 m, the coordinates of each well were determined using ArcGIS Earth software in the SEAS area. In total 45 soil samples: between 0 and 20 cm depths, between 20 and 40 cm depths, between 40 and 60 cm depths, between 60 and 80 cm depths, between 80 and 100 cm depths, were collected for used in this study. The soil samples were taken in the field at different soil types (i.e., during the dry season) and in weather conditions with no rainfall, but sunny [1,4].

In addition, Zardob Experimental Plot from 8 different points in soil samples were taken at a depth of 1 m, were collected for used in this investigation. Accordingly, the condition of the plant and soil in the around of the each well was recorded, for the purpose data of satellite images for mutual comparison with field and laboratory measurements (Table 1).

Initially, the georeferencing of the soil sampling points was carried out, converted and defined according to UTM (Universal Transfer Mercator), which is considered as the international coordinate system. The latitude and longitude of SEAS and Zardob EP have been calculated based on the geodetic datum WGS84.

İn additional, the collected soil samples were chemical analyzed, according to the degree of salinity and humus indicators. Salinity is a measure of the concentration of soluble salts in the soil. Soil salinity is the salt content in the soil. The soil salinity is estimated as measured in the laboratory. It is known that humus is one of the main indicators of soil fertility and assumes an important role as a fertility component of all soils.

Table 1: *Coordinates of soil sampling points and general situation around wells in the study area*

Well number	Universal Transfer Mercator		The condition of the plant and soil around the point	
	SEAS	Zardob PS	SEAS	Zardob PS
1	38 N 729399 4486411	38 N 722115 4450924	Phytomelioration area, Pomegranate garden (1-2 m), field overgrown with liquorice	Grass-plot
2	38 N 729400 4486992	38 N 722166 4450544	a field of barley 10 ha	Grass-plot, prickly place, tamariks grove and etc.
3	38 N 729061 4486501	38 N 722593 4451232	Former paddy field, salinity and broom plant	1 ha field of wheat
4	38 N 729018 4486360	38 N 722735 4451432	Sweet Flag , area under water, reedy place	salt-ridden lands, no plants
5	38 N 728515 4486656	38 N 723248 4452841	saline soil	First the grain was cultivated, after cultivated corn field
6	38 N 728597 4487060	38 N 723280 4452589	Grassy, weeds	Alfalfa, Clover and Natural grass
7	38 N 728117 4486953	38 N 722808 4455249	Saline soil, tamariks, salt grass	First the grain was cultivated, area currently under weeds, natural grass
8	38 N 728169 4487201	38 N 722892 4454671	field of wheat	Field under cotton plant
9	38 N 727583 4486319		Pomegranate garden, pine and the other trees	

Satellite data of the Normalized Difference Vegetation Index can be used to quantify changing patterns in ecosystem productivity [9,10,11]. According to NDVI indicator analyzed on the basis of various multispectral images taken by Landsat 8 and Sentinental-2 L2A in the territory of SEAS and Zardob PS (Table 2).

Table 2: *Conducting generalization on both research areas showed that the vegetation is distributed on the NDVI index based on research materials in the following*

Candition of plants according to NDVI index	Dense vegetation	Moderate vegetation	Sparse vegetation	Open soil
Range of the NDVI index	1.00– 0.60	0.60–0.40	0.40 – 0.20	0.20 – -1.00
Area in SEAS , with hectares	84,76	62,88	38,11	20,64
Area in Zardob PS with hectares	111,56	252,27	220,59	53,88

During carrying out of reclamative researches and processing of the collected data necessary to solve various problems, which of Excel has been used [8]. Excel software was used for generalzlation and statistikal evaluation of the parameters and NDVİ. According to, observation data and result of the chemical analiyse on the soil profile are described in Table 3,4. Based on the results, the analysis is made to determine the relationship between reflectance values and indices of soil salinity to estimate the soil salinity from the setillate image.

In the SEAS area summary statistics of soil salinity in different soil layers and NDVI was performed, and the results, present in Table 3.

