

EVALUATING AND DYNAMICALLY MODELING THE RECLAMATION STATUS INDICATORS OF IRRIGATED LANDS

Mukhammadieva Matluba

Agency of the Hydrometeorological Service under the National Committee for Ecology and Climate Change. PhD, Lead Specialist. Tashkent. Uzbekistan

muhammadieva.m7@gmail.com

Shermatov Ermat

Senior officer, Doctor of Technical Sciences

. «Scientific Research Institute of Irrigation of Water Problems.» Tashkent. Uzbekistan

shermatov51@mail.ru

Sodikova Umida

Senior Researcher, PhD

. «Scientific Research Institute of Irrigation of Water Problems.» Tashkent. Uzbekistan

Ulugbekov Bobur

Senior Researcher

Uzbekistan, PhD. Jizzakh polytechnic institute Jizzakh

ulugbekov.bobur77@gmail.com

Abstract:

Today, achieving high crop yields requires addressing several key challenges. These include developing indicators for the rapid assessment of soil salinity, creating a dynamic model of reclamation conditions for irrigated lands, and establishing a statistical model to develop methods for forecasting cotton yields. Variations in solar energy, along with increases or sharp decreases in air temperature, affect water evaporation, soil moisture, and its thermal condition. These changes, in turn, directly affect the reclamation status of irrigated lands, particularly soil moisture retention, salinization processes, and groundwater level dynamics. The higher the degree of groundwater mineralization, the more intense the soil salinization and, consequently, the higher the plant mortality rate. The critical depth depends on the degree of groundwater mineralization, fluctuations in its level, the mechanical composition of the aeration zone, the climatic zone, the soil water regime, the chemical composition of soluble salts, and the types of agricultural crops. The critical depth of mineralized groundwater depends primarily on the temperature regime of the climatic zone and is described by a linear functional relationship with soil temperature. Of particular importance today is

the use of modern methods to improve the reclamation status of land and increase the efficiency of water use in crop irrigation. In particular, priority is given to research on assessing soil salinity using plant physiological indicators, monitoring groundwater levels and salinity degrees as they relate to soil temperature, and statistically modeling the dependence of saline patches in irrigated areas on solar energy.

Keywords: Degree of mineralization; critical depth; groundwater; capillaries; temperature regime; soil temperature; soil salinization; aeration zone; soil texture.

Introduction

The toxicity threshold of salts in the soil is dependent on several factors: the chemical composition of the salts, specifically the ratio of anions and cations in the pore solution; the moisture level; the soil's hydro-physical properties and mechanical composition; climatic conditions; the cultivation techniques for the crops being grown; and the vegetative period of the agricultural crops. These factors determine the level of risk that the salts in the soil pose to plants.

In general, the presence of soluble salts in the soil, and consequently in the soil solution, negatively affects the growth and development of plants. This is primarily due to an increase in the concentration of the soil solution and a simultaneous rise in osmotic pressure. In turn, an increase in osmotic pressure reduces the ability of plants to utilize water. Observations by various researchers have shown that when the osmotic pressure of the soil solution is above 10–12 atmospheres, plants cease their development.

When the concentration of soluble salts in the soil is between 0.4 % and 0.8 %, most plants cannot develop normally and will produce low yields (within the limits of their biological tolerance). When the number of soluble salts exceeds 1.5 grams per 100 grams of soil, the growth and development of most agricultural crops become impossible. For irrigated soils, the optimal concentration of soluble salts in the soil solution is 3 – 5 g/l. At a concentration of 5 – 6 g/l, plant growth slows slightly, and at 10 – 12 g/l, it is severely inhibited. When the concentration reaches 20 – 25 g/l, the plants will die.

Materials and Methods of the Study

A correlation analysis of the amount of water withdrawn for irrigation and the volume of collector-drainage water in the Kashkadarya region from 2004 to 2023 reveals an upward trend in both the volume of collector-drainage water and the amount of actual return water during this period. This situation indicates a rise in groundwater levels and an increase in salinity.

