Study of pasture biomass and grazing intensity using remote sensing data in mountain area

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Abstract. This article introduces a quantitative framework for evaluating remote sensing data analysis in alpine pasture areas to estimate biomass and evaluate grazing intensity. Our paradigm for measuring vegetation biomass and assessing grazing pressure was established through the use of multispectral satellite imagery and ground-based observations. To get precise estimations of biomass and grazing intensity, the system combines field surveys, machine learning algorithms, and vegetation indices. The suggested approach's efficacy in monitoring pasture health and guiding sustainable land management techniques in hilly areas is evident from the results.

1 Introduction

For livestock grazing, biodiversity conservation, and ecosystem services, mountainous pasture lands are essential. However, anthropogenic activities like overgrazing and changes in temperature are putting more and more strain on these areas [1,2]. Making informed decisions about land management, evaluating pasture health, and advancing sustainable livestock production all depend on monitoring vegetation biomass and grazing intensity. With the use of remote sensing technologies, vegetation dynamics can be observed over wide spatial areas and on a regular basis [3–5]. Researchers can obtain important information on vegetation properties, such as biomass accumulation and grazing consequences, by examining satellite data. To evaluate grazing intensity and estimate biomass in pasture ecosystems, a number of remote sensing approaches have been developed, including vegetation indices and machine learning algorithms. In this article, we suggest a quantitative framework for evaluating the grazing intensity and biomass estimates in mountain pasture areas using remote sensing data analysis [6–8]. The technology combines sophisticated analytical tools, ground-based data, and multispectral satellite imagery to produce precise estimates of grazing pressure and vegetation biomass. The goal of the project is to provide useful information about pasture productivity and health so that alpine pastures can be managed more successfully [8–11]. The climate and vegetation growth patterns in mountainous areas vary significantly with the seasons. Severe winters with a lot of snow can

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make it harder to get to pastures and reduce the amount of fodder available to grazing animals [12–14]. On the other hand, summertime may bring more precipitation and a rise in vegetation, which may have an impact on pasture productivity and grazing patterns. Adapting to seasonal fluctuation and being resilient to harsh weather events are necessary for effective pasture management in the hilly sections of the study area [15–17]. The management of pastures must consider ecological, socioeconomic, and cultural aspects in order to effectively address these unique characteristics and challenges. Implementing sustainable land management practices in the Tashkent region's mountainous regions requires cooperation between government agencies, local populations, researchers, and conservation organizations [18,19].

2 Study area and methods

2.1 Study Area

Mountainous regions are characterized by diverse ecosystems and play a critical role in supporting biodiversity and ecosystem services. Pasturelands in these areas serve as important grazing grounds for livestock, contributing to livelihoods and food security. However, the sustainable management of mountain pastures faces challenges such as overgrazing and habitat degradation. Monitoring pasture biomass and grazing intensity is essential for assessing ecosystem health and guiding management practices [20,21].

The mountainous terrain in the Tashkent region (Figure 1) is characterized by steep slopes, varying elevations, and rugged landscapes. This topographic variability influences pasture distribution, accessibility, and management practices. Grazing animals may prefer certain areas with easier access and more favourable vegetation, leading to uneven utilization of pasture resources. Steep slopes and intensive grazing pressure in mountainous pastures can exacerbate soil erosion and degradation. Soil erosion poses a significant threat to pasture sustainability, leading to loss of soil fertility, reduced water retention capacity, and increased sedimentation in water bodies. Implementing erosion control measures, such as terracing, contour plowing, and vegetative buffers, is essential for mitigating soil degradation and preserving pasture ecosystems. Mountainous regions may be home to traditional pastoralist communities practicing extensive livestock grazing. These communities have deep-rooted cultural traditions and knowledge of local ecosystems, which influence grazing patterns and land use practices. Balancing traditional grazing practices with modern conservation and sustainability initiatives is crucial for preserving biodiversity, ecosystem services, and indigenous livelihoods in the Tashkent region's mountainous areas.

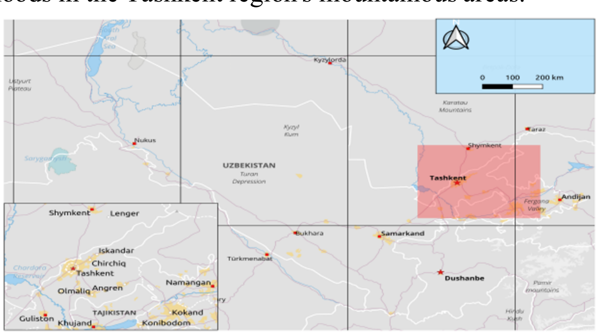

Fig. 1. Study area (Tashkent region, source: OSM modified using QGIS).

