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Mapping of the Salinization Based on the Satellite Image Processing and Measures to Fight against Salinization

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Abstract: The article discusses the mapping of the soil salinisation in the Kur-Araz lowland developed on the basis of the electronic maps of agricultural land according to the results of the digital processing of satellite images from the satellite LANDSAT-TM" in 1998 and "Landsat-8" in 2014, using the contact method. The shown measures and ways of fighting against salinisation of soils are agromeliorative actions.

It was determined that over the past 16 years from 1998 to 2014, as a result of the poor state of the collector-drainage network, the area of medium saline soils increased by 33.2 thousand hectares, and highly saline and saline by 41 thousand hectares in the investigated area.

Key words: Kur-Araz lowland, salinisation, agricultural lands, collector-drainage network, agromeliorative measures, satellite images, digital processing, the satellite LANDSAT-TM and Landsat-8".

1. Introduction

The territory of Azerbaijan is an ancient agricultural region, as a result of the millennial impact of anthropogenic factors, the soil salinization of the irrigated lands is widely spread.

The soil protection and the rational use of arable land is one of the important tasks in agriculture.

Statistics show that currently, 1.78 billion hectares of soil are used in agriculture. 270 million hectares of them make irrigated soils. Despite the fact that in agriculture, by 15.1 percent of the irrigated soils are occupied under acreage, the harvest derived from them is 35-40%.

In many countries (China, India, USA, Pakistan, etc.), the irrigated lands are harvested 2-3 times a year. Along with the advantages, irrigation has also several disadvantages. Depending on the environmental conditions and soil properties, as a result of failure of agromeliorative measures on agricultural lands, irrigated soils expose to salinization.

According to the UN data on agricultural production, it turns out that because of the negative impact of anthropogenic factors during the year the irrigated area of our planet decreases by more than 1 million hectares because of salinization, because of the negative impact of anthropogenic factors during the year.

The Kur-Araz lowland is located in the eastern part of Azerbaijan, between the Caspian Sea and mountain ranges of the Greater and Lesser Caucasus. The land fund of the Kur-Araz lowland is 21536 km2 or 24.5% of the total area of Azerbaijan.

The climate of the lowland is subtropical dry, warm and continental. Summers are dry and hot, winters are relatively warm and dry. The average annual temperature in the lowland range from +14.50 to + 160. The sum of effective temperature provides the

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possibility of cultivation of valuable technical and thermophilic plants.

The vegetation of the Kur-Araz lowland belongs to the phyto-geographical region of semi-desert of the East-Transcaucasian lowland.

Modern cover lowland is essentially a secondary and much poorer than what it was in the beginning of its development. In lowland areas, there are the following vegetation types: desert, semi-desert, gray, gray-meadow and forest.

Many scientists and researchers have investigated the genetic characteristics of soils, the development and spread of salinization and the developing measures to combat salinization in the Kur-Araz lowland at different times. We have found out that the gray type of the soil structure is formed in the main zonal soil type. On the basis of the geographic pattern changes in total soil salinization, in the foothills, there developed diluvial salinization, expressed in moving down the slope salt contained in the rock. In the cones of mountain rivers proluvial-alluvial saline soils are widely spread. The source of this type of salinization is the mineralized groundwater.

In the area of powerful alluvial deposits, the widely-spread alluvial salinization is observed. This form of salinization occurrs at the capillary rise to the surface of the highly saline groundwater, which has no outflow. In the south-eastern part of the lowland, the seaside type of the salinization is observed [1].

Depending on the soil-groundwater conditions and ameliorative situation in the territory of the Kur-Araz lowland in the Mugan-Salyan massif a collector-drainage network with a length of 104 km was constructed in 1934-1935, in the Mil steppe with the length of 830 km was constructed in 1951-1952, in the Shirvan and Karabakh steppe with the length more than 10 000 km was constructed in 1958-1980.

Currently, the length of the collector-drainage network is more than 25000 miles on an area of about 650000 hectares.

As a result of irrigation and drainage construction in the Kur-Araz lowland, there have been major changes and improvement of ameliorative conditions of particular areas.

From 1954 to 1965, inclusive in the Caspian Sea allotted 4604 million m^3 of saline water, containing 113 million tons drainage water, salinization decreased to 29.2 g/l-20.2 g/l.

