EURASIAN JOURNAL OF TECHNOLOGY AND INNOVATION
Innovative Academy Research Support Center
Open access journal www.in-academy.uz

FORECASTING THE DEGREE OF URBANIZATION USING AN ARTIFICIAL NEURAL NETWORK MODEL

Ismailov Ilxom Tursunbayevich
Senior Lecturer at Tashkent State University of Economics
Ermamatova Shohsanam Ermamatovna
Assistant at Tashkent State University of Economics

ARTICLE INFO

Received: 06th June 2024
Accepted: 11th June 2024
Online: 12th June 2024

KEY WORDS

Urbanization, machine learning, neural networks, Samarkand region, forecasting, statistical data, analysis.

ABSTRACT

This research solves the task of forecasting and analyzing the dynamics of the urban population share using an artificial neural network method, taking the Samarkand region as an example. Based on the official data of the State Statistics Committee of the Republic of Uzbekistan, 25 significant factors affecting the degree of urbanization were identified. Then, an artificial neural network model was created. Using this model, forecasts of changes in the urban population share of the Samarkand region for 2023-2025 were made. The obtained results contain data that can be practically applied for managing and regulating urbanization processes.

Introduction: Urbanization refers to the migration of the population from rural to urban areas, "the gradual increase in the share of the population living in cities," and the ways in which each society adapts to changes. It is the process of transitioning from a rural to an urban lifestyle [1]. By 2050, nearly 64 percent of Africa and Asia and 86 percent of the developed world will be urbanized [2]. It is noteworthy that the United Nations recently projected that nearly all global population growth from 2017 to 2030 will be absorbed by cities, i.e., by nearly 1.1 billion new urban dwellers over the next 13 years [3]. Urbanization is the process of population migration from rural to urban areas. This complex process occurs under the influence of several factors. First, as a result of industrial development, new industrial enterprises and production facilities emerge in urban areas. This leads to the creation of new jobs and the migration of the population to cities for employment [4]. Second, the introduction of modern technologies in agriculture may deprive part of the rural population of jobs. This, in turn, leads to the migration of the rural population to cities [5]. Third, the development of the service sector also affects the urbanization process. In modern societies, the service sector is becoming increasingly important, and new jobs are being created in this sector. This factor also contributes to the migration of the population to urban areas [6].

Although developing countries, including Uzbekistan, are also characterized by an acceleration of the urbanization process, its mismanagement can lead to several problems [7]. As a result of poor management of the urbanization process, urban infrastructure may fail to meet the demand for housing, and problems may arise in areas such as transportation, the

environment, and social sectors. Therefore, it is crucial to manage and properly channel the urbanization process [8]. Accurately assessing the degree of urbanization is essential for several critical areas. Issues such as urban planning, infrastructure development, socio-economic policy development, efficient use of resources, and prevention of environmental problems require considering urbanization processes. Currently, the city of Samarkand, located in the center of the Samarkand region of Uzbekistan, is significantly developed [9]. Due to the influx of population into this city and the high rates of urbanization, a number of problems are emerging [10]. In particular, issues related to transport safety, the demand for housing construction, and the obsolescence of existing streets are pressing concerns. Moreover, one of the factors negatively affecting the significant development of the economic environment is the migration of cheap labor from rural areas to urban centers. As a result, there is a shortage of labor in the agricultural sector, and the overall economic activity of the sector decreases [11]. As can be seen from the above, the issue of properly assessing and managing the urbanization process is of urgent importance. This issue is directly related to various areas, including urban development and infrastructure, addressing social problems, rational use of resources, and ensuring environmental sustainability. Therefore, the government must constantly monitor urbanization processes and pursue an effective policy for managing them [12].

In forecasting the urbanization process, various indicators, statistical data from previous periods, and methods used in practice are taken into account. These include population growth rates, birth and death rates, migration processes, and economic activity factors. Additionally, factors such as the standard of living, sources of income, number of jobs, and the state of educational and healthcare institutions are also important in forecasting.

