Karimov Yunus

scientific researcher

Uzbek-Finnish Pedagogical Institute

Yarashev Kuvondiq

director of the Urgut branch of SamSU

named after Sharof Rashidov,

Doctor of Geography (DSc)

EXPERIENCE OF WORLD AND UZBEK SCIENTISTS IN MAPPING SOIL SALINITY THROUGH GEOINFORMATION TECHNOLOGIES

Abstract: *In the article, an analysis of the literature published on the study of soil salinity in our country and around the world was carried out. This growth was potentially analyzed due to the advances in GIS and Remote Sensing, different modeling approaches, the availability of open data sources, and increased awareness of the importance of scientific interest in identifying such ecologically vulnerable areas for land use planning and mitigating or preventing their negative consequences.*

Key words: *Soil salinization, Water absorption, GIS, Climate change.*

Аннотация: *В статье проведен анализ опубликованной литературы по изучению засоления почв в нашей стране и мире. Этот рост был потенциально проанализирован благодаря достижениям в области ГИС и дистанционного зондирования, различным подходам к моделированию, доступности открытых источников данных и повышению осведомленности о важности научного интереса к выявлению таких экологически уязвимых районов для планирования землепользования и смягчения или предотвращения их негативные последствия.*

Ключевые слова: *Засоление почв, Водопоглощение, ГИС, Изменение климата.*

1. Introduction

Soil salinization is one of the potential risks of major environmental disasters due to its extensive socio-economic damage, including its impact on agriculture [1]. Soil salinity problems are mainly caused by the interaction of complex local factors.

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These factors are divided into two large groups: incidental and triggering factors [2, 3]. In many ways, conditions such as slope, elevation, lithology, ditch network density, land use, and soil conditions are considered factors, while precipitation, earthquakes, and human intervention are considered triggers or enhancers [4,5]. Evaluating the complexity and difficulty of designing soil salinization processes and assessing landslide susceptibility is one of the most important issues in international practice [6]. Consequently, various methods and techniques have been introduced to model and evaluate soil salinity sensitivity [7–9].

2. Materials and methods

The main purpose of soil salinity sensitivity analysis is to study in depth the relationship between the agrophysical and agrochemical conditions of the soil and the related factors using statistics, data storage, software, and geographic information systems (GIS) [10, 29]. The Soil Thematic Strategy identifies soil salinity as one of the eight soil threats and encourages the identification of areas with salinity-prone soils in the EU [11, 12]. Adequate understanding of the actual trends and science-based methodologies and methods for predicting the occurrence and behavior of soil salinity as an environmental problem will help increase the adaptive and mitigation capacity of salinity prevention [13, 14, 30].

Over the past two decades, research on saline soils has increased with the use of remote sensing, simulation approaches, and the application of GIS [6, 11, 15, 31]. In this paragraph, we will try to review the literature published in the United States and around the world on the assessment of soil salinity from 2000 to 2020.

From the total of 79 publications indexed in the scientific and technical database "Scopus" from 2000 to 2020 on the assessment of soil salinity in the republic and the world (Fig. 1.2.1), a total of 24 publications were published in the 13 years from 2000 to 2012, while in 2013 this indicator increased sharply and the annual number reached 13. Between 2013 and 2020, an average of 7 publications were published per year (a total of 55 from 2013 to 2020). Until 2013, the number of articles published in international publications decreased, and then a significant upward trend was observed, which showed $R^2 = 0.344$ (Fig. 1.2.1).

