Comparative Analysis of Sentinel-2 MSI and Landsat-8 OLI for Enhanced Land Monitoring

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Abstract. The usage of satellite imagery has been extremely beneficial to many industries, such as environmental monitoring, medical mapping, urban planning, and agriculture. Among the several satellite pictures that are emerging as significant sources of multispectral data that provide crucial insights into the dynamics of the Earth's surface are Sentinel-2 MSI and Landsat-8 OLI. Understanding the differences between these two satellite systems is essential to maximizing their use in various applications. This study examines the advantages and disadvantages of Sentinel-2 and Landsat-8 OLI satellite data. The results enabled the use of the pertinent satellite images to create various themed memories, such as the connection between human health and the environment while creating medical-related geographic maps.

1 Introduction

In the face of global challenges such as climate change, urbanization, and resource management, effective land monitoring has become increasingly vital. Satellite imagery plays a crucial role in providing comprehensive insights into these dynamic processes, enabling stakeholders to make informed decisions regarding land use and environmental sustainability. By harnessing the power of remote sensing, researchers can effectively monitor changes in land cover and land use, which are essential for sustainable development and ecological balance. Two significant missions that offer useful data for a range of applications are Sentinel-2 MSI (Multispectral Instrument) and Landsat-8 OLI (Operational Land Imager), two Earth observation satellites [1,2]. In this research, we have examined the benefits and drawbacks of employing remote sensing indices to work with Sentinel-2 MSI and Landsat-8 OLI satellite data. We want to provide light on their applicability for different Earth observation tasks by contrasting their specifications, data accessibility, geographical

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and spectral resolution, temporal coverage, and cost [3,4]. Images from these multispectral sensors allow detailed monitoring of land cover and land use changes. This spectral diversity facilitates accurate classification of land cover types and provides valuable information for monitoring plant growth, water quality, and geological features [5,6]. Another advantage of accessing Sentinel-2 MSI data is its open and free availability to all users. As part of the Copernicus program, Sentinel-2 MSI data can be freely accessed and downloaded from various online platforms, such as the Copernicus Open Access Center. This democratization of data allows researchers, politicians and the general public to use the capabilities of satellite images for various purposes without financial constraints [7–9].

Additionally, the constant repetition of Sentinel-2 MSI enables quick monitoring of dynamic environmental events such as floods, deforestation, and wildfires. In accordance with a five-day review period, users may respond quickly to new occurrences and are certain of receiving the most recent information. [10,11]. Therefore, appropriate decision-making and disaster management support initiatives meant to stop incidents that endanger public health [12,13]. Despite its many advantages, access to Sentinel-2 MSI data also has some limitations. One of the main problems is cloud cover, which can interfere with optical imaging of the Earth's surface. Although Sentinel-2 MSI uses techniques such as cloud masking and atmospheric correction, cloud cover remains a persistent problem [14–16]. This is especially a problem in areas with frequent cloud cover or during the rainy season. The restricted temporal coverage for specific applications is an additional drawback of using Sentinel-2 MSI data. While a five-day revisit period works well for tracking abrupt changes in land cover, it might not be long enough to capture seasonal variations or long-term patterns in other ecosystems. To acquire extensive temporal coverage, researchers may need to integrate Sentinel-2 MSI images with data from other sources for studies requiring data spanning multiple years [17,18].

Furthermore, the high spatial resolution of the Sentinel-2 MSI requires a larger data volume, which may make it more difficult to process, store, and analyze the data—especially for users with limited computer or internet resources [19].

Despite the growing availability and advancements in satellite data, understanding the specific advantages and limitations of each system is crucial for optimizing their use in land monitoring. This study seeks to compare Sentinel-2 MSI and Landsat-8 OLI, focusing on their specifications, data accessibility, geographic and spectral resolution, temporal coverage, and cost-effectiveness. By addressing the gaps in existing literature regarding the comparative performance of these two satellite systems, this research aims to illuminate their applicability in various Earth observation tasks.