In the Earth sciences, they are increasingly seeking to move from a qualitative, narrative methods of the study of the natural environment to a quantitative one. Space images with measurement capabilities, can serve as one of the most important ways of a direct quantitative study of the geographic patterns.

Features of each region are manifested in the characteristic optical properties of the landscape that forms its appearance. Identifying homogeneous areas according to their optical characteristics, we can solve the problem of physical and geographical zoning. Thus, when photographing the Earth from the Space, we fix its instantaneous state. The spatial structure of this field is such that it can be divided into the components-objects. The term “object” is formed on the basis of criteria arising from the tasks.

2. Tool Development

In 1998, the satellite imagery of the whole territory of Azerbaijan was taken with the artificial Earth satellite (AES) LANDSAT-TM”. On the obtained images in the range 0.45-0.52; 0.52-0.60; 0.63-0.69; 0.76-0.90; 1.55-1.75; 2.08-2.35 and 10.45-12.50 mkm conducted their digital processing.

According to the results of satellite image processing using GIS technologies, there was prepared an electronic map of the agricultural lands of Azerbaijan in the scale 1:50000. The area of the Kur-Araz lowland was designated from this map.

Method of cluster analysis, based on the algorithm of ERDAS-Isodata LANDSAT-TM” TM3, TM4, TM5 was used for the mapping of the agricultural lands in the processing of satellite images.

The processing of satellite data was carried out in two stages: the first stage — segmentation (separation of homogenous entities) and the second stage — classification of the obtained segments of the original image.

The first stage is based on the algorithm of quasi-homogeneous structures. In the second stage, the segmented image is subjected to the classification of one of the methods. A minimum distance method was used in the work, the result of the processing of each structural unit of the investigated area is characterized by one or a group of spectral channels. The boundaries of the investigated site are established on the optical properties of natural objects and landscape indicators. Next, on the basis of this card, using a contact method and GIS technology a map of the saline soils of the Kur-Araz lowland is made.

It should be noted that not only arable lands (grain crops, cotton, vegetables and melons), perennials (orchards, vineyards), pastures, forest, water bodies, etc., but also the area of highly saline and alkaline soils are recognized on an electronic map of the agricultural land, based on the space images, therefore, in the mapping of salinization of the investigated area, the map of the agricultural area of highly saline and alkaline is changed for the map of the salinization.

The saline survey carried out in the Kur-Araz lowland shows that the amount of salt at a depth of 0-50 cm, under arable land and perennial plantations varies in the range of 0.18 to 0.40% of what characterizes non-saline and slightly saline soils. Therefore, on the prepared electronic map of the agricultural lands, these areas include the map of the non-saline and slightly saline soils.

The soil samples were taken, the analysis of the aqueous extract was carried out and their area was identified based on the amount of the salt on the map of the salinization for the study of the areas with moderate saline soils in the investigated area.

Thus, using electronic map of the agricultural lands of the Kur-Araz lowland, our proposed method is a map of salinization of the investigated area (Fig. 1).