Data and Methods

Training Data

The Samarkand region is located in the central part of Uzbekistan, which has historical cities and rich cultural heritage in Central Asia. It was established on January 15, 1938. This region is located in the central part of the republic, in the basin of the middle course of the Zarafshan River. Its borders are adjacent to the Navoi region in the west and northwest, Jizzakh in the north and northeast, Kashkadarya in the south, and Tajikistan in the southeast.

Forming the dataset is one of the important steps in creating an artificial neural network model. Within the scope of this research, necessary data sources were used to forecast the degree of urbanization in the Samarkand region. Training sample data was collected from the official website www.stat.uz of the State Statistics Agency under the President of the Republic of Uzbekistan to create an artificial neural network model.

Artificial Neural Network Model:

In this research, an artificial neural network training model was tested to forecast the degree of urbanization in the Samarkand region. The main goal was to maximize accuracy and take into account the factors affecting urbanization.

Neural Network was used to identify non-traditional and non-linear relationships present in complex datasets. It helped assess the impact of human activities and intangible factors on the urbanization process.

$$y = f(W * x + b)$$

EURASIAN JOURNAL OF TECHNOLOGY AND INNOVATION
Innovative Academy Research Support Center
Open access journal www.in-academy.uz

Where:

x - input vector

y - output vector

W - weight matrix

b - bias vectors

f - activation function

Since each model has its own advantages and disadvantages, combining them and performing optimization allowed for more accurate forecasting of the degree of urbanization.

Data Preparation

As mentioned above, the official website of the State Statistics Committee of Uzbekistan, www.stat.uz, was selected as the main source for analyzing the demographic, infrastructure, and socio-economic indicators of the Samarkand region. From this source, 96 separate datasets were used for the period between 2000 and 2022. A special method was employed to identify the factors influencing the degree of urbanization. Specifically, 96 separate training samples were used. To precisely identify the samples related to the urbanization process, a correlation heatmap analysis was performed.

The correlation heatmap analysis method allows determining the degree of interrelation between various factors. With the help of this method, 30 separate samples with a high correlation with the degree of urbanization were identified. The application of such an approach ensured the accuracy and reliability of the research.

During the research, a correlation heatmap analysis was conducted to identify the factors influencing the degree of urbanization in the Samarkand region. The analysis revealed that 30 training samples had a high correlation with the urbanization process. Subsequently, each of these 30 samples was studied in-depth. During the detailed examination of the samples, it was found that some data was incomplete. This could have negatively affected the accuracy of the research. Therefore, 5 training samples with incomplete data were removed from the research scope. The remaining 25 samples were recognized as the factors most strongly influencing the degree of urbanization based on the results obtained from the correlation heatmap (Figure 1).