2.2 Data Acquisition

Multispectral satellite images from the Landsat 8 OLI satellite were utilized for the study area. Remote sensing data were collected and analyzed during the spring, summer, and autumn. These analyses were used to compile ground-based measurements of plant biomass and grazing intensity. Therefore, we can refer to the data collection flowchart, which outlines the complete process of data collection, processing, and output. (Figure.2).

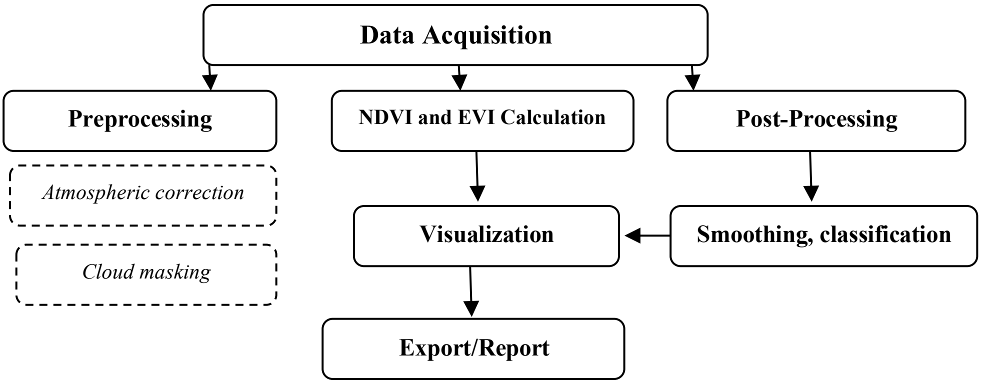

Fig. 2. Data Acquisition flowchart.

2.3 Biomass Estimation

To measure the greenness and biomass of the vegetation, vegetation indices were calculated from satellite data, such as the Enhanced Vegetation Index (EVI) and Normalized Difference Vegetation Index (NDVI). Ground-based biomass measurements in the analysis of remote sensing data are employed to establish empirical correlations between biomass values and various plant parameters. Two formulas were [3,22].

$$NDVI = \frac{NIR-Red}{NIR+Red} \quad (1)$$

$$EVI = \text{Green}\frac{\text{NIR}-Red}{(\text{NIR+C1})\text{x}(\text{Red}-\text{C2})\text{x}(\text{Blue+L})} \quad (2)$$

Where, NIR - near infrared, R-red and B-blue bands of Landsat sensor, C- values as coefficients for atmospheric resistance and L- value to adjust for canopy background.

2.4 Grazing Intensity Assessment

Spatial variations in grazing pressure were identified throughout the research region by the evaluation of grazing intensity. The satellite imagery-derived regional distribution of markers of grazing intensity and he observed patterns of plant degradation and biomass depletion are shown in Figure 3 in areas with high grazing intensity.

The precision of the grazing intensity assessment and biomass estimation models is assessed using independent validation datasets gathered from randomly chosen field plots. To evaluate how well the models predict biomass and grazing intensity data, measures such as coefficient of determination and root mean square error (RMSE) are computed [23].

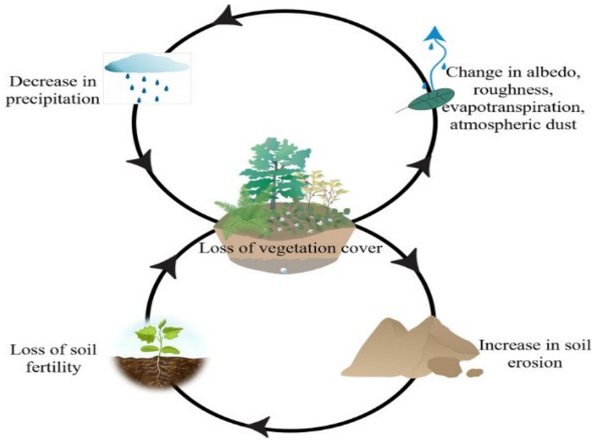

Fig. 3. The observed patterns of plant degradation and biomass depletion.

3 Results

Study of biomass pastures was conducted using remote sensing data to map mountain areas and open lands. The index was able to differentiate between pastures areas and open land using ArcGIS software, and the classification performance was effective due to the significant spectral responses of both land types in all Landsat 8 OLI bands pasture change map for seasonal revealed a mixture of NDVI index and bare land change classes. While there were significant land cover changes in some areas during this period, extensive pastures and open land were not converted to other land uses. Some apparent grass changes were due to agricultural activities.

The use of ArcGIS to confirm land cover classes in the researched area is necessary for high NDVI algorithms, it is crucial to remember. As illustrated in the land cover categories validated differences in the univariate statistical values of radiation heat flux parameters. As seen in Figure 4, the spatial parameters showed a progressive change in the values of each parameter.