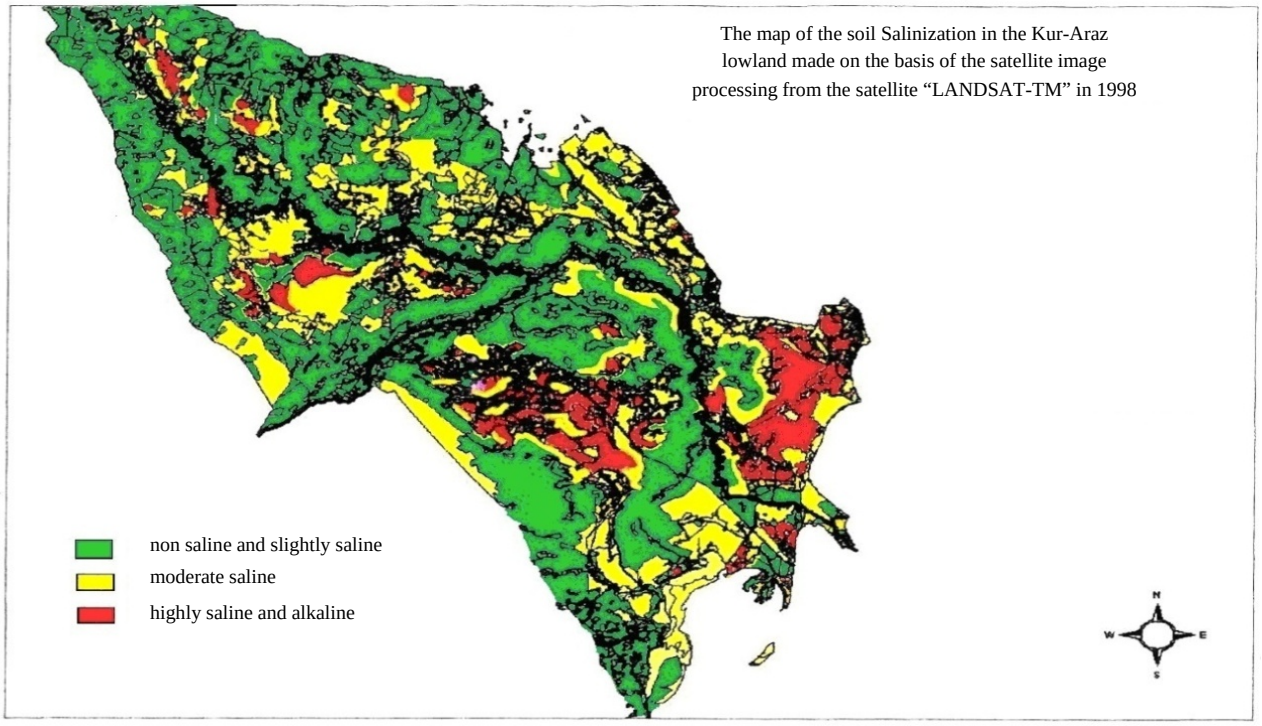

Fig. 1 Map of Salinization (1998).

In 2014, the satellite “Landsat-8” survey was carried out in Azerbaijan. According to the results of the digital processing of satellite images, using GIS technology a map of the agricultural lands of the Kur–Araz lowland in the scale 1:50000 was made and on the basis of the developed method, we made a map of Salinization (Fig. 2).

