O‘ZBEKISTON MILLIY UNIVERSITETI XABARLARI, 2026, [2]
ISSN 2181-7324

BIOLOGIYA
http://journals.nuu.uz
Natural sciences

UO‘K:631.9:332.3(575.112)

Oybek MAMARAXIMOV,
O‘zbekiston Milliy universiteti dotsenti
E-mail:oybekmamarahimov74@gmail.com
Navfal JALILOV,
O‘zbekiston Milliy universiteti magistranti
E-mail: navfaljalilov@gmail.com

Toshkent davlat agrar universiteti O‘rmonchilik va landshaft dizayn kafedrasi professori, b.f.d. T.Maxkamov taqrizi asosida

DETECTION OF LAND USE AND LAND COVER CHANGES USING SENTINEL-2 SATELLITE DATA

Annotation

This article analyzes land use and land cover changes in the Syrdarya region using intelligent systems-classified sentinel-2 satellite data. The results show that the extent of residential areas and water bodies has increased, while open lands have significantly decreased. Agricultural lands remain the dominant land use type, whereas only minor changes have been observed in rangelands and forests. The analysis is aimed at supporting effective land resource management, taking into account the impacts of demographic growth and urbanization.

Keywords: Land use, land cover, LULC, change detection, Sentinel-2, Syrdarya region, agriculture, industrial areas, water bodies.

ОПРЕДЕЛЕНИЕ ИЗМЕНЕНИЙ ЗЕМЛЕПОЛЬЗОВАНИЯ И ЗЕМЕЛЬНОГО ПОКРОВА НА ОСНОВЕ ДАННЫХ СПУТНИКА SENTINEL-2

Аннотация

В данной статье изменения землепользования и земельнего покрова в Сырдарьинской области классифицированы на основе интеллектуальных систем и проанализированы с использованием данных спутника Sentinel-2. В результате показано, что площади населённых территорий и водных объектов увеличились, тогда, как площади открытых земель значительно сократились. Сельскохозяйственные земли остались основным типом землепользования, в то время как на пастбищах и в лесных зонах наблюдались незначительные изменения. Проведённый анализ направлен на эффективное управление земельными ресурсами с учётом влияния демографических процессов и урбанизации.

Ключевые слова: землепользование, земельный покров, LULC, выявление изменений, Sentinel-2, Сырдарьинская область, сельское хозяйство, индустриальные территории, водные объекты.

SENTINEL-2 SUN’IY YO‘LDOSH MA’LUMOTLARI ASOSIDA YERLARNING FOYDALANILISHI VA YER QOPLAMIDAGI O‘ZGARISHLARNI ANIQLASH

Annotatsiya

Ushbu maqolada Sirdaryo viloyatida yerdan foydalanish va yer qoplami o‘zgarishlari intellektual tizimlar asosida tasniflangan va Sentinel-2 sun’iy yo‘ldosh ma’lumotlari yordamida tahlil qilingan. Natijada, axoli hududlari va suv obyektlari hajmi oshgani, ochiq yerlar esa sezilarli darajada qisqargani ko‘rsatilgan. Qishloq xo‘jaligi hududlari asosiy yerdan foydalanish turi bo‘lib qolgani, yaylov va o‘rmonlarda esa kichik o‘zgarishlar kuzatilgan. Tahlillar demografiya va urbanizatsiya ta’sirini hisobga olgan holda yer resurslarini samarali boshqarishga qaratilganligi keltirilgan.

Kalit so‘zlar: Yerdan foydalanish, yer qoplami, LULC, o’zgarishlarni aniqlash, Sentinel-2, Sirdaryo viloyati, qishloq xo‘jaligi, industrial hududlar, suv ob’ektlari.

Introduction. Land use refers to lands modified and used by humans for various purposes, such as farming, recreational and industrial purposes, while land cover refers to biological, and physical objects covering earth surface. These terms in environmental and geographical fields are often used, and inextricably linked to each other, yet cannot be studied in separation. Simply, land use and land cover (LULC) is the outcome of human and ecological interactions shaped by diverse impacts [1].

