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SIRDARYO VILOYATIDA TUPROQ SHOʻRLIGI SIZOT SUVLARI SATHI VA MINERALLASHUVI OʻZGARISHINI OʻRGANISH USULLARI

МЕТОДЫ ИЗУЧЕНИЯ ЗАСОЛЕНИЯ ПОЧВ, УРОВНЯ СТОКА, МИНЕРАЛИЗАЦИИ СТОКА В СЫРДАРЬИНСКОЙ ОБЛАСТИ

RESEARCH METHODS FOR CHANGES IN SOIL SALINITY, SEEPAGE WATER LEVEL, AND SEEPAGE WATER MINERALIZATION IN THE SYRDARYA REGION

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Annotatsiya

Oxirgi tadqiqotlar shuni koʻrsatdiki, tuproq shoʻrlanishi, oqib chiquvchi suv sathi va oqib chiquvchi suvning minerallashuvini geografik xaritalash, kuzatish, baholash va monitoringi an'anaviy yondashuvlarni geoaxborot tizimlari usullari bilan birlashtirish orqali samarali amalga oshirilishi mumkin. Geoaxborot tizimlari sizga GISga asoslangan topilmalarning toʻgʻriligini tasdiqlash va keyingi dala tadqiqotlari natijalarini ilgari surish imkoniyatini beradi.

Аннотация

Недавние исследования показали, что географическое картографирование, отслеживание, оценка и мониторинг засоленности почвы, уровней стока и минерализации стока могут быть эффективно выполнены путем сочетания традиционных подходов с методами ГИС. Геоинформационные системы позволяют подтвердить точность данных, полученных с помощью ГИС, и улучшить результаты дальнейших полевых исследований.

Abstract

Recent research has demonstrated that the geographical mapping, tracking, assessment, and monitoring of soil salinity, seepage water levels, and seepage water mineralization may be effectively accomplished by integrating conventional approaches with geoinformation systems methods. Geoinformation systems provide you the ability to validate the veracity of GIS-based findings and promote the findings of subsequent field studies.

Kalit soʻzlar: *Tuproqning shoʻrlanishi, sızma suv darajasi, sızma suvining minerallashuvi, GIS, iqlim oʻzgarishi*

Key words:*Soil salinity, seepage water level, seepage water mineralization, GIS, climate change*

Ключевые слова: *Засоление почвы, уровни фильтрата, минерализация фильтрата, ГИС, изменение климата*

INTRODUCTION

Recent studies have shown that combining traditional methods with geoinformation systems (GIS) methods is an effective tool in monitoring, tracking, evaluating, and monitoring the spatial mapping of soil salinity (SS), seepage water levels (WL), and seepage water mineralization (SWM) [9, 10]. Geoinformation systems (GIS) allow working with data, promoting the results of additional field experiments, and verifying and confirming the accuracy of GIS-based results [10, 11]. Currently, GIS technologies are widely used in the detection and assessment of soil salinity in irrigated areas and in mapping certain data (i.e., WL and SWM data) that cannot be obtained by GIS itself. This wide application favors the achievement of excellent results [12], and these results are an important element of this research in accurate mapping.

A number of experts and scientists from developed and developing countries have studied and determined the interrelationships between SS, WL, and SWM, as well as climatic and other anthropogenic factors, using GIS-based approaches (i.e., spatial interpolation, vegetation, and salinity indices) [3, 8]. Consequently, the ongoing process of soil salinization under climate change conditions in irrigated lands with increased WL and SWM has been extensively studied, and scientifically adequate scientific conclusions have been drawn and confirmed. In addition, the GIS approaches used in these studies may yield the intended results when replicated in other areas with similar geomorphology to the study area [5, 13–15].

LITERATURE ANALYSIS AND METHODS

From a national point of view, in Uzbekistan, Eshchanov [4], Ibragimov [16], Polatov et al. [6], Ibrohimov et al. [17], and Sultanov et al. [7] also use GIS approaches within certain limits in the analysis and evaluation of WL, SSM, and TSh. The main limitations were identified as the lack of specialists in the field of geoinformatics and the limitation of the correct methodology for mapping these three variables (WL, SWM, and SS). In addition, researchers continued to rely on traditional field approaches to mapping. In these studies, three tools based on GIS—Inverse Distance Weighting (IDW), Spline, and Kriging interpolation methods—were tested and applied for their potential to map spatial changes of variables in a short period of time. All three methods are compared with each other as a matter of exact mapping. As a result, the Kriging method revealed the second-best results in mapping the interpolated WL, while the IDW method mapped all variables excellently. Regarding the results of these studies, the Spline method showed the largest error in mapping all variables, and Kriging was the second most suitable option for mapping WL. The use of both to map these three variables is strongly discouraged, and instead, the use of IDW is recommended in the Uzbekistan ecosystem [2].