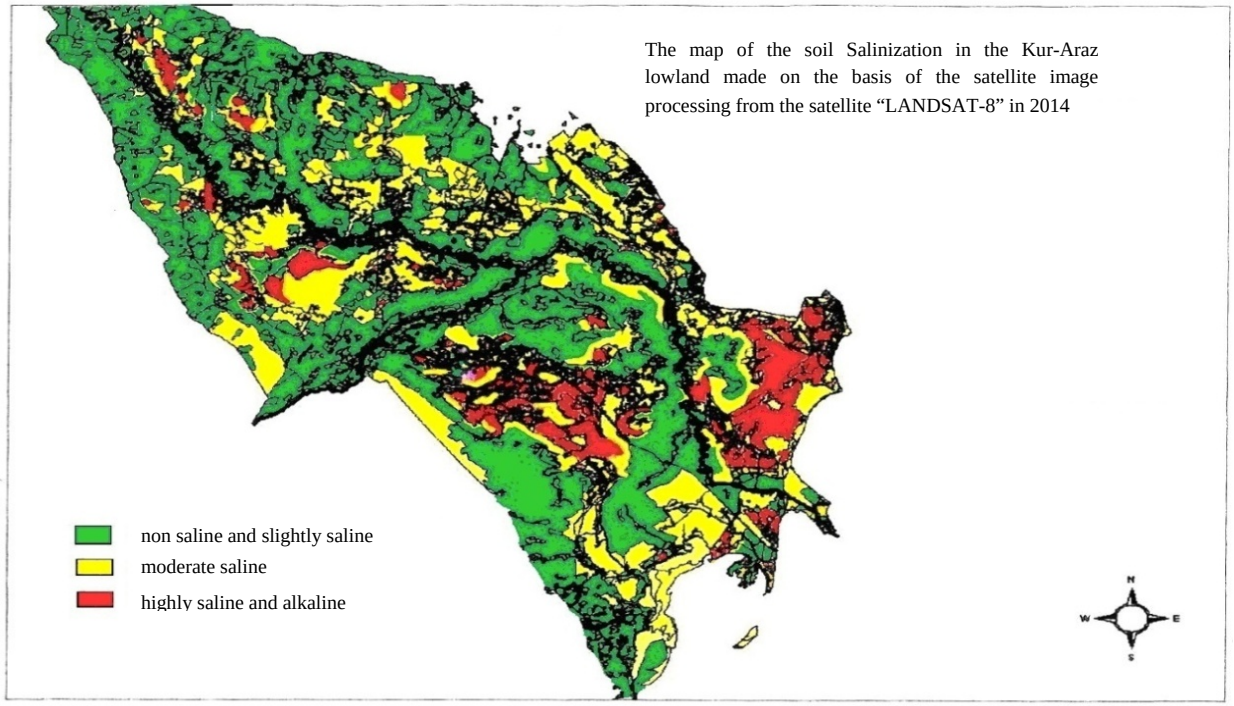

Fig. 2 Map of Salinization (2014).

The map of Salinization in the Kur-Araz lowland in 2014, shows that in the investigated area, the Salinization has significally increased for 16 years since 1998 [2].

3. Evaluation

The table below shows the change of the ameliorative condition of the Kur-Araz lowland, based on the results of the satellite images (1998 and 2014).

The Table 1 shows that in 1998, the area of non-saline and slightly saline soils was 894.2 thousand hectares in the investigated site.

Table 1 Salinization of soils of Kur-Araz Lowland.

No.	Degree of Salinization	1998	2014
1	Non-saline and slightly saline	Area, thousand	hectares
2	Moderate saline	894.2	820.0
3	Highly-saline and alkaline	364.0	405.0

As a result of non-compliance of agromeliorative measures in the territory of the Kur-Araz lowland, the area of non-saline and slightly saline soils decreased by 74.2 thousand hectares, and highly saline and alkaline land increased by 41 thousand hectares from 1998 to 2014.

It should be noted that the increase of the salinized soils of Kur-Araz lowland for a specified period (1998-2014) is mainly due to the poor condition of the collector-drainage network in the investigated site, as well as agronomical and agromeliorative measures in the areas under arable land [3].

Exploitation term of the ameliorative construction, according to the accepted norms is provided by 35-40 years. At present, the term of exploitation of the collector-drainage network in the territory of many regions of the Kur-Araz lowland has expired. Therefore, the network can’t work at full capacity.

So, as a result of the investigation of the soils, it was determined that one of the main causes of salinisation of cultivated areas is the increase of the groundwater in the upper soil layers.

To prevent salinization, as well as to improve the development of plants, the most important requirement is a proper rotation of the crops on the arable lands.

The experiments showed that the cultivation of legumes, particularly alfalfa improves soil structure. This kind of plants, covering the soil surface protects the field against excessive evaporation.

The root system of alfalfa reaches 1-1.5 meters of depth. Soil, planted alfalfa have a high degree of absorption due to the specifics of its root system. When properly done, the water absorption of soils in such fields helps to decrease the groundwater level in these areas, which gives the possibility of improving physical and chemical properties of the soil. There accumulate chemical elements, especially nitrogen, which are a nutrient for the soil. Crops give a richer harvest in subsequent years on these soils.

4. Conclusion

Checking the ecological condition of the Kur-Araz steppe showed that the collector-drainage system, especially in the Shirvan and the Mil steppe, destroyed. In many places, there was a destruction of the walls of the drainage, also appeared reeds and other water-demanding plants inside it (Fig. 3). This situation has led to the increase of groundwater level up to 1.5 m, and in some places even up to 1m, which is the cause of the increased salinization in these soils.

Fig. 3 The reeds and other water-demanding plants inside the drainage network.

To prevent salinization of the Kur-Araz lowland, we need to perform the following agroameliorative actions properly:

(1) to follow agrotechnical rules, watering the acreage of soils, to hold the specified norms for the plants on the lands;

(2) to control the flow of the water of the collector-drainage network;

(3) to carry out the cleaning of the collector-drainage network and to deepen it to the design level (3M) everywhere;

(4) to make 1 and 2-row shelterbelts on both banks of irrigation channels of the acreage;

(5) to conduct flushing of alkaline areas.

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