Table 1. The relationship between the amount of water used for irrigation and the volume of collector-drainage water

Years	Actual volume of water used for irrigation million m ³	Drainage water from the collector (CDS) million m ³	the actual amount of returned water %
1	2	3	4
2004	5206	1343	-3,47
2005	5872	2906,23	8,86
2006	5832	2868,79	8,12

Years	Actual volume of water used for irrigation million m ³	Drainage water from the collector (CDS) million m ³	the actual amount of returned water %
2007	6091,1	3499,95	12,92
2008	4823,1	411,13	-10,57
2009	4403	-612,23	-18,36
2010	5001	844,49	-7,28
2011	6331	4084,35	17,37
2012	5406,2	1831,55	0,23
2013	5755,7	2682,93	6,71
2014	5434,8	1901,22	0,76
2015	4810	379,22	-1082
2016	5213,8	1362,86	-3,33
2017	5356,8	1711,213	0,68
2018	5585,2	2267,59	0,35
2019	4544,2	-268,27	-15,74
2020	6247,2	3880,21	15,82
2021	5490,88	2037,83	1,80
2022	5160	1231,81	-4,33
2023	5309,4	1595,74	4,92
Average	5393,7	1801,02	4,08

The equation for the dependence of water returned from collector drainage on the water taken for irrigation. $CDS_{2022-2023}=0.3551197$, $Q_{w,t} = -41.2844 \pm 82.4$ million m³, $R=0.8847$. The dependence of the groundwater level on the amount of water taken for irrigation $Q_{w,t}=171.4994+2.203$, $Q_{cds}= \pm 202.6$ million m³. The amount of water taken for irrigation and the amount of water consumed (returned) in the Kashkadarya region and its districts for 2022–2023 are presented. These data were used to analyze the irrigation water balance and the share of water returned through the collector-drainage system. There is a direct correlation between the volume of water taken for irrigation and the water returned via collector drainage: the more water is taken, the more water is typically returned. The increase in the amount of returned water in 2023 is explained by an increase in irrigation volume or a rise in the groundwater level (Table 1).

Based on the data from the reclamation expedition and the analyses conducted, empirical indicators of the relationship between the level of soil salinity and solar energy intensity were developed and calculated using a standard statistical correlation program.

$$S_{\text{unsalted}} = 4791,6194 - 3,48424P; R = -0,8071$$

$$S_{\text{slightly}} = 754794,87 - 418,60465P; R = -0,9371$$

$$S_{\text{moderately}} = 743,48837P - 973713,6; R = 0,9989$$

$$S_{\text{strongly saline}} = 225,58139P - 297333,29; R = 0,9725$$

Results and discussion

The graphs showing the empirical dependence of variously salinized areas in the Kashkadarya region on solar energy indicate that the salinity levels of irrigated lands change with an increase in energy. Specifically, the correlation coefficient values for non-saline and slightly saline lands are R

= -0.8071 and $R = -0.9371$, respectively, demonstrating a decreasing trend. The correlation coefficients for moderately saline and strongly saline lands were $R = 0.9989$ (moderately saline lands) and $R = 0.9725$ (strongly saline lands), which means we can see an increase in the values. Creating a dynamic model of land reclamation indicators for irrigated lands, based on solar energy and groundwater data, has been identified as crucial for planning reclamation measures, ensuring the rational use of soil and water resources, achieving sustainable agricultural development, and controlling soil salinity.

Conclusion

Therefore, the following method, which enables the rapid assessment of soil salinity, will significantly help us address the challenges of determining salinity levels in irrigated lands and developing an improved statistical model to achieve high crop yields.