Increasing human activities and global climate change are major drivers of Land Use and Land Cover (LULC) changes, leading to critical challenges in natural resource management, sustainable development, and environmental conservation, particularly in arid and semi-arid regions [2]. The typical changes in LULC include the transformation of agricultural areas, desert areas, and bare lands into residential or industrial areas. While these changes are widely accepted as positive, natural balance in nature can be disrupted, and fertile lands essential for human survival can be lost. To avoid such disruptions, timely LULC change detection is important. In addition, long-term sustainable land management requires to fully capture the spatial and temporal variations in LULC [3].

In recent decades, the remote sensing technologies have emerged as powerful and game-changing in the field of environmental monitoring and management. Especially, monitoring LULC through space and time has become easier in the context of these technologies. Currently, multiple datasets and imageries are available, with the land satellite (Landsat), Sentinel, and Moderate Resolution Imaging Spectroradiometer (MODIS) being the most popular ones. Using these datasets, especially in LULC change detection, important results necessary for decision-making can be achieved [4].

Sentinel 2, compared to other datasets, are commonly being used in environmental studies and spatiotemporal monitoring. They have a temporal resolution of 10 m and 5-day revisit cycle, which makes it suitable for accurate and rapid

assessments. Furthermore, they have a capability of identifying subtle and negligible changes and can be integrated with machine learning algorithms in order to improve classification accuracy [5].

Literature review.

Uzbekistan has experienced significant LULC changes across its vast territory since last century. Also, there have been multiple studies dedicated to analyzing LULC changes, particularly in mountainous regions. Similarly, these studies have used Landsat, and Sentinel imageries along with machine learning algorithms to better understand and map the majora changes. From local perspective, for example, Juliev and et al. analyzed LULC changes using Landsat 5 and 8 data in the Bustanliq district in the Tashkent province [6]. Similarly, Alikhanov and et al. analyzed the same region, with a focus on mountain glaciers and urban expansion [7]. Alikhanov and et al assessed the vegetation cover change in Ugam-Chatkal National Park for 1991 and 2022, which is also located in Tashkent province [8]. Alikhanov and et al. also predicted LULC changes using CA–Markov model and Random Forest algorithms while considering the past LULC changes [9]. Aslanov et al. used Landsat 5 and 8 data for capturing green areas in the Tashkent city as the city is expanding and at the same time green areas are shrinking [10]. It should be noted that Edlinger and and et al utilized Landsat time series data to reconstruct irrigation systems in the Kashkadarya province [11]. However, the main limitations of these studies are that the LULC changes in regions allocated to agriculture have not been considered. In this regard, the current study selects Syrdarya region as its research area and focuses on how LULC have changed in this region using Sentinel-2 imageries.

Study area.

The Syrdarya province is chosen in this study as it is both agriculturally and economically important region in Uzbekistan. The province covers approximately 4,300 km² (equivalent to around 430,000 ha), and shares borders with the Kazakhstan, Tajikistan, and Jizakh and Tashkent provinces of Uzbekistan and located on the left bank of the Syrdarya river [12]. The province comprises 8 administrative districts, namely Syrdarya, Boyout, Sardoba, Gulistan, Mirzaabad, Saykhunabad, Khovos, and Akaltin. The semi-arid climate dominates the region with dry and hot summers and cold winters. The mean air temperature exceeds 14°C per year. Annual precipitation is low, occuring in winter and spring [13].

AI-based Sentinel-2 dataset description

Sentinel-2 imageries integrate remote sensing data, especially high-resolution (10 m) data, with advanced and modern machine learning algorithms and artificial intelligence to map LULC. It has been developed by Esri and Microsoft. The ready-to-use dataset consists of billions of image pixels selected by humans from over 20,000 globally scattered points in partnership with the National Geographic Society. The final dataset classifies the land surface into nine LULC types and covers the time span from 2017 to 2024 [14]. For the purpose of this study, the LULC data were downloaded the platform above and spatially clipped the boundaries of the Syrdarya Province. During this procedure, out of nine LULC classes, only seven types were identified, namely water, trees (or forest), flooded vegetation, Crops (or cropland), Built areas, bare ground and rangeland.