This study aims to evaluate the strengths and weaknesses of both Sentinel-2 MSI and Landsat-8 OLI by comparing their technical specifications, data availability, processing requirements, and overall utility for various applications in land monitoring. By identifying the most suitable contexts for each satellite's use, this research intends to provide insights that can guide future remote sensing applications and improve decision-making processes in land management and environmental monitoring.

The structure of this paper is organized as follows: we will first outline the methodologies used for comparison, followed by a detailed analysis of the advantages and disadvantages of each satellite system. Finally, we will discuss the implications of our findings for future research and practical applications in land monitoring.

2 Methods

This research primarily focuses on the comparative analysis of two significant Earth observation satellite systems: Sentinel-2 MSI (Multispectral Instrument) and Landsat-8 OLI (Operational Land Imager). Both satellites are designed to provide high-resolution

multispectral imagery for monitoring and analyzing land cover and land use changes over time.
Sentinel-2, part of the Copernicus program initiated by the European Space Agency (ESA), features a constellation of two satellites (Sentinel-2A and Sentinel-2B) that collectively offer a temporal revisit time of approximately five days at the equator. This capability enables timely observations of dynamic environmental events, such as agricultural practices, deforestation, and natural disasters. With a spectral range covering 13 bands, including visible, near-infrared, and shortwave infrared wavelengths, Sentinel-2 MSI is particularly effective in vegetation analysis, soil and water quality assessment, and land cover classification.
In contrast, Landsat-8, operated by the United States Geological Survey (USGS), continues the legacy of the Landsat program that began in 1972. With a revisit period of 16 days, Landsat-8 provides high-quality imagery in 11 spectral bands, including unique thermal infrared bands that are beneficial for studying surface temperatures and vegetation health. The Landsat program has a long historical archive, making it invaluable for analyzing long-term land use changes and environmental trends.
The main aim of downloading the required materials for this study was to compare the Sentinel-2 MSI and Landsat-8 OLI data. It did not select a particular field to focus on studying on the primary focus was on the examination of inadequacies in the data download procedure from Sentinel-2 MSI and Landsat-8 OLI satellites, as well as the benefits and drawbacks of utilizing specialized software to operate with this data [20,21].
To facilitate this comparison, we utilized ArcGIS Pro software developed by ESRI, known for its robust capabilities in analyzing satellite imagery and determining the quality of remote sensing data. The data for this study was sourced from [insert specific sources or platforms] and selected based on [insert selection criteria, e.g., cloud cover, time of acquisition]. The study particularly examines data from May and June, as these months typically coincide with the peak vegetation index, thus yielding high-quality NDVI results.
We employed two widely used remote sensing indices: the Normalized Difference Vegetation Index (NDVI) and the Normalized Difference Water Index (NDWI). The NDVI calculation was performed using the following formula:

$$NDVI = NIR - RED/NIR + RED \qquad \text{Equation 1}$$

Where: For Sentinel-2 : NDWI=(Band3-Band8A)/(Band3+Band8A)

$$NDWI = (GREEN - NIR)/(GREEN + NIR) \qquad \text{Equation 2}$$

Where: For Landsat-8: NDVI=(Band3-Band5)/(Band3+Band5)

The table 1 presents a detailed comparison of the spectral channels between Sentinel-2 MSI and Landsat 8-9 OLI. Each band is designed to capture specific wavelengths of light from the electromagnetic spectrum, which is critical for various applications in environmental monitoring, such as assessing vegetation health, water quality, and land cover classification. The resolution of each band indicates the size of the area represented by each pixel. For instance, Sentinel-2's Bands 2 (Blue) and 3 (Green) have a finer resolution of 10 meters, allowing for more detailed imagery, while Sentinel-2's Band 1 (Ultra-Blue) and Band 9 (Short Wave Infrared) have a coarser resolution of 60 meters. In contrast, most Landsat 8-9 bands have a resolution of 30 meters, with thermal bands initially having a 100-meter resolution before being resampled to 30 meters for consistency.
Each band captures light at specific wavelengths measured in nanometers (nm). For example, Band 4 (Red) in Sentinel-2 captures light at 665 nm, which is particularly useful for monitoring plant health. The Landsat bands correspond to specific spectral ranges; for example, Band 4 of Landsat 8-9 captures light in the 0.64-0.67 µm range.