RESULTS AND DISCUSSION

Analysis of long-term data on soil salinity in Uzbekistan has been carried out mainly based on traditional, outdated methods. In addition, GIS approaches for mapping the three variables (WL, SWM, and SS) were applied in a limited time frame (only one year) and at the system boundary (district level). These studies focused only on cross-validation of GIS maps, but the level of accuracy of these maps was not determined. Nevertheless, scientific data and maps created according to the GIS technique that monitor soil salinity in agricultural land over time with rising WL in areas near WL that are highly mineralized are insufficient. Another shortcoming of these studies is that the influence of climatic factors on the dynamic changes of WL, SWM, and SS has not been sufficiently studied. In view of these weaknesses, performing multi-year data analysis, expanding the spatial scale, evaluating the accuracy of GIS maps, evaluating the influence of climate factors, and establishing a deeper level of interrelationship between WL, SWM, and SS will be novelties of this study. Therefore, the first objective of this chapter is to analyse and map the dynamic and spatial changes of WL, SWM, and SS under climate factors for 20 years (2000–2019). At the same time, the second goal is to integrate traditional research methods with proven GIS methods on the example of the irrigated lands of the Syrdarya region in Uzbekistan.

Since 1991, SWM and WL in the irrigated areas of Syrdarya region have been systematically studied by the hydro-geological reclamation expedition of Syrdarya region (HMESR) [18] from about 1500 observation wells under the Ministry of Water Management (Fig. 1).

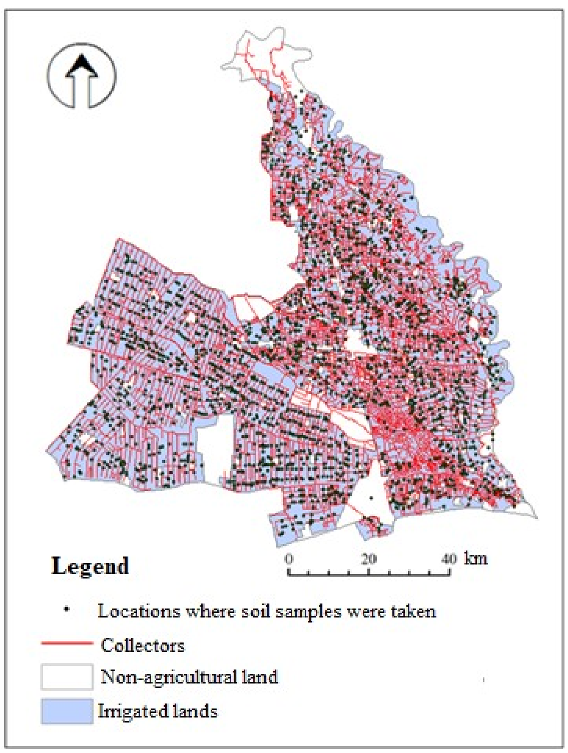

Fig. 1. Field monitoring wells located in Syrdarya region

HMESR usually conducts this monitoring on a quarterly basis. As for SS, the Cadastre Agency under the State Tax Committee (formerly the State Committee for Land Resources, Geodesy, Cartography, and State Cadastre) and HMESR are the main organisations responsible for monitoring and conducting field expeditions. Since 1994, an assessment of the actual condition of the soil by SS has been carried out. These two organisations conduct SS assessments twice a year, at the beginning of the country's growing season (spring, April) and at the end of the season (autumn, October).

Thus, these multi-year numerical data collected from official tables for the three variables from 2000 to 2019 have been used as primary data in this chapter.

It should be noted that the author of the dissertation also participated in fieldwork in 2019 and 2020 (appendices). As of October 2019–2020, groundwater and soil samples were taken from 287,200 irrigated lands in the Syrdarya region at an average of 3,800 monitoring points and 1,500 wells.