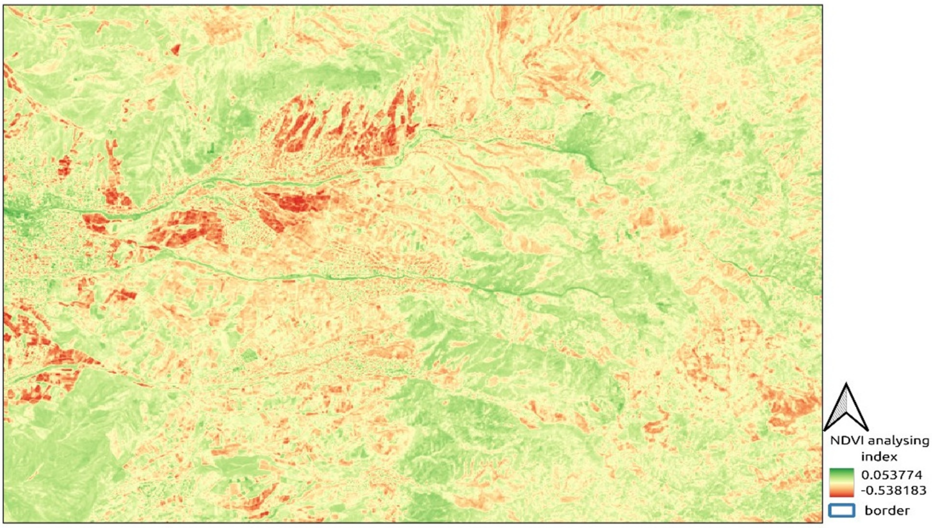

Fig. 4. The map of analysing biomass depletion.

A comparison of the classes and classification accuracy for each land cover class is shown in Figure 5. For all forest and bare land cover categories, which indicated a rise and drop in classification accuracy, respectively, the land cover categories showed a relative gain in accuracy.

The analysis of the biomass considered a seasonal period spanning from spring to October. About 61% of the entire research area was covered in grass in the spring, barren and open ground made up almost 28%, and agricultural land made up approximately 12%. Bare land and open ground increased significantly between spring and autumn, making up as much as 45 percent of the total area (Figure 5).

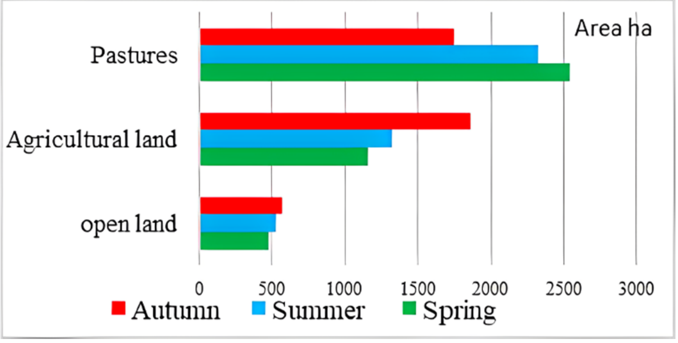

Fig. 5. The observed patterns of plant degradation and biomass depletion.

By comparison, there was a 19% fall in grass cover, which went from 61% in the spring to 42% in the autumn. The pattern changed the most in fallow land. It is noteworthy that in the early seasons, almost 32% of the total area was made up of open and barren ground; during the seasonal period, this percentage rose to about 7%. These significant shifts in the grass cover underscore the necessity of keeping an eye on and efficiently managing pasture use to preserve the ecological balance and preserve natural resources.

4 Conclusion

This study concludes that there are major benefits to using remote sensing data for grass cover changes. Accurate Landsat data and remote sensing methods are useful tools for tracking these changes and evaluating their effects. The findings make it clear that monitoring data and information from remote sensing can be used to assess how the grass cover is changing. There is a greater chance of deterioration in the Mountains and Highlands research area due to a significant decline in grazing and an increase in open land areas. This process is accelerated by the complicated topography seen in mountainous and sub-mountainous areas. When open spaces are used inefficiently, the soil's fertile layer may burn and the fields become degraded. This suggests that shifting ground could result in landslides, flooding, and soil erosion in the future, which could turn into a persistently occurring threat.

As a result, this area's landslide susceptibility mapping in the future can make use of the grass land cover change maps that this study produced. The impact of dynamic anthropogenic causes on land cover change in the region is indicated by the pasture areas included in the grass land cover change map. These maps can help local government land use planning and natural hazard warning systems by providing relevant information to stakeholders. To reduce natural hazard losses, government agencies, stakeholders, and landslide susceptibility mappers can benefit from the maps. Overall, this study's findings highlight the need of precise Landsat data and remote sensing techniques for evaluating and tracking changes in land cover and their effects, particularly in hilly and sub-mountainous areas where these changes may pose serious risks.

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