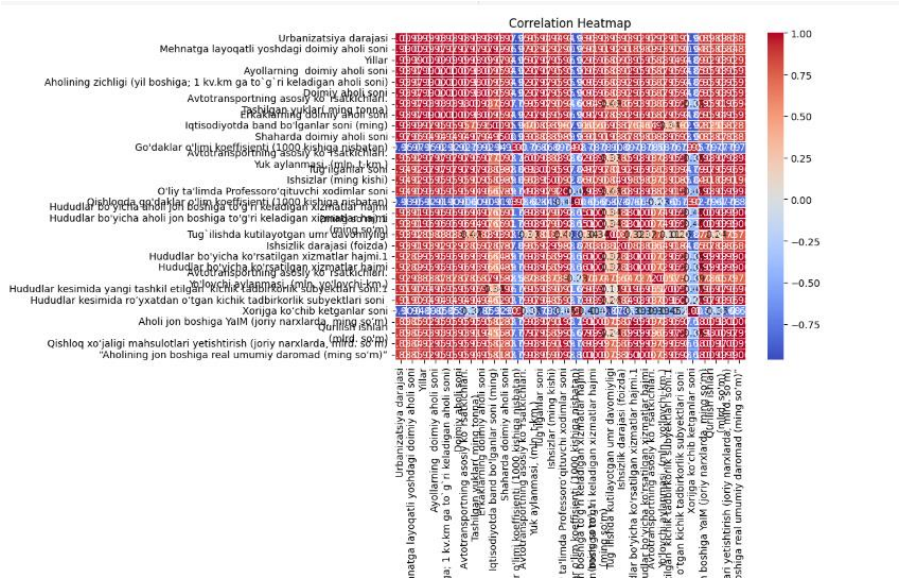
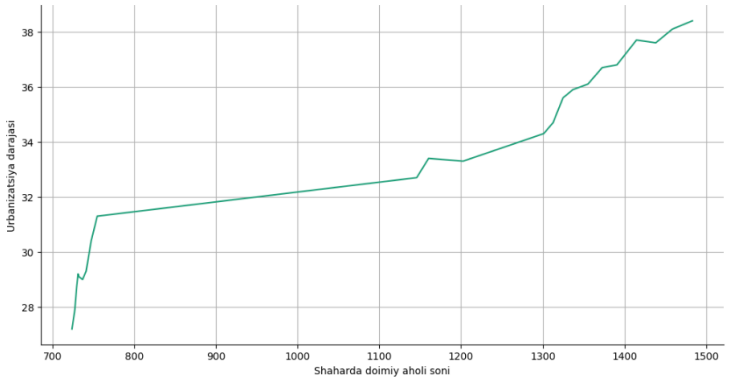
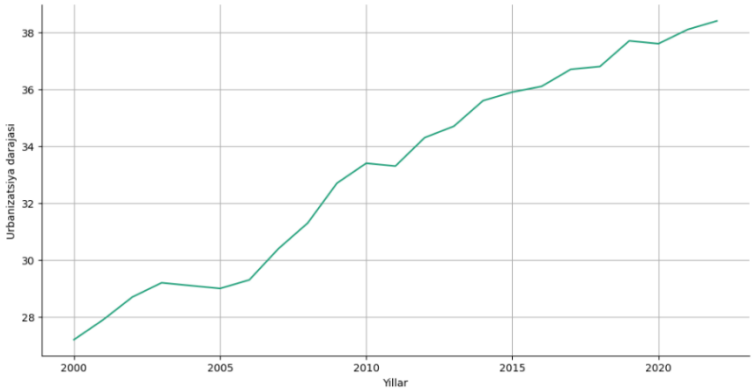


Figure 1. 25 training samples selected from the correlation heatmap.

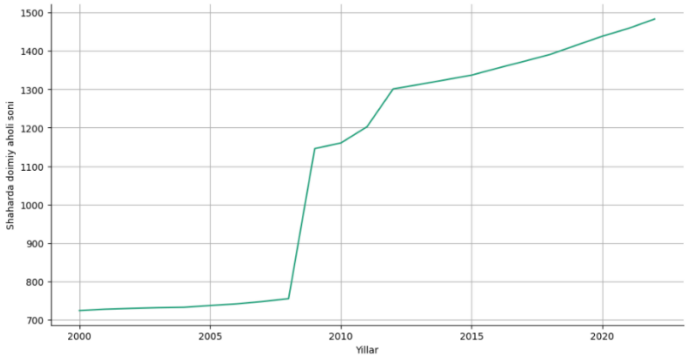
In the following graph, we can see the increasing order of the degree of urbanization in the Samarkand region relative to the population of the city of Samarkand.



In the following graph, we can see the increasing order of the degree of urbanization in the Samarkand region over the years.



In the following graph, we can see the increasing population of the city of Samarkand over the years. Here, we can witness a sharp increase in the population of the city of Samarkand starting from 2008.



Data Testing and Error Detection

During the research, it was decided to use an artificial neural network training model to study more deeply the factors influencing the degree of urbanization in the Samarkand region. For this, the data from the previously selected 25 training samples were used. The dataset needed to be divided into training and test portions. For this purpose, the samples were split into two parts - 90% for training and the remaining 10% for testing. Using the data from the training part, the artificial neural network model was trained, and its performance was

studied. The data from the test part was intended for testing and evaluating the model's performance on new, unfamiliar data.

Root Mean Square Error (RMSE) The root mean square error (RMSE) is a performance metric that measures the difference between the values predicted by the model and the observed values.