Groundwater samples were taken from two different wells, one for shallow groundwater (0–3 m) and one for relatively deep groundwater (> 3 m), while soil samples were taken from 0–30 cm, 30-70 cm, and 70–100 cm. A total of 11,200 soil samples were taken from the soil layer, while laboratory analyses were carried out to determine SWM and SS in laboratory conditions. In our study, 0–30 cm and 30-70 cm soil samples taken from the soil layer were analysed. 70–100 cm. As for deep soil samples, they do not significantly contribute to the overall results of the sampling point.

Primary WL, SWM, and SS data were studied mainly from 2000 to 2015, and maps were created for the years 2016–2019 depicting changes in time and distance of the three variables to formalise the accuracy of GIS methods by juxtaposing them with primary tabular data. These maps are based on measurements from groundwater monitoring wells and soil sampling points in the province. The distance between wells and soil sampling sites is somewhat unevenly distributed, ranging from 500 to 1000 metres. Since this study consists of mapping the dynamic spatial changes of classified WL, SWM, and SS in the irrigated lands of the Syrdarya region, below are the classification tables (Table 1). These three variables are hypothetically inseparable, interdependent, and significantly dependent on the following factors: irrigation and land practises, soil properties, drainage efficiency, crop type, and critical depths. 3 m for the conditions of Uzbekistan. more than WL proved to be safe according to SS, and 2-3 m. with WL is weakly dangerous, 1.5–2 m. is moderately dangerous, 1-1.5 m. is seriously dangerous, and 0–1 m. is confirmed as extremely dangerous.

These scientists categorised SWM in irrigated areas of Uzbekistan by determining chloride (Cl) concentrations that do not adversely affect crop growth and development throughout the growing season (Table 1) [19].

Table 1 SWM classification for irrigated areas of Uzbekistan according to chloride (Cl) content

Dry residue, г/л	**Cl^-, мг/л**
0-1	0.0 – 0.164
1-3	0.164 – 0.494
3-5	0.494 – 0.822
5-10	0.822 – 1.64
>10	> 1.64

Starting in 2006, the determination of SS in soils during the field expedition was determined using a digital conductor-thermometer (hereafter DCTh metre) "Progress 1T" [1, 2]. This instrument is characterised by its light weight, simple structure, and convenient orientation of electronic components, which are relatively common and convenient for use in field work. Additionally, a small hand shovel and auger were used in some situations where the soil was too compact to sample.

Rhoades et al. [20] found that SS values for irrigated land determined by the DCTh meter can be used to classify SS to determine the extent to which total soluble salts do not adversely affect overall yield for the growing season (Table 2).

Table 2 Soluble salts, Cl content and SS level with reference to DCTh values

Salt concentration		**PKT, (dS/м)**	**Cl**	**Soil salinity level**	**Effects on crops**
г/л	dS/см				
0-3	0-4.5	0-2	> 0.01	-	You don't notice
3-6	4.5-9	2-4	0.01-0.03	Weak	Reduced yield of sensitive crops
6-12	9-18	4-8	0.031-0.07	Average	Decrease in yield from all crops
> 12	> 18	> 8	> 0.071	Strong	Only halophytes can survive

Vector maps showing SWM, WL, and SS maps for irrigated lands in the Syrdarya region were created by the IDW interpolation method using ArcGIS 10.8 software [21]. IDW handles a direct mathematical scheme formed by statistical modelling representing the data generation process [22, 23]. This process, in turn, is very effective in this study because of its gap-filling ability and boundaries between groundwater wells and soil samples. Ibragimov [16], Ibrohimov et al. [17], Eshchanov [4], Sultanov et al. [7], and Polatov et al. [24] found that minimal errors were observed when creating WL, SSM, and SS maps using the IDW method. The results obtained during the above-mentioned studies have proven that the IDW interpolation method provides appropriate results when sufficient data is loaded. Considering this aspect, as it is a one-sided effect that even the IDW method cannot show a perfect result with 100% accuracy, the overall accuracy of the generated IDW maps of irrigated areas was determined by comparing the quantitative tabular results based on GIS with the official tabular data.

