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PROSPECTS FOR THE APPLICATION OF REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGIES IN MONITORING PASTURE LANDS

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Abstract: This study examines the application of remote sensing and Geographic Information System (GIS) technologies for assessing the condition, productivity, and spatial dynamics of pasture lands. Remote sensing provides an efficient approach for obtaining timely, objective, and large-scale information on land surface characteristics, vegetation status, and environmental changes. GIS technologies enable the integration, storage, processing, analysis, and visualization of multisource geospatial data, thereby supporting comprehensive monitoring of pasture ecosystems. The methodological framework includes image preprocessing, mosaicking, spectral index calculation, raster classification, and pixel-based spatial analysis using ArcGIS software. These procedures facilitate the extraction of quantitative information on vegetation cover, pasture degradation, biomass distribution, and the influence of natural and climatic factors on land productivity. Landsat 8 satellite imagery was employed as the primary data source due to its suitable spatial and spectral resolution. The results demonstrate that the combined use of remote sensing and GIS technologies provides reliable spatial and statistical information for evaluating pasture conditions, identifying degradation trends, and supporting sustainable pasture management and decision-making processes.

Key words: remote sensing, GIS, Landsat 8, pasture land monitoring, land cover mapping, vegetation assessment, spatial analysis.

Introduction

The monitoring of land facilitates the acquisition of data regarding the physical, chemical, biological, and geometric characteristics of a given territory. Consequently, this enables the assessment of the natural environment's condition and the observation of temporal changes. These capabilities underpin the creation of land use maps and the execution of monitoring and predictive analyses [7].

Currently, the acquisition of data at an advanced technical level is facilitated through remote sensing methodologies. This approach allows for the rapid collection of extensive information regarding the condition of vast areas [9]. Specifically, aerial imagery provides an objective evaluation of the existing circumstances and aids in the implementation of strategies aimed at their efficient utilization.

In recent years, the utilization of remote sensing data has yielded significant advancements in disaster preparedness and the early warning of cyclones, droughts, and floods. However, the effective application of remote sensing data necessitates the processing of extensive volumes of information and the integration of this data with information sourced from other platforms, such as cartographic or hydrometeorological station materials. Such tasks are contingent upon the availability of appropriate software tools. Consequently, as the reliance on remote sensing data intensifies, there is a concomitant increase in the application of geographic information system (GIS) technologies.

Methodology: Remote sensing encompasses the technological processes utilized to observe the Earth's surface through the deployment of aerial and spaceborne vehicles that are equipped with diverse imaging instruments. This methodology facilitates remote observation, allowing for data collection without direct physical interaction with the object of interest [10, 2, 8, 7]. The approach is

designed to yield reliable data expeditiously, thereby supporting the execution of essential planned activities.

Remote sensing methodologies are predicated upon the utilization of sensors deployed on spacecraft, which are adept at the digital processing of electromagnetic radiation and proficient in capturing data across an extensive spectrum of electromagnetic wavelengths [2].

Depending on the specific tasks involved, one may utilize low-, medium-, and high-resolution data. It is important to acknowledge that remote sensing methodologies primarily yield images of the Earth's surface, and that meaningful conclusions can be derived through the processing of these images [8]. Consequently, satellite imagery serves not only as a valuable tool for disaster management but also proves to be highly effective for agricultural applications, particularly through the analysis of near-infrared images to evaluate crop conditions. It is imperative to emphasize that, contingent upon the research objectives, the selection of geospatial data sources based on the spatial resolution of satellite imagery is of paramount significance.

The selection of a satellite's orbital position is a critical factor in capturing images of the Earth's surface. This is attributable to the fact that the capabilities of satellite sensors are predominantly influenced by the parameters associated with their respective orbits.

Various types of orbital configurations are necessitated for continuous monitoring (as in meteorological applications), for the compilation of global maps (such as land cover mapping), or for selective imaging in urban areas [7]. Generally, it can be observed that an increase in altitude corresponds to an expansion in spatial coverage; however, this is accompanied by a reduction in spatial resolution.

The majority of sensors employed in Earth observation primarily measure reflected solar energy, while a subset is designed to detect the energy emitted by the Earth itself [7]. Consequently, different forms of electromagnetic radiation yield distinct types of information regarding the characteristics of the Earth's surface.

Electromagnetic radiation across various wavelengths presents numerous differences; nonetheless, all forms—from radio waves to gamma radiation—exhibit the same fundamental physical characteristics [2].