The bands are classified based on the type of light they capture, such as "Visible and Near Infrared" (VNIR) or "Short Wave Infrared" (SWIR). This classification aids users in understanding the environmental features that can be analyzed with each band.
This table serves as a valuable resource for researchers and practitioners, providing essential information to guide the selection of satellite imagery based on spectral range, spatial resolution, and specific analytical needs for effective land monitoring.

Table 1 Description of Landsat 8 OLI and Sentinel-2 MSI spectral channels

Sentinel 2 (MSI) bands				Landsat 8-9 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) bands			
Band	Resolution	Central Wavelength	Description	Bands	Description	Wavelength (micrometers)	Resolution (meters)
B1	60 m	443 nm	Ultra-Blue (Coastal and Aerosol)				
B2	10 m	490 nm	Blue	Band 1	Coastal aerosol	0.43-0.45	30
B3	10 m	560 nm	Green	Band 2	Blue	0.45-0.51	30
B4	10 m	665 nm	Red	Band 3	Green	0.53-0.59	30
B5	20 m	705 nm	Visible and Near Infrared (VNIR)	Band 4	Red	0.64-0.67	30
B6	20 m	740 nm	Visible and Near Infrared (VNIR)	Band 5	Near Infrared (NIR)	0.85-0.88	30
B7	20 m	783 nm	Visible and Near Infrared (VNIR)	Band 6	Shortwave Infrared (SWIR) 1	1.57-1.65	30
B8	10 m	842 nm	Visible and Near Infrared (VNIR)	Band 7	Shortwave Infrared (SWIR) 2	2.11-2.29	30
B8a	20 m	865 nm	Visible and Near Infrared (VNIR)	Band 8	Panchromatic	0.50-0.68	15
B9	60 m	940 nm	Short Wave Infrared (SWIR)	Band 9	Cirrus	1.36-1.38	30
B10	60 m	1375 nm	Short Wave Infrared (SWIR)	Band 10	Thermal Infrared (TIRS) 1	10.6-11.19	100 (resampled to 30)
B11	20 m	1610 nm	Short Wave Infrared (SWIR)	Band 11	Thermal Infrared (TIRS) 2	11.50-12.51	100 (resampled to 30)
B12	20 m	2190 nm	Short Wave Infrared (SWIR)				

3 Results

Based on the research findings, the following considerations were made using Sentinel-2 and Landsat-8 data. Put another way, I was able to gather more accurate information about the area using Sentinel-2 data processing than I was using Landsat-8 data. The distinctions between these two satellite data sets can be ascertained via an NDVI index computation.

Since spatial resolution is a major factor in this, a summary of the key features of Landsat-8 data is required. To begin with, compared to Sentinel-2 MSI, the area coverage is substantially larger. One of the primary benefits of streamlining the data processing procedure is this. The Landsat satellites, in contrast to the Sentinel-2 MSI, have a thermal infrared band that offers useful data on variations in surface temperature.

This thermal data is essential for purposes such as monitoring urban hotspots, estimating the amount of water in crops, and detecting volcanic activity. If the area we are researching covers a larger area, the desired result can be achieved using Landsat-8 OLI data. On the other hand, if the area we need to observe occupies a small area, even though more time passes, the Sentinel-2 MSI data gives us a very effective result (Fig. 1).

Fig.1. High-resolution image of the place (RGB).