After assessing the accuracy of the interpolated maps, a statistical analysis was performed to determine the extent to which the three variables (WL, SWM, and SS) and climate factors (annual average seasonal air temperature and annual seasonal precipitation) affect the variation over time and distance. Long-term climate data of 3 weather stations located in the Syrdarya region were obtained from the Hydrometeorological Service Centre of Uzbekistan (Uzgidromet) [25] as an open source, and the annual data of these 3 weather stations were obtained in triangular form. In statistical analyses, Pearson correlation and linear regression models were analysed to demonstrate true correlation using Rstudio as a potential programme to identify factor correlations [26, 27].

In our further studies, all MODIS data sets were first reduced to the size of the Syrdarya region area and adjusted to the WGS 1984 UTM Zone 42 N reference system. After that, we extracted the irrigated land using the NDVI index. We separated pixels that were not covered by vegetation using a MOD13A2-based vegetation index and an NDVI threshold of 0.3. Only vegetation cover (NDVI > 0.3) was used for the remainder of the analysis on the thermographic dataset and other remote sensing datasets. We determined mean values for various parameters, including surface temperature (T) and NDVI. SPSS statistical software was used for statistical analysis [3]. Our primary strategy was analysis of variance (ANOVA), and F values were compared to assess the performance of different measures. Timely monitoring of irrigated fields is crucial. We repeated our study during the growing season to find the ideal period for salinity monitoring. All available images from April to September 2016–2019 were analysed, and F values for T and NDVI were calculated.

CONCLUSIONS

In short, when the hydrogeological conditions of irrigated soils change, arid (automorphic) soils begin to transition to semi-humid (poluhydromorphic) and humid (hydromorphic) soils. At this time, the external characteristics of the soil change on a very large scale, and the process of the movement of chemical elements is activated, in which the negative activity of the soil and subsoil layers, the salts that salt the underground water, becomes high or comes to the fore. Such manifestations lead to a decrease in soil fertility, and if the drainage system is not implemented and the necessary cleaning measures are not carried out, the land may become unusable for agriculture. Periodic attraction of soils to negative wetting (hydromorphism) in the process of external and internal gradual development occurs in the region of pale gray soils and the desert zone. These areas almost include the Syrdarya and Jizzakh regions in the Central Mirzachol plain. In addition, the processes of desertification in the soils of these regions are also being determined. In order to end these negative processes and increase soil fertility, it is necessary to apply and carry out collective melioration and agrochemical measures.

This chapter explored mapping techniques based on collected field data to provide areas of potential hazard and susceptibility to high WL, SWM, and SS. The integration of GIS technologies made it possible to create an accurate map of these three variables and make the results based on GIS practical and scientific. Encapsulation of the mapping results of the IDW maps created for WL, SWM, and SS, taking into account the existing errors in the formation of measures, was carried out. A practical and validated IDW interpolation method is strongly recommended for practical application in this province or such a semi-arid region.

REFERENCES

1. Akramkhanov A. et al. Geoderma Environmental factors of spatial distribution of soil salinity on fl at irrigated terrain // Geoderma. Elsevier B.V., 2011. Vol. 163, № 1–2. P. 55–62.
2. Kulmatov R. et al. Assessment of the Space-Time Dynamics of Soil Salinity in Irrigated Areas Under Climate Change: a Case Study in Sirdarya Province, Uzbekistan // Water, Air, Soil Pollut. Water, Air, & Soil Pollution, 2021. Vol.

232, № 5. P. 216.

3. Ibrakhimov M., Khalid U., Sultanov M. Combining remote sensing and modeling approaches to assess soil salinity in irrigated areas of the Aral Sea Basin // Cent. Asian J. Water Res. 2019. Vol. 5, № 2. P. 65–81.

4. Eshchanov R. Agro-ecological principles of sustainable land and water use: In the case of Khorezm province. Urgench State University named after Al-Khorezmi, Uzbekistan, 2008. 329 p.

5. Ibrakhimov M. et al. The dynamics of groundwater table and salinity over 17 years in Khorezm // Agric. Water Manag. Elsevier B.V., 2011. Vol. 101, № 1. P. 52–61.

6. Pulatov A. et al. Soil salinity mapping by different interpolation methods in Mirzaabad district, Syrdarya Province // IOP Conf. Ser. Mater. Sci. Eng. 2020. Vol. 883, № 1. P. 012089.

7. Sultanov M. et al. Modelling End-of-Season Soil Salinity in Irrigated Agriculture Through Multi-temporal Optical Remote Sensing, Environmental Parameters, and In Situ Information // PFG – J. Photogramm. Remote Sens. Geoinf. Sci. Springer International Publishing, 2018. Vol. 86, № 5–6. P. 221–233.