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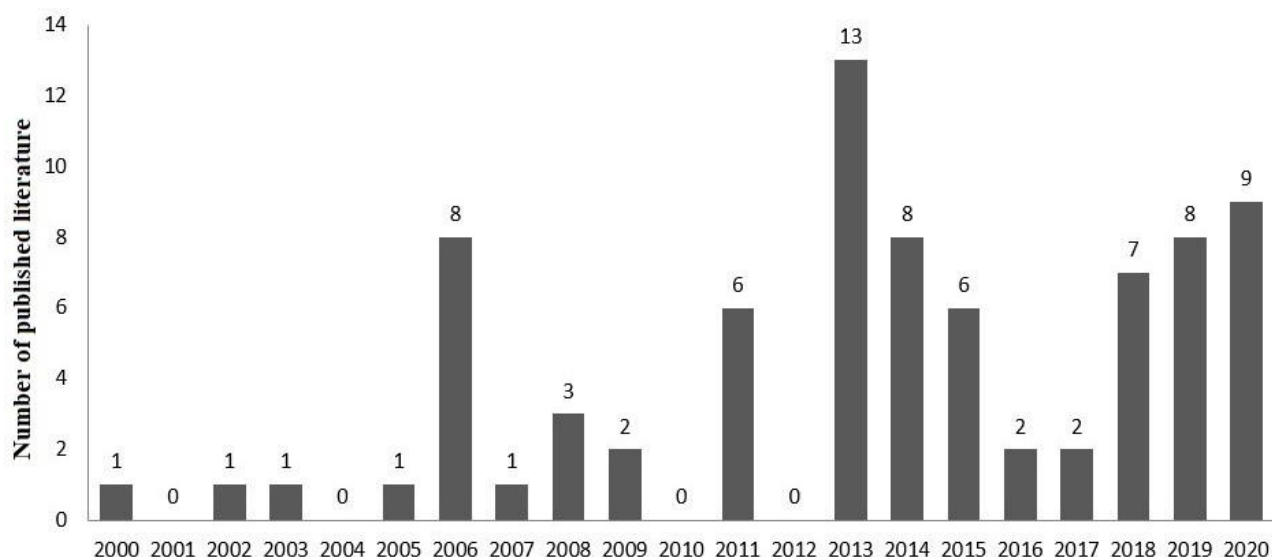
Fig 1.2.1. The number of books on the topic of soil salinization in the Republic and around the world in 2000 and 2020