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N} ||y(i) - \hat{y}||^2}{N}}$$

Where:

n – number of observations

y – true observations

ŷ – predicted observations

Forecasting Using the Neural Network Model

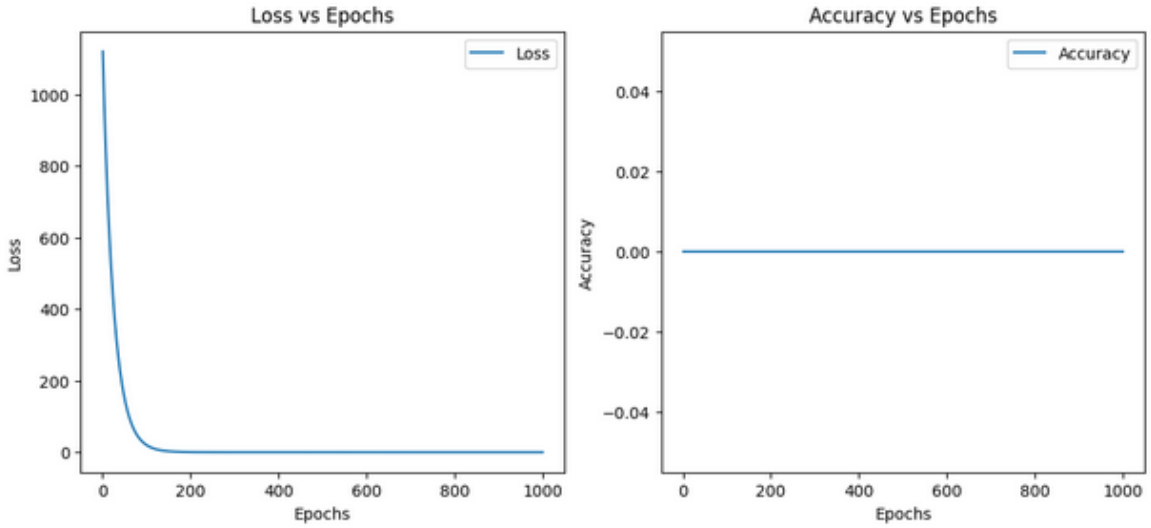
The neural network model is an artificial neural network model constructed similarly to the human biological neural network, with the ability to learn and adapt. This model was also trained and tested based on the data from the 25 important training samples. During this process, 90% of the data was separated as the training part for training the model, and the remaining 10% was separated as the test part for testing. Training the neural network model and testing the model on real data took some time. As a result, the model's real and predicted urbanization indicators were compared in a special table. As can be seen from this table, the forecasts of the neural network model were very close to the real situation compared to other models.

Randomly Sampled	Forecasted Degree of Urbanization	Actual Degree of Urbanization
5	34.314	34.1
1	27.710087	27.9
7	35.33388	35.6

Additionally, the root mean squared error (RMSE) metric, which represents the overall effectiveness of the model, was calculated. For the neural network model, the RMSE value was only 0.44187. This is a significantly lower value compared to the RMSE values of other machine learning models. Therefore, the effectiveness of the neural network model was found to be very high.

RMSE = 0.44187

EURASIAN JOURNAL OF TECHNOLOGY AND INNOVATION
Innovative Academy Research Support Center
Open access journal www.in-academy.uz



Results

During the research, an artificial neural network model was used to analyze and forecast the degree of urbanization in the Samarkand region. The experiments showed that the artificial neural network model achieved the highest efficiency. The neural network model was specifically trained based on the data from the previously obtained 25 training samples, and its effectiveness was tested at a high level. Then, with the help of the model, the degree of urbanization in the Samarkand region for 2023, 2024, and 2025 was forecasted. The forecast results were presented in a special table format. This table reflects the urbanization indicator for each year as a percentage. According to the forecasts, the urbanization process in the Samarkand region will not change significantly over the next three years.