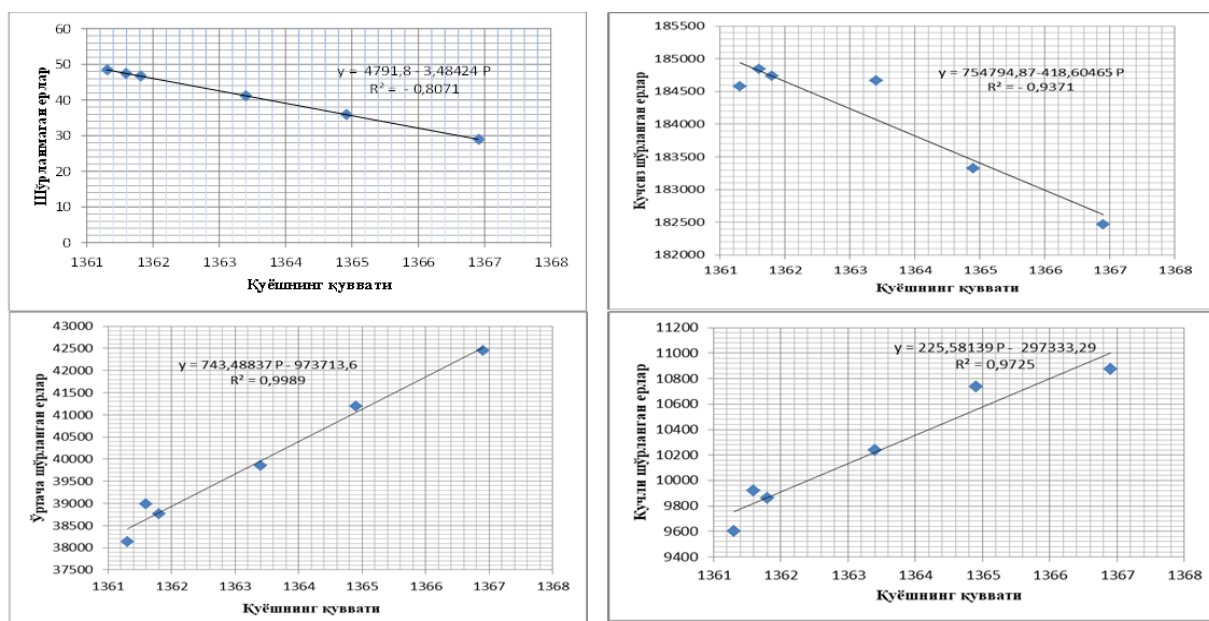


Figure 1. Empirical correlation between solar energy and various types of saline areas in the Kashkadarya region

Literature:

- [1] Eygenson M.S. «Sun, weather and climate» L.: Hydrometeorological publication. Leningrad. 1963 p. 273.
- [2] Mazikov V.M. «Soil Salinization in the New Irrigation Zone of the Golodnaya Steppe According to Aerial Survey Data.» “Pochvovedenie”, no. 10 (1978): 74–86.
- [3] Mukhammadieva, M., Ishchanov, J., Mirkhosilova, M., Shermatov, E. (2025). The temperature of the planet Earth in the 85°–25° latitude range. “Web of Technology: Multidimensional Research Journal”, 3 (1), 39–42.
- [4] Kovda V.A., Egorov V.V. – «Assessment of lands for irrigation and drainage. Soils of the middle belt as an object of irrigation» //Fan Publishing House. MOSCOW, 2008, pp. 72–105.
- [5] Ikramov R.K. Principles of Water-Salt Regime Management for Irrigated Lands in Central Asia under Conditions of Water Resource Scarcity. Tashkent. GIDROINGEO. 2001. p. 193.

- [6] Müller, P., Koyman, R., Shtorm, R. (1982). Tablitsy po matematicheskoy statistike. Finansy i statistika. pp. 191–200.
- [7] Ye. Shermatov M.T. Muxammadiyeva. «An Algorithm for Calculating and Analyzing the Temperature Variability of Planet Earth.» International Scientific and Practical Conference dedicated to the memory of V.P. Zvolinsky, Academician of the Russian Academy of Sciences, and the 30th anniversary of the founding of the FSBI «PAFS RAS.».
- [8] Data from the Qashqadaryo Regional Melioration Expedition. 2020–2023.
- [9] I. P. Abrol, J. S. P. Yadav, and F. I. Massoud, *Salt-Affected Soils and Their Management*, FAO Soils Bulletin No. 39. Rome, Italy: Food and Agriculture Organization of the United Nations, 1988.
- [10] J. D. Rhoades, F. Chanduvi, and S. Lesch, *Soil Salinity Assessment: Methods and Interpretation of Electrical Conductivity Measurements*, FAO Irrigation and Drainage Paper No. 57. Rome, Italy: Food and Agriculture Organization of the United Nations, 1999.
- [11] R. Munns and M. Tester, “Mechanisms of salinity tolerance,” *Annual Review of Plant Biology*, vol. 59, pp. 651–681, 2008, doi: 10.1146/annurev.arplant.59.032607.092911.
- [12] E. V. Maas and S. R. Grattan, “Crop yields as affected by salinity,” in *Agricultural Drainage*, R. W. Skaggs and J. van Schilfgaarde, Eds. Madison, WI, USA: American Society of Agronomy, 1999, pp. 55–108.
- [13] C. Omuto, R. Vargas, E. M. Abdelmagid, N. Mohamed, K. Viatkin, and Y. Yusuf, *Mapping of Salt-Affected Soils: Technical Manual*. Rome, Italy: Food and Agriculture Organization of the United Nations, 2020.
- [14] Food and Agriculture Organization of the United Nations, *Global Map of Salt-Affected Soils (GSASmap) v1.0*. Rome, Italy: FAO, 2021.
- [15] Food and Agriculture Organization of the United Nations, *Global Status of Salt-Affected Soils*. Rome, Italy: FAO, 2024.