Wavelength (λ) serves as a distinguishing feature of various forms of electromagnetic radiation. The blue wavelength within the spectrum is approximately 0.45 μm and is predominantly employed for measuring the depth of aquatic environments as well as for differentiating between soil and vegetation types. The green wavelength spans approximately 0.50 to 0.60 μm, facilitating the distinction between turbid and clear water, the presence of oil on the water surface, and the health of vegetation. The red wavelength is situated around 0.60–0.70 μm, whereas the near-infrared wavelength ranges from approximately 0.70 to 1.1 μm; these wavelengths are utilized to differentiate various conditions of vegetation, to create coastal maps, and to categorize different types of vegetation [4, 5]. Consequently, image data derived from these specific wavelengths can be instrumental in the study of pasture lands, particularly in assessing vegetation cover and productivity, evaluating water availability, and identifying areas deficient in vegetation.

Remote sensing data necessitate processing through Geographic Information System (GIS) technologies. These data are regarded as a fundamental source of GIS information, integrating diverse datasets acquired from both spaceborne and airborne platforms. They represent a critical component of remote sensing as a communication medium, facilitating the synthesis of cartographic and aerospace methodologies. This integration is attributed to the capabilities of GIS, which encompass the collection, storage, processing, analysis, graphical visualization, and modeling of spatial and pertinent information regarding the represented entities. Furthermore, GIS supports the resolution of informational and computational challenges utilizing digital cartographic, analog, and textual data [2, 3, 10, 6]. Thus, GIS can be conceptualized as a contemporary computer-based technology designed for the prediction of objects, events, and phenomena.

Methods such as remote sensing significantly enhance the capacity to generate datasets for the compilation of pasture maps across various spatial and temporal scales. Additionally, they offer materials that can be seamlessly integrated with existing maps, databases, and field studies.

The primary applications of remote sensing in cartography encompass the assessment of land use patterns and the identification of environmental degradation, pollution, and deterioration of natural ecosystems [1].

In contemporary contexts, precise mapping of managed land cover is essential for effective monitoring, comparative analysis, evaluation of potential uses, and strategic planning. The analysis and monitoring of optimal land management practices, comparison of usage levels, land allocation, implementation of sustainable land management, and support for ecosystem services and land market strategies all necessitate the mapping of spatial trends.

Analysys and discussions:

Based on the information presented, the utilization of Landsat 8 satellite data is deemed appropriate for acquiring spatial data in alignment with the research objectives.

Landsat 8 data is accessible through the open database of the U.S. Geological Survey (http://earthexplorer.usgs.gov), where researchers can download multi-year imagery of the study area from the comprehensive collection captured by the Landsat 8 satellite [20].

The analysis of land conditions, productivity, and the adverse effects of natural factors utilizing satellite imagery and ArcGIS software necessitates the execution of several methodological steps. These steps encompass the integration of images, conducting calculations across their spectral ranges, classifying the resultant data, and quantifying area metrics for the identified classes.

In instances where the study area comprises multiple collections of imagery, image mosaicking is employed to generate high-resolution images and ensure the reliability of the data obtained.

Mosaicing images requires several steps in the ArcGIS program: Toolboxes → System Toolboxes → Data Management Tools.tbx → Raster → Raster Dataset → Mosaic To New Raster (Fig. 1).

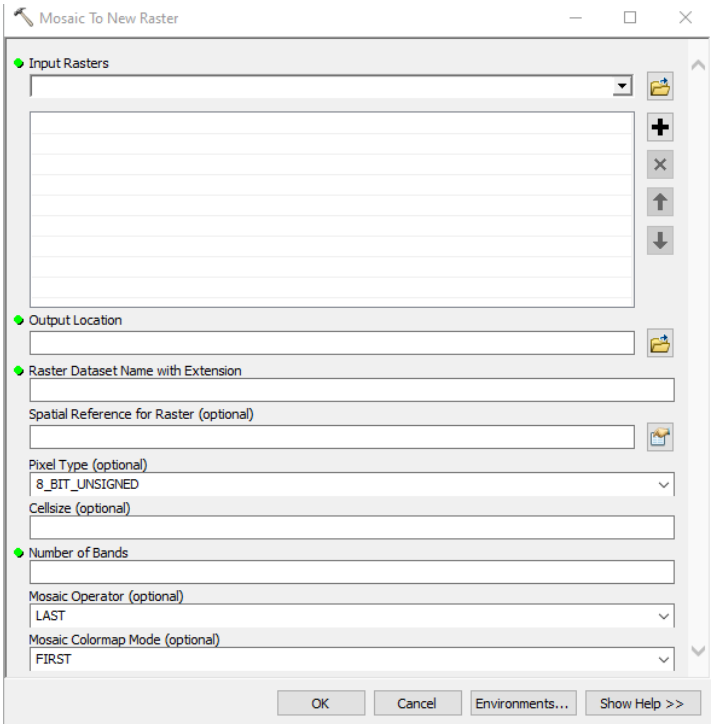


Figure 1. Window for Mosaic To New Raster

After selecting the necessary images, calculations are performed for their bands. They are: Toolboxes → System Toolboxes → Spatial Analyst Tools.tbx → Map Algebra → Raster Calculator (Fig. 2).