8. Kulmatov R.A., Adilov S.A., Khasanov S. Evaluation of the spatial and temporal changes in groundwater level and mineralization in agricultural lands under climate change in the Syrdarya province, Uzbekistan // IOP Conf. Ser. Earth Environ. Sci. 2020. Vol. 614, № 1. P. 012149.

9. Alikhanov B. et al. Land cover change in Tashkent province during 1992 – 2018 // IOP Conf. Ser. Mater. Sci. Eng. 2020. Vol. 883, № 1. P. 012088.

10. K. Jagannathan V.J. An approach to demarcate Ground water potential zones through Remote Sensing and Geographic Information System remote sensing and a geographical information system // Int. J. Remote Sens. 1996. Vol. 17, № 10. P. 1867–1884.

11. Solomon S., Quiel F. Groundwater study using remote sensing and geographic information systems (GIS) in the central highlands of Eritrea // Hydrogeol. J. 2006. Vol. 14. P. 1029–1041.

12. Li Y., Zhao M., Li F. Soil respiration in typical plant communities in the wetland surrounding the high-salinity Ebinur Lake // Front. Earth Sci. 2018. Vol. 12, № 3. P. 611–624.

13. Ivushkin K. et al. Remote Sensing of Environment Global mapping of soil salinity change // Remote Sens. Environ. Elsevier, 2019. Vol. 231. P. 111260.

14. Nayak T.R., Gupta S.K., Galkate R. GIS Based Mapping of Groundwater Fluctuations in Bina Basin // Aquat. Procedia. Elsevier B.V., 2015. Vol. 4. P. 1469–1476.

15. S. Sadat-Noori, K. Ebrahimi A.L. Groundwater quality assessment using the Water Quality Index and GIS in Saveh-Nobaran aquifer , Iran // Env. Earth Sci. 2013. Vol. 71, № 9. P. 3827–3843.

16. Ibrakhimov M. Spatial and temporal dynamics of groundwater table and salinity in Khorezm (Aral Sea Basin), Uzbekistan. 2004. 186 p.

17. Ibrakhimov M. et al. Understanding surface water – groundwater interactions for managing large irrigation schemes in the multi-country Fergana valley , Central Asia // Agric. Water Manag. Elsevier, 2018. Vol. 201. P. 99–106.

18. LSBAIS. Long-term monitoring results of groundwater depth and mineralization in Syrdarya province. Gulistan, 2020.

19. Akramkhanov A., Sommer R., Martius C. Comparison and sensitivity of measurement techniques for spatial distribution of soil salinity // Irrig Drain. Syst. 2008. Vol. 22. P. 115–126.

20. Rhoades J., Chanduvi F. Soil salinity assessment: Methods and interpretation of electrical conductivity measurements. Rome, Italy, 1999. 517 p.

21. ESRI. ArcGIS Desktop: Release 10.6: 10.6. Redlands, CA: Environmental Systems Research Institute, 2018.

22. Lakshmi S.D.M. Comparative analysis of spatial interpolation with climatic changes using inverse distance method // J. Ambient Intell. Humaniz. Comput. Springer Berlin Heidelberg, 2020. P. 1–10.

23. Souza, Thaigo Juncal, Canedo Medeiros, Jose, Cruz Goncalves, Alessandro, Senra Martinez A. A method to identify an accidental control rod drop with inverse distance weighted interpolation // Ann. Nucl. Energy. 2020. Vol. 145. P. 107462.

24. B. Alikhanov, SH. Alikhanova, R. Oymatov, Z. Fayzullaev A.P. Land cover change in Tashkent province during 1992 – 2018 // IOP Conf. Ser. Mater. Sci. Eng. 2020. Vol. 883, № 1. P. 012088.

25. Uzhydromet (Center of Hydrometeorological Service of the Republic of Uzbekistan). Raw data on climate factors (Karakalpakstan). 2021.

26. Edelmann D., Móri T.F., Székely G.J. On relationships between the Pearson and the distance correlation coefficients // Stat. Probab. Lett. Elsevier B.V., 2021. Vol. 169. P. 108960.

27. RStudio Team. RStudio: Integrated Development for R: 3.62. Boston, MA, 2017.