№	Years	Forecasted Degree of Urbanization
1	01.01.2023 y.	38.042699%
2	01.01.2024 y.	38.808788%
3	01.01.2025 y.	38.915726%

These forecast results will help local authorities consider the potential consequences of urbanization, develop appropriate measures, and take additional steps. Consequently, it creates an opportunity to prevent problem situations in a timely manner and effectively manage urban development.

Conclusion

In this research work, the problem of forecasting and analyzing the urbanization process was solved using an artificial neural network method, taking the Samarkand region as an example. Initially, the official data of the State Statistics Committee of the Republic of Uzbekistan was used, and 25 important training samples related to the degree of urbanization were identified. Subsequently, an artificial neural network model was built based on the data from these samples, and its effectiveness was tested. The results showed that our artificial neural network model had the highest accuracy and reliability, with an RMSE value of only 0.44187. Furthermore, with the help of the neural network model, the degrees of urbanization in the Samarkand region for 2023, 2024, and 2025 were forecasted. According to this, the urbanization process in the region will not develop at a very rapid pace, and an increase of only 0.9 percent is expected over the three-year period. From the overall results, it can be

concluded that the use of modern technologies and the artificial neural network method has created an opportunity to more accurately forecast the urbanization process and analyze the factors influencing it. Such approaches are crucial for governments and local authorities in effectively managing urban development. Additionally, the experience gained during the research can play an important role in forecasting and analyzing urbanization processes for other regions. The new approaches applied in this field allow for the conservation of excessive resources and the prevention of negative consequences of urbanization.

This research has made a significant contribution to developing methods for forecasting and analyzing complex processes such as urbanization using an artificial neural network model. In the future, work in this area should be further improved and implemented in practice.

References:

1. National Library of Medicine (NLM) (2014). 'Urbanization'
2. The Economist (2012) "Urban life: Open-air computers"..
3. Doroyevna, R. N. (2023). The Modern Approaches to Location Determination of Commercial Confidential Information in the System of Civil Law Objects. *Journal of Intellectual Property and Human Rights*, *2*(10), 1-7.
4. Doroyevna, R. N. (2022). Trade Secrets and Know-How as Objects of Intellectual Property Rights: Problems of Correlation and Legal Regulation. *American Journal of Social and Humanitarian Research*, *3*(11), 388-394.
5. Раимова, Н. (2010). Значение конфиденциальной информации в условиях рыночной экономики. *Обзор законодательства Узбекистана*, (1-2), 21-24.
6. Раимова, Н. (2011). Ответственность за нарушение права на конфиденциальную информацию. *Обзор законодательства Узбекистана*, (3), 17-21.
7. Раимова, Н. Д. (2016). Об особенностях уголовно-правовой охраны коммерческой тайны предприятия по законодательству Республики Узбекистан. *Российский следователь*, (22), 43-46.
8. Раимова, Н. (2016). Актуальные проблемы правовой защиты коммерческой тайны в республике Узбекистан. *Обзор законодательства Узбекистана*, (2), 28-29.
9. Раимова, Н. (2017). Информация как объект правового регулирования. *Обзор законодательства Узбекистана*, (1), 47-48.
10. Narkulovna, D. N. (2023). THE ROLE OF INTERACTIVE METHODS IN SCIENCE TEACHING. *SCIENCE AND SCIENTIFIC RESEARCH IN THE MODERN WORLD*, *1*(7), 76-80.
11. Джураева, Н. Н. (2023). БОШЛАНҒИЧ СИНФ ЎҚУВЧИЛАРИНИ ТАБИИЙ (SCIENCE) ФАНЛАРДАН КЎНИКМАЛАРИНИ ШАКЛЛАНТИРИШДА ВИРТУАЛ ТАЪЛИМ ТЕХНОЛОГИЯЛАРИДАН ФОЙДАЛАНИШ. *ILM FAN TARAQQIYOTIDA ZAMONAVIY METODLARNING QO'LLANILISHI*, *3*(6), 134-139.
12. Narkulovna, D. R. N. (2024). BOSHLANGICH SINFLARGA TABIIY FANLARNI OQITISHDA EKOLOGIK TUSHUNCHALARNI SHAKLLANTIRISHNING AHAMIYATI. *worldly knowledge conferens*, *7*(1), 95-98.
13. Джураева, Н. Н. (2023). БОШЛАНҒИЧ СИНФ ЎҚУВЧИЛАРИНИ ТАБИИЙ (SCIENCE) ФАНЛАРДАН КЎНИКМАЛАРИНИ ШАКЛЛАНТИРИШДА ВИРТУАЛ ТАЪЛИМ