Spatiotemporal changes in LULC

Spatiotemporal changes of LULC in the Syrdarya province Using AI-classified Sentinel-2 Level-2A LULC data imagery, seven LULC classes were identified in the study area and they are as follows Water, Forest, Flooded vegetation, Cropland, Built-up area, Bare land, and Rangeland. Although the classification algorithm is designed to indentify nine classes, only seven were observed due to the absence of Ice/Snow and cloud cover. Figure 1 presents the major spatial and temporal shifts in LULC within eight districts of the province from 2017 to 2024. Indubitably, the cropland areas have been the dominant land use type from 2017 to 2024. This showcases how the important irrigated agriculture is in all districts. The water bodies showed minor fluctuations in extent, with a noticeable reduction between 2020 and 2021, which is particularly visible in the Mirzaabad district. This decline could be attributed to the Sardoba reservoir failure occurred in 2020, which resulted in the release of a large amount of water, and shrunk in size [15]. The area covered by forest is quite negligible and is primarily located in the upper part of the Syrdarya district, near the Syrdarya River, where the environment is suitable for their growth and development. The flooded vegetation and bare land are seen nearly invisible types on the LULC spatial map, appearing only in small areas around the water bodies such as the Sardoba reservoir and Mirzaabad district [15].

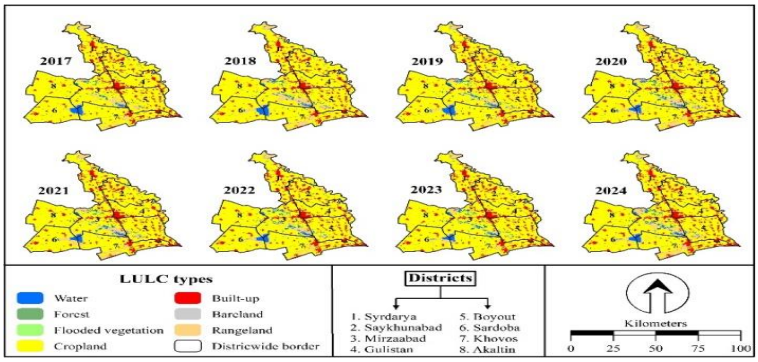

Fig. 1. The spatiotemporal changes of LULC types

However, the built-up areas could be spotted easily, showing expansion in the central part of the province, particularly in the Gulistan district, across all periods. Similarly, the rangeland is also eye-catching in the Mirzaabad, Boyovut, Sardoba, and Khovos district. Due to their closeness to the international borders with Kazakhstan and Tajikistan, the rangeland in the districts of Mirzaabad and Khovos could not have been exploited for either agriculture or residential purposes. Overall, the spatial LULC map of the Syrdarya Province reveals moderate to significant changes in water bodies and built-up areas, whereas changes in forest and flooded vegetation are negligible. Meanwhile, the cropland and bare land areas have undergone moderate to significant reductions in extent, due to population growth and the residential area expansion.

The changes of LULC types in hectare from 2017 to 2024 was calculated and shown in the Figure 2. It could provide insights into land transformation trends across the study area. The province’s landscape is dominantly cropland, which occupied the largest portion of the territory. Its area ranged from 329,857 ha in 2024 to a peak of 348,948 ha in 2017. Despite minor annual fluctuations, the cropland remained the dominant type of land use on agriculture.

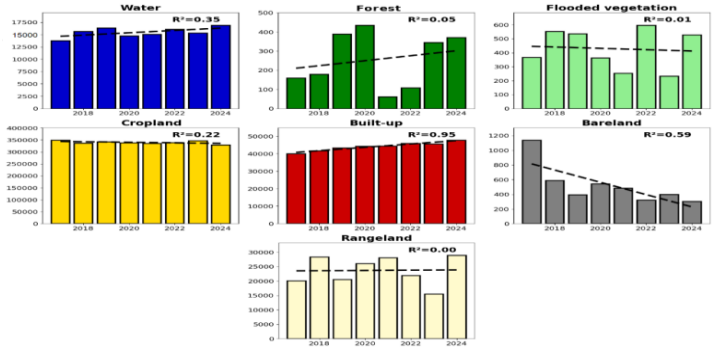

Fig. 2. Dynamic changes in LULC

The water bodies have demonstrated a consistent increasing trend (R=0.35) with 13,785 ha in 2017 to 16,911 ha in 2024, gaining more than 3,100 ha over the study period. This is linked to the Sardoba reservoir that had an impact on water bodies in 2020. The forest areas have also shown a nearly consistent trend from 155 ha in 2017 to 349 ha in 2024, with sharp fluctuations occuring between 2019 and 2020.