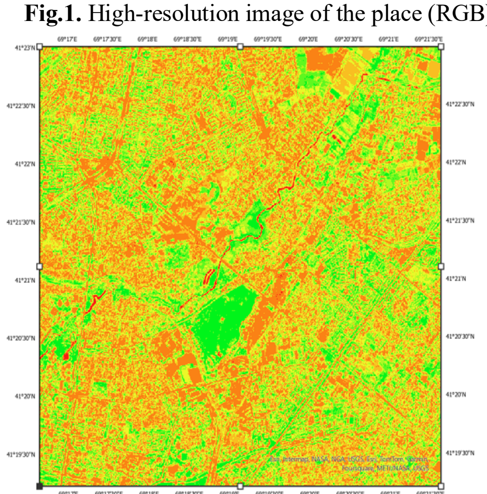

Fig. 2. Sentinel-2 MSI NDVI 2023 (May-June)

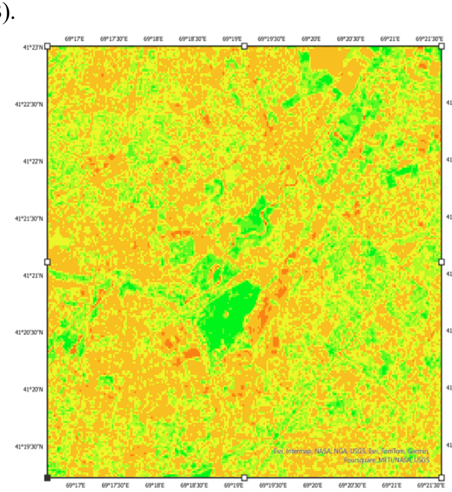

Fig.3. Landsat-8 OLI NDVI 2023 (May-June)

In this research work, we worked with medium resolution images obtained from Sentinel-2 MSI and Landsat-8 OLI sensors. Results were obtained by determining NDVI and NDWI indicators from remote sensing indices on these images. The main goal of this research work was to study whether it is possible to better determine the solution to the problems caused by observing changes on the earth's surface with the data of these two satellites (Fig.4,5,6,7). With its advanced imaging capabilities, we can see Landsat-8 OLI doing well in detecting other natural disasters such as wildfires or floods, and Land Surface Temperature. We can use Sentinel-2 data to conduct research on objects such as agriculture and forestry and urban planning.

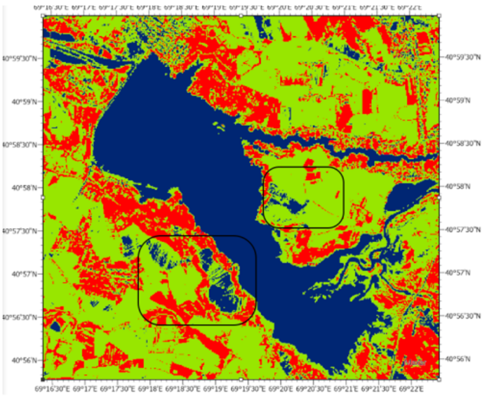

Fig. 4. Sentinel-2 MSI 2023 (May-June)

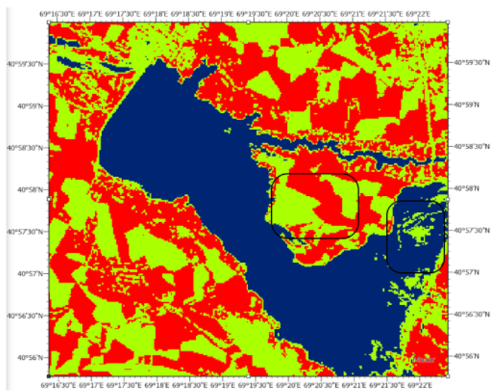

Fig. 5. Landsat-8 OLI 2023 (May-July)

Fig.6. Sentinel-2 MSI RGB

Fig.7. Landsat-8 OLI RGB

The results made it possible to refer to the appropriate satellite images in the process of creating various thematic memories (including the issue of environmental and human health relations in the creation of medical geographic maps). The correct use of medium-precision satellite data in the field of remote sensing makes it possible to find more accurate solutions to problems on the surface of the earth.