ТЕХНОЛОГИЯЛАРИДАН ФОЙДАЛАНИШ. *ILM FAN TARAQQIYOTIDA ZAMONAVIY METODLARNING QO'LLANILISHI*, *3*(6), 134-139.
14. Togaymurodov, J. K. (2024). A LOOK AT THE ZAKIROV DYNASTY. *Web of Discoveries: Journal of Analysis and Inventions*, *2*(5), 152-156.
15. Togaymurodov, J. K. (2024). THE LEGACY LEFT BY BOTIR ZAKIROV. *European Science Methodical Journal*, *2*(5), 186-191.
16. Togaymurodov, J. (2023). SOCIAL POTENTIAL OF RELIGIOUS TOLERANCE. *Galaxy International Interdisciplinary Research Journal*, *11*(5), 215-218.
17. Yuldoshev, U. R. (2017). THE USAGE OF STYLISTIC DEVICES: METAPHOR, METONYMY, HYPERBOLE IN UZBEK AND ENGLISH HUMOROUS TEXTS. *Научно-методический и теоретический журнал*.
18. Yuldoshev, U. R. (2017). Peculiarities of translation of Uzbek national anecdotes into English. *Philological sciences. Graduate School Scientific Papers*, *6*, 50-54.
19. YOLDOSHEV, U. (2014). Çeviri Sürecinde Çizgi Roman Özgünlüklerininin İngilizce ve Özbekçe Karşılaştırmalı Analizi. *Motif Akademi Halkbilimi Dergisi*, *7*(13), 237-242.
20. Юлдошев, У. Р. (2018). English borrowing as the main way education computer slang. *Молодой ученый*, (41), 204-206.
21. Yuldoshev, U., & Yuldosheva, M. (2021). Lingvostylistic and lingvocultural features of literary translation. *Turkish Online Journal of Qualitative Inquiry*, *12*(7).
22. DER GEBRAUCH, D. V. K. I. FOYDALANILGAN ADABIYOTLAR. *DAF-UNTERRICHT IM DIGITALEN ZEITALTER*, 130.
23. Ibrohimjon o'g'li, A. Q., & Urunbayevna, O. I. (2022). NEMIS FRAZEOLOGIZMLARNING RIVOJLANISH TARIXI VA TARAQQIYOTI HAMDA O'ZBEK FRAZEOLOGIZMLARI BILAN QIYOSIY TAHLILI. *Galaxy International Interdisciplinary Research Journal*, *10*(10), 202-205.
24. Одилович, Қ. М. (2024). ОЛТИН ҚАЗИБ ОЛИШ КОРХОНАЛАРИДА ТАШКИЛИЙ ФАОЛИЯТ-САМАРАЛИ БОШҚАРИШ ТИЗИМИНИНГ АСОСИ. *Scientific Journal of Actuarial Finance and Accounting*, *4*(04), 126-133.
25. Косимов, М., Халкулова, Х., & Эрматов, Н. (2024). ГИДРОГЕОЛОГИЧЕСКАЯ ОБСТАНОВКА НА КАРЬЕРЕ «КАЛЬМАКЫР». *Евразийский журнал технологий и инноваций*, *2*(4), 52-58.
26. Kosimov, M., & Malyushenko, D. (2024). MITIGATION OF ENVIRONMENTAL HAZARDS IN THE DEVELOPMENT OF DEPOSITS BY OPEN-PIT AND UNDERGROUND METHODS. *Collection of scientific papers «SCIENTIA»*, (April 5, 2024; Valencia, Spain), 121-124.
27. Qazaqovna, X. M. (2023). CONTENT AND CHARACTERISTICS OF ANDRAGOGIC EDUCATION FOR FUTURE SPECIALISTS. *Journal of Survey in Fisheries Sciences*, *10*(1S), 3248-3252.
28. Kazaqovna, K. M. (2023). PSYCHOLOGICAL ASPECTS OF AGGRESSIVE BEHAVIOR IN ADOLESCENTS. *Open Access Repository*, *4*(03), 18-22.
29. Умурзакова, М. Н. (2021). " Ўзбекистонда аҳолини ижтимоий ҳимоя қилишда тиббий суғуртани ривожлантиришнинг истиқболлари". *Т.: ЎзМУ*, *57*.
30. Nodir, K. U. (2020). Stages and scenarios of health insurance market development in Uzbekistan. *International Journal of Psychosocial Rehabilitation*, *24*(4), 1996-2005.

