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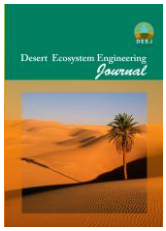

Assessing the Effect of Vegetation Condition on its Interaction with Soil Surface Moisture in a Semi-Arid Region

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Extended Abstract

Introduction: Vegetation cover and soil moisture are fundamental, interdependent components of terrestrial ecosystems, playing a crucial role in maintaining ecological balance. This relationship is particularly critical in arid and semi-arid regions, where soil moisture—primarily derived from precipitation—is a key limiting factor for plant growth and survival. Conversely, vegetation significantly influences the hydrological cycle; dense cover enhances water infiltration and soil water retention capacity, thereby creating a positive feedback loop. A reciprocal relationship between vegetation cover and surface soil moisture (0–10 cm) is therefore well-conceptualized. However, the precise nature and strength of this linkage, and how it is modulated by varying vegetation conditions, have not been directly and comprehensively examined at a regional scale. This study aims to address this gap by first quantifying the general relationship and then assessing how different vegetation conditions affect this critical interaction.

Materials and Methods: This study was conducted in the semi-arid regions of Ilam Province, Iran. Landsat 8 Operational Land Imager (OLI) satellite imagery was employed as the primary data source. Remote sensing technology was used to calculate two key indices: vegetation condition and soil surface moisture. The Normalized Difference Vegetation Index (NDVI) and the Modified Soil Adjusted Vegetation Index (MSAVI) were utilized to assess vegetation cover. For soil moisture, the Normalized Difference Water Index (NDWI) and the Land Surface Water Index (LSWI) were calculated. The derived NDVI and MSAVI maps were classified into distinct vegetation condition categories based on predefined value thresholds. The relationship between these vegetation indices (NDVI, MSAVI) and the soil moisture indices (NDWI, LSWI) was then analyzed using linear regression. All spatial and statistical analyses were performed using the TerrSet 2020 software system.

Results: The analysis revealed that the MSAVI index was more suitable for representing vegetation conditions in the semi-arid study area, as it demonstrated reduced sensitivity to soil background reflectance. Linear regression between the vegetation and soil moisture indices showed strong, positive relationships. The highest overall correlations were observed between NDVI and NDWI ($r = 0.75$) and MSAVI and NDWI ($r = 0.75$). A more detailed examination across different vegetation condition classes showed that the strength of this relationship was directly influenced by vegetation cover. Areas classified as having "excellent" vegetation cover exhibited the strongest correlation with soil moisture (maximum $r = 0.91$ between the NDVI class and moisture indices). In contrast, the "no cover" class showed the weakest relationship (minimum $r = 0.25$ between the MSAVI class and LSWI).

Discussion and Conclusion: This study successfully quantified the dynamic relationship between vegetation cover and surface soil moisture in a semi-arid region using remote sensing indices (NDVI, MSAVI, NDWI, LSWI) and linear regression analysis. The key finding was the superior performance of the MSAVI index in characterizing vegetation conditions, attributable to its algorithm's correction for soil background reflectance, a common source of noise in sparsely vegetated, semi-arid landscapes. The results confirm a strong, positive correlation between vegetation cover and soil moisture. Crucially, this relationship was found to be non-uniform; it intensified with increasing vegetation density. This finding

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empirically validates the established ecological principle that denser vegetation enhances water retention capacity, suggesting a positive feedback loop between plant growth and soil water availability. In conclusion, these findings underscore the critical role of vegetation management in the hydrological dynamics of semi-arid ecosystems. The methodologies applied demonstrate the utility of remote sensing as a powerful tool for monitoring these interactions. Therefore, we recommend the integration of such indices into sustainable land and water management strategies to guide restoration efforts and combat desertification effectively.

Keywords: Vegetation indices, MSAVI, NDVI, Soil surface moisture indices, LSWI, NDWI, Satellite images, Pearson correlation coefficient.