Table 3: *Statistics of research material at soil sampling point in the SEAS area*

Statistics of research materials	**Dry residu,% S**						**Humus, % N**			***NDVI***
	Soil layer (cm)						Soil layer (cm)			
	0-20	***20-40***	***40-60***	***60-80***	***80-100***	***0-100***	***0-20***	***20-40***	***0-40***	
Mean	1,826	1,739	1,709	1,690	1,629	1,718	1,750	0,539	1,144	0,350
Standard Error	0,710	0,490	0,487	0,511	0,516	0,535	0,306	0,139	0,155	0,061
Median	0,684	1,312	1,274	0,984	1,13	1,1172	1,55	0,450	1,200	0,35
Standard Deviation	2,130	1,471	1,460	1,532	1,547	1,605	0,917	0,417	0,464	0,182
Sample Variance	4,537	2,165	2,131	2,347	2,394	2,575	0,840	0,174	0,215	0,033
Kurtosis	-1,664	-1,530	-1,365	-0,485	-0,897	-1,317	-0,204	2,185	-1,347	0,589
Skewness	0,770	0,517	0,612	0,892	0,713	0,736	0,450	1,555	0,175	0,580
Range	4,858	3,712	3,714	4,326	4,234	4,152	2,95	1,3	1,275	0,6
Minimum	0,102	0,126	0,158	0,138	0,104	0,142	0,45	0,15	0,5	0,1
Maximum	4,96	3,838	3,872	4,464	4,338	4,294	3,4	1,45	1,775	0,7
Count	9	9	9	9	9	9	9	9	9	9
Confidence Level (95,0%)	1,637	1,131	1,122	1,178	1,189	1,233	0,704	0,15	0,5	0,140

Table 3 shows statistics characteristics of soil salinity of different vegetation types.

Summary statistics of soil salinity was performed in different soil layers, and the results, present in Table 3, indicated that the average soil salinity value was comparatively high with regard to the generally accepted limit for most agricultural crops. Soil salinity is multi-factorial phenomenon, i.e., caused by various factors or combinations of factors.

In the Zardob EP area summary statistics of soil salinity in different soil layers and NDVI was performed, and the results, present in Table 4. Table 4 shows statistics characteristics of soil salinity of different vegetation types.

IV. Discussion

The minimum and maximum values of soil salinity were 1,629 % in 80 - 100 cm soil layer and 1,826 % in 0 - 20 cm soil layer, respectively in the SEAS area . Descriptive statistics showed, the average soil salinity value was comparatively high in 0-20 cm (the maximum value was 4,96 %). The results showed that Standard Error of dry residu (%) for 0 - 20, 20 - 40, 40 – 60, 60 - 80 and 80 - 100 cm was 0.710, 0.490, 0.487, 0,516 and 0.516. There are degree of salinization within the upper 1 m of soil and aeration zone according to, average by between from 0,142 to 4,294%, weakly, moderately and strongly saline soils, respectively.

And by the amount of humus, these soils are considered poorly secured. If in the 0–20 cm layer the humus content was 1,75 % , then in the 20–40 cm layer its amount was only 0.54% in the SEAS area. These soils according to the graduation, adopted in our republic, are considered low humus by the content of humus.

Table 4: *Statistics of research material at soil sampling point in the Zardob EP area.*

Statistics of research materials	Dry residue, %						Humus, %			NDVI
	Soil layer (cm)						Soil layer (cm)			
	0-20	20-40	40-60	60-80	80-100	0-100	0-20	20-40	40-60	
Mean	0,675	0,592	0,798	0,762	1,179	0,801	1,375	1,356	1,200	0,544
Standard Error	0,239	0,181	0,333	0,297	0,613	0,315	0,343	0,388	0,372	0,078
Median	0,502	0,457	0,474	0,566	0,577	0,515	1,025	1,025	0,700	0,600
Standard Deviation	0,675	0,513	0,942	0,841	1,735	0,890	0,971	1,097	1,053	0,219
Sample Variance	0,456	0,263	0,888	0,707	3,010	0,792	0,942	1,203	1,109	0,048
Kurtosis	1,783	0,639	5,950	5,693	7,228	7,040	-1,892	-1,520	-1,701	2,193
Skewness	1,512	1,276	2,362	2,259	2,649	2,596	0,435	0,543	0,661	-1,037
Range	1,942	1,46	2,892	2,616	5,246	2,787	2,45	2,85	2,6	0,75
Minimum	0,118	0,106	0,132	0,116	0,156	0,17	0,25	0,2	0,2	0,1
Maximum	2,06	1,566	3,024	2,732	5,402	2,957	2,7	3,05	2,8	0,85
Sum	5,402	4,736	6,382	6,092	9,432	6,409	11	10,85	9,6	4,35
Count	8	8	8	8	8	8	8	8	8	8
Confidence Level(95,0%)	0,564	0,429	0,788	0,703	1,450	0,744	0,811	0,917	0,881	0,183

In addition, study to condition of plants and humus index (from Table1,2) was found accodingly 3,4% in well 9 (under the pomegranate orchard) where the humus index is the highest, the lowest value 0,4% in well 4 (under swamp and salinity), respectively, around of the points where the soil samples were taken.