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In addition, our research shows that most of the 79 articles are 32 or 41% articles on research topics, followed by 31 articles in conference proceedings (39%), 11 separate chapters in books (14%), 2 (3%) review articles, one survey, scientific recommendations, and a textbook (Fig. 1.2.2).
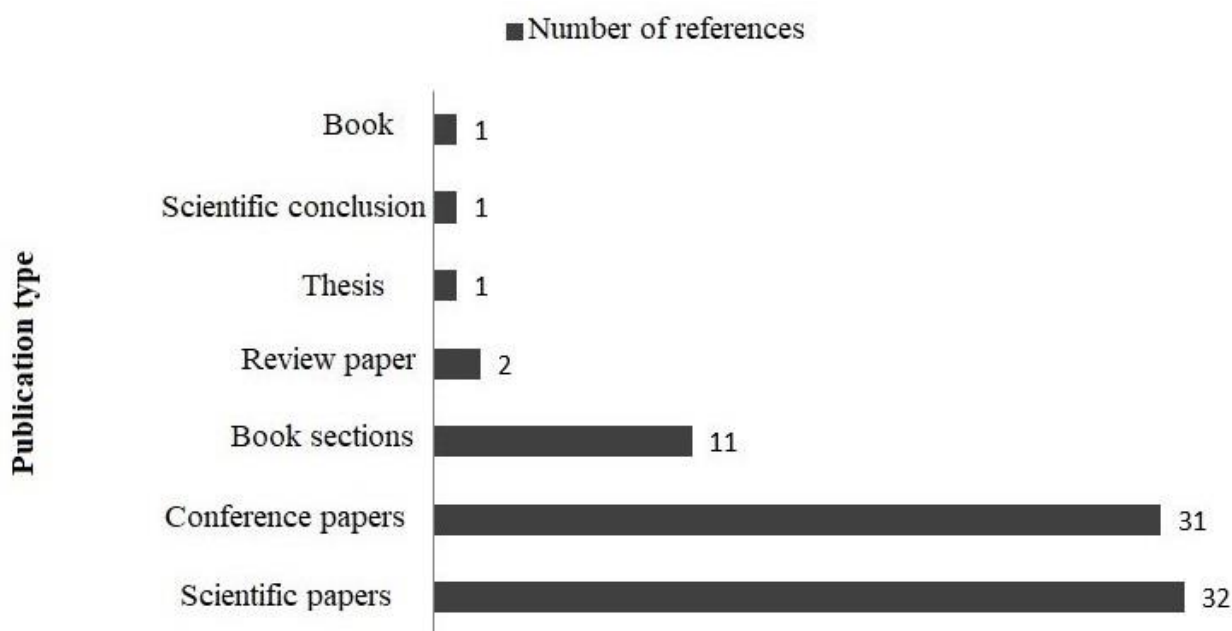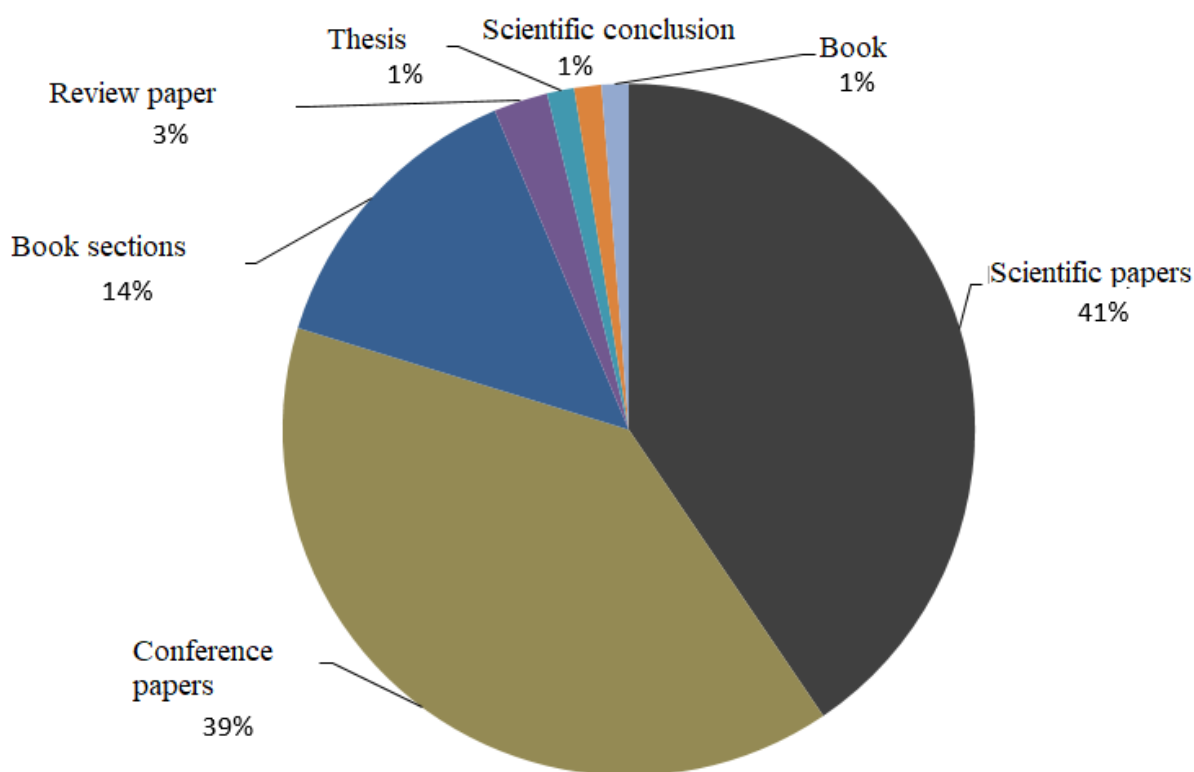
Fig 1.2.2. Type of publications reviewed.