4 Conclusion

Numerous advantages are highlighted by a comparison of the relative benefits and downsides of employing spatial data from Sentinel-2 and Landsat-8 OLI for land monitoring.

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Both Sentinel-2 and Landsat-8 OLI offer valuable data for monitoring changes in land cover, land use, and environmental dynamics; nevertheless, the specific characteristics and capabilities of each tool influence which one is more appropriate for a particular purpose. Additionally, a comparison of Landsat-8 OLI and Sentinel-2 OLI reveals that each satellite system has special advantages for land monitoring applications. Landsat-8 OLI is an excellent option for trend monitoring and regional-scale analysis because to its intermediate geographic resolution and long-term data consistency. However, because Sentinel-2 offers multispectral images, greater spatial resolution, and a shorter revisit time, it is particularly helpful for following rapid changes at small scales and accurately mapping land surface characteristics. Choosing of Landsat-8 OLI and Sentinel-2 to utilize will depend on the specific needs of the monitoring project, including the need for geographic resolution, temporal frequency, spectrum requirements, and data availability. Combining data from the two platforms can improve the comprehensiveness of land monitoring initiatives and offer complementing insights. The release of publicly accessible data from Sentinel-2 and Landsat-8 OLI, taken together, represents a significant advancement in the capabilities of global land monitoring and gives stakeholders access to valuable spatial data for informed decision-making and sustainable land management practices.

References

1. P. Shanmugapriya, S. Rathika, T. Ramesh, and P. Janaki, International Journal of Current Microbiology and Applied Sciences **8**, 2270 (2019)
2. D. Poursanidis, N. Chrysoulakis, and Z. Mitraka, International Journal of Applied Earth Observation and Geoinformation **35**, 259 (2015)
3. M. I. Ramos, A. J. Gil, F. R. Feito, and A. García-Ferrer, Computers and Electronics in Agriculture **57**, 135 (2007)
4. H. Yin, A. V. Prishchepov, T. Kuemmerle, B. Bleyhl, J. Buchner, and V. C. Radeloff, Remote Sensing of Environment **210**, 12 (2018)
5. O. Ruzikulova, N. Sabitova, and G. Kholdorova, E3S Web of Conferences **227**, 03004 (2021)
6. A. J. Tatem, S. Adamo, N. Bharti, C. R. Burgert, M. Castro, A. Dorelien, G. Fink, C. Linard, M. John, L. Montana, M. R. Montgomery, A. Nelson, A. M. Noor, D. Pindolia, G. Yetman, and D. Balk, Population Health Metrics **10**, 1 (2012)
7. D. Rivera-Marin, J. Dash, and B. Ogutu, Journal of Arid Environments **206**, 104829 (2022)
8. R. Oymatov, I. Musaev, M. Bakhriev, and G. Aminova, E3S Web of Conf. **401**, 02005 (2023)
9. U. Mukhtorov, B. Sultanov, M. Li, K. Khushvaktova, S. Saidova, and Z. Valieva, E3S Web Conf. **386**, 05011 (2023)
10. A. Jumanov, S. Khasanov, A. Tabayev, G. Goziev, U. Uzbekov, and E. Malikov, IOP Conference Series: Earth and Environmental Science **614**, 012150 (2020)
11. A. Inamov, S. Sattorov, A. Dadabayev, and A. Narziyev, IOP Conf. Ser.: Earth Environ. Sci. **1068**, 012016 (2022)
12. D. Bazarov, S. Umarov, R. Oymatov, F. Uljaev, K. Rayimov, and I. Raimova, E3S Web of Conferences **264**, (2021)
13. S. Abdurakhmonov, I. Abdurahmanov, D. Murodova, A. Pardaboyev, N. Mirjalolov, and A. Djurayev, in *InterCarto, InterGIS* (Lomonosov Moscow State University, 2020), pp. 319–328
14. I. Aslanov, IOP Conference Series: Earth and Environmental Science **1068**, 011001 (2022)