The Descriptive statistics of the NDVI index, around of the soil sampling points, accordingly to the Mean for the study area was 0,350, the Standard Deviation was 0.182, and minimum and maximum values were 0.1 and 0.7, respektivly. A low standard deviation indicates that the values are close to the mean, while a high standard deviation indicates that the values are dispersed over a wider range.

The minimum and maximum values of soil salinity were 0,592 % in 20 - 40 cm soil layer and 1,179 % in 80 - 100 cm soil layer, respectivel in the Zardob EP area

Descriptive statistics showed, the average soil salinity value was comparatively high in 80-100 cm (the maximum value was 5,402 %). The results showed that Standard Error of dry residu (%) for 0 - 20, 20 - 40, 40 – 60, 60 - 80 and 80 - 100 cm was 0,239, 0,181 , 0,333 , 0,297 and 0,613. There are degree of salinization within the upper 1 m of soil and aeration zone according to, average by between from 0,17 to 2,957%, weakly, moderately and strongly saline soils, respectively.

In the 0–20 cm layer the humus content was 1,375% , then in the 20–40 cm layer its amount was only 1,356% in the Zardob EP area. These soils according to the graduation, adopted in our republic, are considered moderately humus by the content of humus.

In addition, study to condition of plants and humus index (from Table1,2) was found accodingly 2,57 % in well 2 (on the bank of the Kura) where the humus index is the highest, the lowest value 0,22% in well 4 (completely unplanted, uncultivated land), respectively, around the points where the soil samples were taken.

The Descriptive statistics of the NDVI index, around of the soil sampling points, accordingly to the Mean for the study area was 0,544, the Standard Deviation was 0.219, and minimum and maximum values were 0.1 and 0.85, respektivly.

Statistical analysis between the soil salinity (dry residue, S,%), Humus(%) and the environmental indices derived from satellite images (NDVI) was performed. Pearson's correlation coefficient (R), calculated were in the soil layer, 0 - 20, 20 - 40, 40 - 60 and 60 - 80 cm, respectively. Pearson's correlation coefficient measures the strength and direction of the relationship between: soil salinity and NDVI, Humus and NDVI, respectively.

The statistical analysis of soil sampling of the soil salinity (with dry residue), humus and NDVI level indicated carryed out and obtained following results in area of SEAS.

For every land use plots, soil samples were taken at two depths: 0–20 cm (topsoil layer) and 20–40 cm (subsoil layer) using soil auger. Results indicated that NDVI values (database of Landsat 8 and Sentinel-2 satellites image) and humus were better correlated with Humus ($R_{0-20}=0{,}68, R_{0-40}=0{,}90$, respectively) which indicates a strong relationship than the other paramert. Comparative resalts show that direction of the relationship between, humus and NDVI, respectively, as NDVI increases, humus also trend to increase. Humus have been decrease from topsoil layer ($R_{0-20}=0{,}69$) to subsoil layer ($R_{20-40}=0{,}55$), respectively.

The correlation coefficient of soil salinity between NDVI of 0 - 20, 20 - 40, 40 – 60, 60 - 80 and 80 - 100 cm were $R_{0-20}=-0{,}51, R_{20-40}=-0{,}50, R_{40-60}=-0{,}42, R_{60-80}=-0{,}41, R_{80-100}=-0{,}50$, respectively.

The statistical analysis of soil sampling of the soil salinity (with dry residue), humus and NDVI level indicated carryed out and obtained following results in area of Zardob PS.

For every land use plots, soil samples were taken at two depths: 0–20 cm (topsoil layer) and 20–40 cm (subsoil layer) using soil auger. Results indicated that NDVI values (database of Landsat 8 and Sentinel-2 satellites image) and humus were better correlated with Humus ($R_{0-20}=0{,}68, R_{0-40}=0{,}90$, respectively) which indicates a strong relationship than the other paramert. Comparative resalts show that direction of the relationship between, humus and NDVI, respectively, as NDVI increases, humus also trend to increase. Humus have been decrease from topsoil layer ($R_{0-20}=0{,}31$) to subsoil layer ($R_{20-40}=0{,}27, R_{40-60}=0{,}25$), respectively.

The correlation coefficient of soil salinity between NDVI of 0 - 20, 20 - 40, 40 – 60, 60 - 80 and 80 - 100 cm were $R_{0-20}=-0{,}89, R_{20-40}=-0{,}83, R_{40-60}=-0{,}81, R_{60-80}=-0{,}77, R_{80-100}=-0{,}75, R_{0-100}=-0{,}85$, respectively.

Research of satellite images based on vegetation index, visual images of different wells (general condition of plants, height, etc.) and with laboratory analysis results (dry residue, humus) has shown that it is completely identical. Relationships between soil salinity and spectral indices differ for bare and vegetated soil surfaces.

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