It was found that 11 countries, such as Belgium, Kazakhstan, Kyrgyzstan, Uzbekistan, Germany, Russia, Tajikistan, Canada, France, Italy, and Great Britain, are interested in conducting research on soil salinity in the republic and around the world. Scientists from Kazakhstan published a total of 16 articles in 20 years, 2 articles in the first 10 years, and 14 articles in the next 10 years, respectively. In the case of Kyrgyzstan, 11 articles were published, including 3 articles from 2000 to 2010 and 8 articles from 2011 to 2020. Over the past 20 years, scientists and researchers in our republic have published 10 articles on the study of soil salinity, of which 2 were published in the first 10 years of 2000 and 8 in the second 10 years (Fig. 1.2.3). German scientists published 2 and 4 articles in 2000–2010 and 2011–2020, respectively, while Russian researchers published 5 articles in 20 years (Fig. 1.2.3). In the first decade, Tajikistan, France, Italy, and Great Britain had no articles at all, while in the second decade, each had one article. Only Canadian scientists did not publish an article on land susceptibility to soil salinization in 2011–2020, but they published two articles in the first 10 years (Fig. 1.2.3).
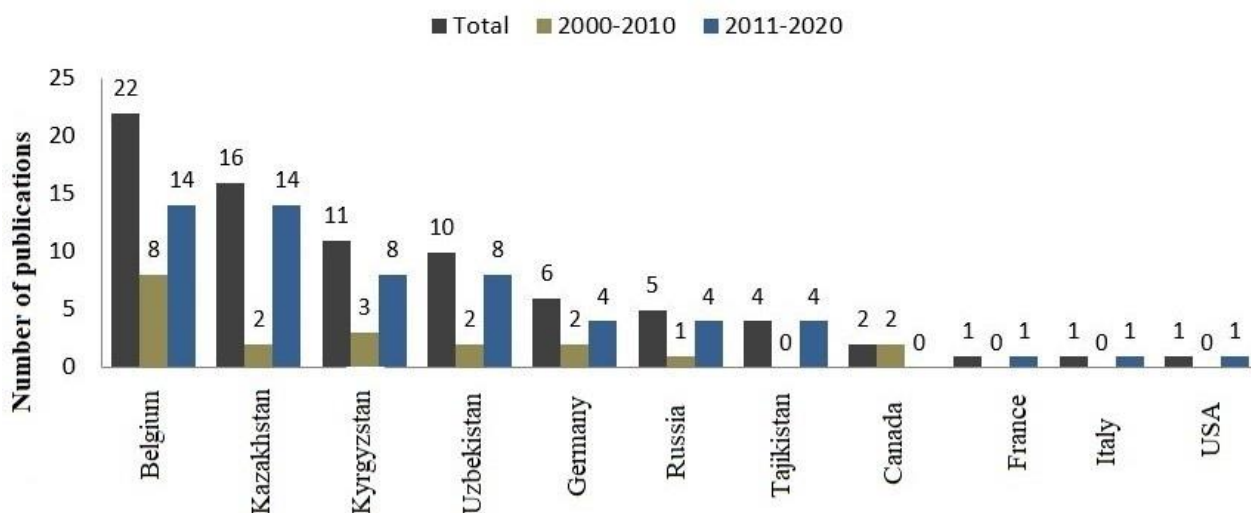
Fig 1.2.3. Number of publications by country from 2000 to 2020

Based on the data of the publications from a geographical point of view, in the period 2000–2020, in terms of the share of scientific articles published about soil salinity in the republic and the world, Asia surpassed Europe and North America, accounting for 52%, Europe for 46%, and North America for 2% (Fig. 1.2. 4).
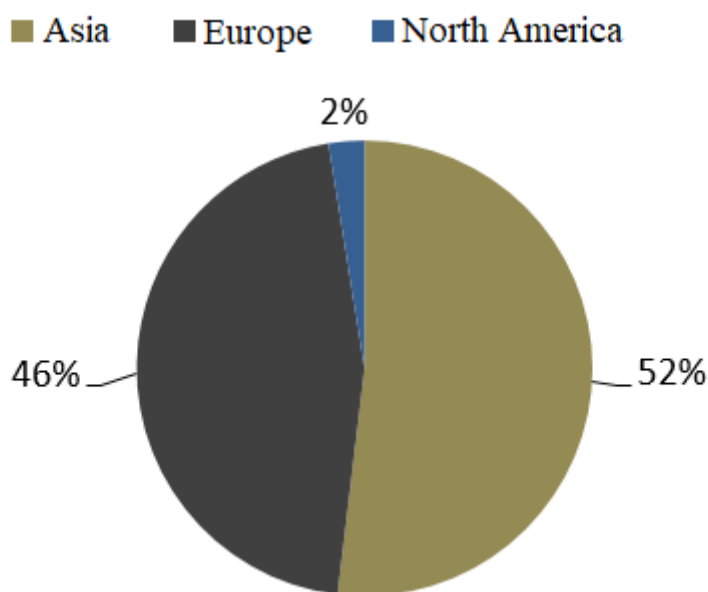
Fig 1.2.4. Publications by geographic region