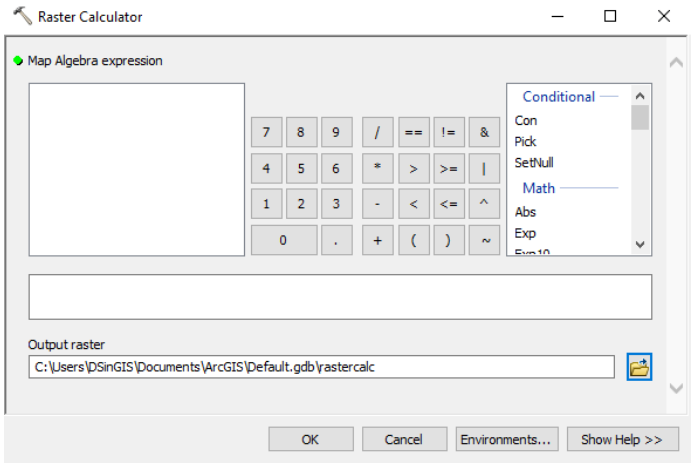


Figure 2. Window for performing calculations across the bands of satellite images

After the bandss are calculated using the given formulas, they are classified into classes, which is carried out as follows: Toolboxes → System Toolboxes → Spatial Analyst Tools.tbx → Segmentation and Classification → Classify Raster (Fig. 3).

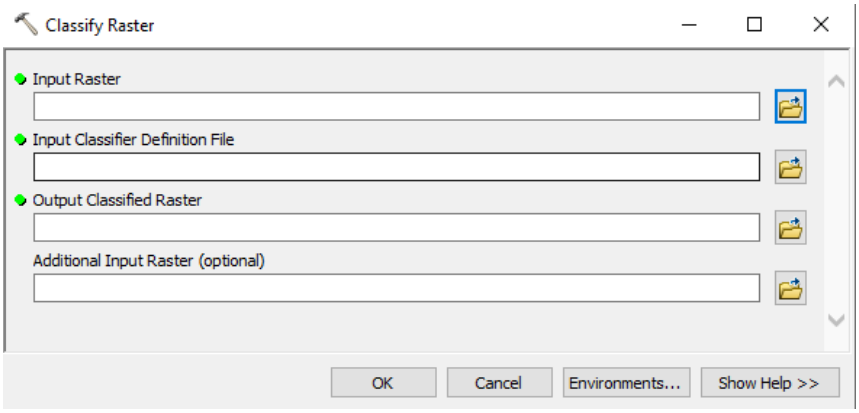


Figure 3. Window for classifying image data into classes

Upon classifying the image data into distinct categories, it becomes feasible to extract pixel information. The process for obtaining pixel data is executed through the following sequence: Toolboxes → System Toolboxes → Spatial Analyst Tools.tbx → Reclass → Reclassify (Fig. 4).

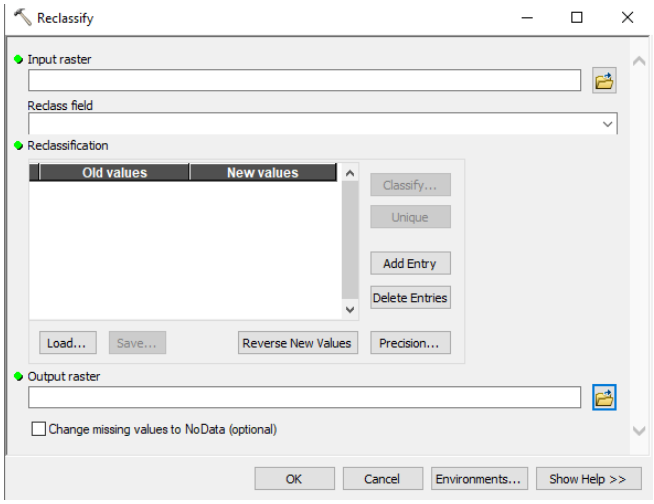


Figure 4. Window for obtaining pixel data from classified information

The precision of the acquired images directly influences the reliability of the pixel data, which offers insights into the spatial distribution of geographic features within the study area. This information is instrumental in quantifying the extent of vegetation coverage in pastoral lands and identifying areas of land degradation.