15. S. Goibberdiev, G. Ikromkhodjaev, Z. Tajekeev, T. Ismailov, U. Mukhtorov, and I. Aslanov, E3S Web of Conf. **443**, 06013 (2023)
16. S. Islomov, I. Aslanov, G. Shamuratova, A. Jumanov, K. Allanazarov, Q. Daljanov, M. Tursinov, and Q. Karimbaev, in *XV International Scientific Conference "INTERAGROMASH 2022,"* edited by A. Beskopylny, M. Shamtsyan, and V. Artiukh (Springer International Publishing, Cham, 2023), pp. 1908–1914
17. N. Sabitova, O. Ruzikulova, and I. Aslanov, E3S Web of Conferences **227**, 03003 (2021)
18. S. Narbaev, S. Abdurahmanov, O. Allanazarov, A. Talgatovna, and I. Aslanov, E3S Web of Conferences **263**, 04055 (2021)
19. S. He, H. Shao, W. Xian, Z. Yin, M. You, J. Zhong, and J. Qi, Remote Sensing **14**, (2022)
20. M. Langford and D. J. Unwin, Cartographic Journal **31**, 21 (1994)
21. H. Singh Pokhariya, (2023)
22. F. Mirchooli, S. H. Sadeghi, and A. Khaledi Darvishan, Remote Sensing Applications: Society and Environment **19**, 100359 (2020)
23. V. K. Gautam, P. K. Gaurav, P. Murugan, and M. Annadurai, Aquatic Procedia **4**, 739 (2015)
24. Yu. Usmanov, E3S Web Conf. **386**, 05010 (2023)
25. B. Sultanov, N. Abdurazakova, O. Shermatov, O. Fayziev, A. Jumanov, and N. Dekhkanova, E3S Web Conf. **284**, 03006 (2021)
26. A. Jumanov, S. Khasanov, A. Tabayev, G. Goziev, U. Uzbekov, and E. Malikov, IOP Conf. Ser.: Earth Environ. Sci. **614**, 012150 (2020)
27. C. Opp, M. Groll, O. Semenov, L. Shardakova, Y. Kovalevskaya, R. Kulmatov, I. Normatov, and I. Aslanov, E3S Web Conf. **575**, 04001 (2024)
28. S. Egamberdiev, M. Kholmurotov, E. Berdiev, T. Ochilov, R. Oymatov, and Z. Abdurakhmonov, E3S Web Conf. **284**, 03015 (2021)
29. A. Jumanov, S. Khasanov, A. Tabayev, G. Goziev, U. Uzbekov, and E. Malikov, IOP Conference Series: Earth and Environmental Science **614**, 012150 (2020)
30. M. Khamidov, A. Inamov, U. Islomov, and Z. Mamatkulov, E3S Web of Conf. **365**, 01008 (2023)
31. U. Makhmudova, S. Khasanov, A. Karimov, and S. Abdurakhmonov, Ecohydrology & Hydrobiology **23**, 484 (2023)
32. M. Bakiev and K. Khasanov, International Journal of Geoinformatics **17**, 37 (2021)
33. S. Shokirov, T. Jucker, S. R. Levick, A. D. Manning, and K. N. Youngentob, Remote Sens Ecol Conserv rse2.381 (2024)
34. I. Musaev, A. Bokiev, and M. Botirova, E3S Web of Conferences **227**, 05004 (2021)
35. B. Muslimbekov, N. Teshaev, S. Abdurakhmonov, and O. Gaybulloev, E3S Web Conf. **563**, 03068 (2024)
36. R. Oymatov, I. Musaev, M. Bakhriev, and G. Aminova, E3S Web of Conf. **401**, 02005 (2023)