3. Results

Our analysis showed that approximately 60–65% of the reviewed publications focused on the study of soil salinity in African countries. Summarizing the studied literature, the methods used in the study of soil salinity in the republic and the world were divided into 3 main groups: geotechnical, geophysical, and statistical (Table

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1.2.1). Geotechnical methods are mainly related to the ecological and chemical characteristics and properties of the soil and their influence on erosion processes [9, 14, 16, 17].

Geophysical methods are also widely used in the study of soil salinity. The natural disturbance of the natural conditions of the soil without the human factor and electrical conductivity are the main methods used for zones with active salinization processes [5, 15, 18, 21].

Statistical methods are mainly related to spatial analysis using GIS and remote sensing methods. The authors who conducted research on the creation of a soil salinity map using statistical methods mentioned the issue of a lack of data for the Central Asian region and our republic [3, 22, 31]. Several studies have been conducted on soil salinity mapping using various statistical methods, and the obtained results correspond to 70–85% [3, 12, 15, 18, 22, 23].

From Table 1.2.1, we can see that one of the factors that accelerates soil salinization is often caused by environmental problems caused by human factors and climate change.

Table 1.2.1 Methods used in the study of soil salinity in the Republic and the world

Methods	Description	Precipitating factors	Environmental problems
Geotechnician	Soil properties, slope stability analysis	Mining activity and urbanization	Landslides and flows
Geophysicist	Seismic refraction, electrical conductivity	Seismic and tectonic movements, artificial dams	Landslides, rocks, debris flows, flash floods
Statistics	Susceptibility to salinity	Anthropogenic influences, salt migration, precipitation, high mineralization, GLOF	Landslides and flows

Remote sensing using GIS was rarely used in soil salinity studies before 2005 and was reported in five literature reviews from 2005 to 2007, but was not used at all