31. Умурзакова, М. (2024). ТИББИЙ СУҒУРТА ТИЗИМИНИ ТАШКИЛ ЭТИШНИНГ ҚИЁСИЙ ТАҲЛИЛИ. *Прикладные науки в современном мире: проблемы и решения*, *3*(4), 16-18.
32. Умурзакова, М. (2024). СОҒЛИҚНИ САҚЛАШ СОҲАСИНИ ТИББИЙ СУҒУРТА АСОСИДА МОЛИЯЛАШТИРИШ МОДЕЛИ. *Ижтимоий-гуманитар фанларнинг долзарб муаммолари/Актуальные проблемы социально-гуманитарных наук/Actual Problems of Humanities and Social Sciences.*, *4*(1).
33. Axmatov, S. T. A. O. G., & Umurzakova, M. N. (2024). O'ZBEKISTONDA YASHIL IQTISODIYOTNI SHAKLLANTIRISH VA RIVOJLANTIRISHDA XORIJ TAJRIBASINI O'RGANISH. *Oriental renaissance: Innovative, educational, natural and social sciences*, *4*(4), 159-170.
34. Shoxrux, A., & Umurzakova, M. N. (2023). JAHONDA ENERGETIKA SIYOSATINI AMALGA OSHIRISH TAJRIBASI VA UNDAN O'ZBEKISTONDA FOYDALANISH. *Scientific Impulse*, *2*(15), 830-834.
35. Arabovna, A. N. (2024). O'zbekiston Respublikasi Xalq Demokratik Partiyasi Faoliyati Tarixi. *Miasto Przyszłości*, *46*, 168-172.
36. Абуллаева, Н. (2024). КАШТАЧИЛИК БУЮМЛАРИНИНГ ИЖТИМОИЙ-МАДАНИЙ ТУРМУШДАГИ АҲАМИЯТИ. *Interpretation and researches*, *2*(3 (25)).
37. Arabovna, A. N. (2023). MUSTAQILLIK YILLARIDA O'ZBEKISTON RESPUBLIKASIDA TASHKIL ETILGAN SIYOSIY PARTIYALAR. *TADQIQOTLAR*, *28*(1), 104-107.
38. Абдуллаева, Н. (2023). КАШТАЧИЛИК БУЮМЛАРИДА АНЪАНА ВА ИННОВАЦИЯЛАРНИНГ УЙҒУНЛАШУВИ. *Talqin va tadqiqotlar*, *1*(32).
39. Абдуллаева, Н. А. (2023). ФАРҒОНА ВОДИЙСИ ХАЛҚЛАРИ КАШТАДЎЗЛИГИНИНГ ИННОВАЦИОН ЖАРАЁНЛАРИ. *Экономика и социум*, (9 (112)), 387-392.
40. Abdurakhmanov, K., Zikriyoev, A., Shadibekova, D., Khojamkulov, D., & Raimjanova, M. (2022, December). Limits and challenges of human resource technological talents in AI age. In *Proceedings of the 6th International Conference on Future Networks & Distributed Systems* (pp. 202-209).
41. Маматов, Б., Носиров, Э., Хўжамқулов, Д., & Шарафхўжаева, К. (2007). Кичик бизнес ва хусусий тадбиркорлик лойиҳаларини молиялаштириш. *Ўқув қўлланма. ТМИ*, *2007*.