Conclusion: The application of Geographic Information System (GIS) technologies to the processing of Landsat 8 satellite data, following the designated sequence, facilitates the assessment of pasture land conditions and productivity. Additionally, it enables the identification of adverse impacts from natural factors. Furthermore, the methodologies employed significantly enhance the capability to evaluate future dynamics of changes in pasture lands, utilizing both the derived imagery and quantitative data.

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ПЕРСПЕКТИВЫ ПРИМЕНЕНИЯ ТЕХНОЛОГИЙ ДИСТАНЦИОННОГО ЗОНДИРОВАНИЯ И ГЕОИНФОРМАЦИОННЫХ СИСТЕМ В МОНИТОРИНГЕ ПАСТБИЩНЫХ ЗЕМЕЛЬ

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Аннотация: В данном исследовании рассматривается применение технологий дистанционного зондирования Земли и географических информационных систем (ГИС) для оценки состояния, продуктивности и пространственной динамики пастбищных угодий. Дистанционное зондирование представляет собой эффективный инструмент получения оперативной, объективной и крупномасштабной информации о характеристиках земной поверхности, состоянии растительного покрова и изменениях окружающей среды. ГИС-технологии обеспечивают интеграцию, хранение, обработку, анализ и визуализацию пространственных данных из различных источников, что способствует комплексному мониторингу пастбищных экосистем. Методический подход включает предварительную обработку спутниковых изображений, их мозаицирование, расчет спектральных индексов, классификацию растровых данных и пиксельный пространственный анализ с использованием программного обеспечения ArcGIS. Указанные методы позволяют получать количественные показатели растительного покрова, деградации пастбищ, распределения биомассы и влияния природно-климатических факторов на продуктивность земель. Результаты исследования подтверждают, что совместное использование снимков Landsat 8 и ГИС-технологий обеспечивает получение достоверной пространственной и статистической информации для оценки состояния пастбищ, выявления процессов деградации и принятия обоснованных решений в области устойчивого управления пастбищными ресурсами.

Ключевые слова: дистанционное зондирование, ГИС, Landsat 8, мониторинг пастбищных земель, картографирование земельного покрова, оценка растительности, пространственный анализ.

ЖАЙЫЛЫМДЫҚ ЖЕРЛЕРДІ МОНИТОРИНГТЕУДЕ ҚАШЫҚТАН ЗОНДТАУ ТЕХНОЛОГИЯЛАРЫ МЕН ГЕОАҚПАРАТТЫҚ ЖҮЙЕЛЕРДІ ҚОЛДАНУ ПЕРСПЕКТИВАЛАРЫ

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Аннотация: Бұл зерттеуде жайылымдық жерлердің жағдайын, өнімділігін және кеңістіктік динамикасын бағалауда қашықтықтан зондтау және географиялық ақпараттық жүйелер (ГАЖ) технологияларын қолдану мәселелері қарастырылады. Қашықтықтан зондтау жер бетінің сипаттамалары, өсімдік жамылғысының жай-күйі және қоршаған ортадағы өзгерістер туралы жедел, объективті және кең ауқымды ақпарат алудың тиімді құралы болып табылады. ГАЖ технологиялары әртүрлі көздерден алынған кеңістіктік деректерді біріктіруге, сақтауға, өңдеуге, талдауға және көрнекі түрде ұсынуға мүмкіндік береді, бұл жайылым экожүйелерін кешенді бақылауды қамтамасыз етеді. Әдістемелік негіз спутниктік суреттерді алдын ала өңдеуді, мозаикалауды, спектрлік индекстерді есептеуді, растрлық деректерді

жіктеуді және ArcGIS бағдарламалық қамтамасыз етуі негізінде пиксельдік кеңістіктік талдауды қамтиды. Бұл әдістер өсімдік жамылғысының жай-күйі, жайылымдардың тозуы, биомасса таралуы және табиғи-климаттық факторлардың жер өнімділігіне әсері жөнінде сандық мәліметтер алуға мүмкіндік береді. Зерттеу нәтижелері Landsat 8 спутниктік суреттері мен ГАЖ технологияларын бірлесіп қолдану жайылымдардың жағдайын бағалау, деградация үрдістерін анықтау және жайылым ресурстарын тұрақты басқару бойынша негізделген шешімдер қабылдау үшін сенімді кеңістіктік және статистикалық ақпарат беретінін көрсетті.

Түйін сөздер: қашықтықтан зондтау, ГАЖ, Landsat 8, жайылымдық жер мониторингі, жер жамылғысын картографиялау, өсімдіктерді бағалау, кеңістіктік талдау.