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in the literature published from 2008 to 2012. Nevertheless, researchers have started using remote sensing techniques using GIS. Scientists did not use GIS and remote sensing to study soil salinity in 2017; however, they published 12 articles on this topic from 2018 to 2020 (Fig. 1.2.5). Interestingly, the growth rate of the widespread use of GIS and remote sensing in landslide studies was $R^2 = 0.4$. Overall, it can be said that remote sensing research using GIS was not used at all in articles published during the 11 years and only in articles included in 9 of the last 20 years.
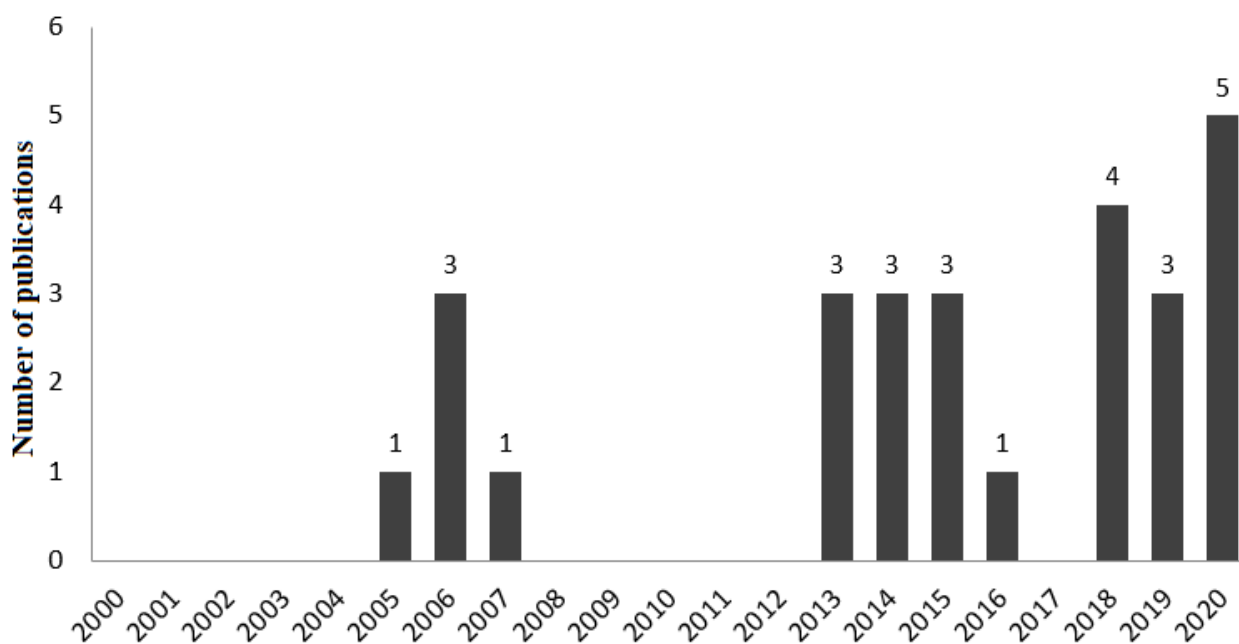
Fig 1.2.5. The role of GIS and remote sensing in the study of soil salinity during 2000-2020

Our analysis revealed that 56 factors influencing the occurrence and behavior of soil salinity were identified in 79 papers published between 2000 and 2020. The most commonly used factor of soil salinity is mentioned in 42 publications. In addition, soil type was the second most frequently used factor in publications, which was used in 18 studies. Over a period of 20 years, 15 publications identified soil biology, 13 publications identified soil erosion and soil organic matter degradation, and 11 publications identified mineral fertilizer use as potential factors [24, 25]. In addition, 10 literatures mentioned the factor of natural landslides, and scientists used land topography as the main factor in nine literatures. Deforestation, soil alkalinity, and agricultural activities have been considered factors in soil salinization research, each

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of which has been used in seven papers from 2000 to 2020 [8, 14]. In addition, land surface slope and land use land cover were taken as factors affecting the salinization process, and each of these factors was used in 5 publications, and air temperature, urbanization, mountain glaciers, and seismic processes were used in a total of 16 publications [9, 17, 26, 27]. During the period 2000–2020, each of the 11 factors, such as elevation, soil-forming rocks, curvature, digital terrain model, water erosion, ground motions and vibrations, inappropriate use of land resources, soil texture, unstable masses, and vibrations, were used in three literatures. [11,15,19,28].

4. **Conclusions**

According to the reviewed literature, 32 of the 79 pieces of literature indexed in the scientific and technical database "Scopus" were journal articles, followed by 31 conference reports, 11 book chapters, 2 review articles, 1 scientific note, a short survey, and textbooks. In the last 10 years, the publication rate on the topic of soil salinity has increased dramatically by 300%. During the years 2000–2020, 43 scientists from 11 countries conducted research on soil salinity. 41 different methods were used in the 79 publications reviewed.

Among them, soil salinity sensitivity and ecological hazard mapping based on GIS and Remote Sensing techniques were the most commonly used in salinity studies in about 24% of the literature published in 2000–2020. GIS and Remote Sensing were not used at all in the published literature between 2000 and 2010 and have gradually been used in studies included in the last nine years. In 53.2% of the 56 factors examined in the study of soil salinity in the republic and the world in 2000–2020, soil salinity was considered the main and potential factor causing environmental problems, followed by soil type, application of mineral fertilizers, ecological and biological properties of soil, and agricultural economic activities.

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