Meanwhile, the flooded vegetation varied between 232 ha (2023) and 597 ha (2022), which follows seasonal and hydrological water cycles. As mentioned above, the cropland was the dominant land use type, accounting for the majority of land cover across all years. Although it declined a little bit from 348,948 ha in 2017 to 329,857 ha in 2024, it seemed to have remained the backbone of the local economy and food production. The built-up areas exhibited a constant increase from 40,081 ha in 2017 to 47,670 ha in 2024, highlighting a significant urban expansion. The bare land, in contrast, declined sharply, being just 305 ha in 2024 from 1,136 ha in 2017. The rangeland, although some fluctuations were observed, presented no increasing trend, with a minimum of 15,581 ha in 2023 and a maximum of 28,923 ha in 2024.

Conclusion. In this paper, LULC changes in the Syrdarya province of Uzbekistan were evaluated using Sentinel-2 data from 2017 to 2024 period. Results show that the built-up areas have significantly expanded, while forest areas and water bodies have experienced a moderate increase over the last eight years. The bare land has exhibited a substantial decline. The cropland, although, remained the dominant land use type, its overall extent decreased negligibly. Other LULC types such as flooded vegetation and rangeland remained stable, exhibiting a steady trend over the years.

REFERENCES

1. Rawat J., Kumar M., Egypt. J. Remote Sens. Space Sci. 18 (2015) 77–84. https://doi.org/10.1016/j.ejrs.2015.02.002
2. Yang A., Sun G., ISPRS Int. J. Geo-Inf. 6 (2017) 59. https://doi.org/10.3390/ijgi6030059
3. Mathewos M., Lencha S. M., Tsegaye M., Land 11 (2022) 1632. https://doi.org/10.3390/land11101632
4. Rawat J., Biswas V., Kumar M., Egypt. J.Remote Sens. Space Sci. 16 (2013) 111–117. https://doi.org/10.1016/j.ejrs.2013.04.002
5. Esa E., Assen M., Legass A., Environ. Syst. Res. 7 (2018). https://doi.org/10.1186/s40068-018-0122-0
6. Juliev M., Pulatov A., Fuchs S., Hübl J., Pol. J. Environ. Stud. 28 (2019) 3235–3242. https://doi.org/10.15244/pjoes/94216
7. Alikhanov B., Alikhanova S., Oymatov R., Fayzullaev Z., Pulatov A., IOP Conf. Ser. Mater. Sci. Eng. 883 (2020) 012088. https://doi.org/10.1088/1757-899x/883/1/012088
8. Alikhanov B., Pulatov B., Samiev L., Forum Geogr. 38 (2024). https://doi.org/10.23917/forgeo.v38i1.3824
9. Alikhanov B., Pulatov B., Samiev L., Forum Geogr. 38 (2024) 121–137. https://doi.org/10.23917/forgeo.v38i2.4221
10. Aslanov I., Mukhtorov U., Mahsudov R., Makhmudova U., Alimova S., Djurayeva L., Ibragimov O., E3S Web Conf. 258 (2021) 04012. https://doi.org/10.1051/e3sconf/202125804012
11. Edlinger J., Conrad C., Lamers J., Khasankhanova G., Koellner T., Remote Sens. 4 (2012) 3972–3994. https://doi.org/10.3390/rs4123972
12. Khasanov S., Li F., Kulmatov R., Zhang Q., Qiao Y., Odilov S., Yu P., Leng P., Hirwa H., Tian C., Yang G., Liu H., Akhmatov D., Agric. Water Manag. 263 (2022) 107444. https://doi.org/10.1016/j.agwat.2021.107444
13. Kulmatov R., Khasanov S., Odilov S., Li F., Water Air Soil Pollut. 232 (2021). https://doi.org/10.1007/s11270-021-05163-7
14. Karra K., Kontgis C., Statman-Weil Z., Mazzariello J.C., Mathis M., Brumby S.P., in *IGARSS 2021-2021 IEEE International Geoscience and Remote Sensing Symposium* (IEEE, 2021). https://doi.org/10.1109/igarss47720.2021.9553499
15. Xiao R., Jiang M., Li Z., He X., Int. Appl J. Earth Obs. Geoinf. 107 (2022) 102705. https://doi.org/10.1016/j.jag.2022.102705