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Assessing Vegetation Quality for Soil Protection: A Case Study of the Oum Er-Rbia Watershed, Ouled Sidi Driss Upper

Souad Ourabit [1 *], Abderrahim Ettaqy [2], Mohamed El Ghachi [3]

[1,3] Department of Geography, Dynamics of Landscapes, Risks and Heritage Laboratory, Faculty of Letters and Human Sciences, Sultan Moulay Slimane University, Beni Mellal, Morocco

[2] Environmental, Ecological and Agro-industrial Engineering Laboratory, Faculty of Sciences and Technics, University of Sultan Moulay Slimane, Béni Mellal, Morocco

[*]Corresponding author: souadourabit1@gmal.com

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Abstract:

Mountainous areas are often colonized by vegetation, which plays a crucial role in protecting soils from degradation. However, this protection varies spatially from one area to another depending on the quality of the vegetation cover. The Oum Er-Rbia watershed (upstream of Ouled Sidi Driss) is a basin inhabited by a variety of vegetation, ranging from natural to artificial. Due to the effects of climate change and human activities, this area experiences soil degradation that varies in space depending on the type of vegetation present and its quality as a means of protection against degradation. In this context, our objective is to study the quality of vegetation as a means of soil protection. To do this, we calculated four sub-indices using a Geographic Information System (GIS): the fire risk index (FR), the drought resistance index (DR), the erosion protection index (EP), and the vegetation cover density index (VC). By overlaying these four sub-indices using the Map Algebra function, we obtained the vegetation quality index (VQI). Our results show that 81% of the watershed's total area is covered by very low-quality vegetation.

Keywords: Vegetation Quality, Soil Protection, Soil Degradation, Oum Er-Rbia Watershed.

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تقييم جودة الغطاء النباتي لحماية التربة: دراسة حالة حوض أم الربيع، عالية أولاد سيدي دريس

سعاد أوربيط [1*]، عبد الرحيم عبد الرحيم التقي[2]، محمد الغاشي [3]

[3،1] شعبة الجغرافيا، مختبر دينامية المشاهد، المخاطر والتراث، كلية الآداب والعلوم الإنسانية، جامعة السلطان مولاي سليمان، بني ملال، المغرب

[2] مختبر الهندسة البيئية والإيكولوجية والصناعية الزراعية، كلية العلوم والتقنيات، جامعة السلطان مولاي سليمان، بني ملال، المغرب

الملخص

تعتبر المناطق الجبلية من المناطق الأكثر استيطانا بالغطاء النباتي، والذي يلعب دورًا مهما في حماية التربة من التدهور. ومع ذلك، تختلف هذه الحماية مكانياً من منطقة إلى أخرى اعتماداً على جودة الغطاء النباتي. يعتبر حوض أم الربيع (عالية

أولاد سيدي دريس) حوضًا مأهولًا بأنواع متنوعة من النباتات، تتراوح بين النباتات الطبيعية والاصطناعية. نظرًا لتأثيرات تغير المناخ وأنشطة الإنسان، تشهد هذه المنطقة تدهورًا في التربة يتباين مكانيًا اعتمادًا على نوع النباتات الموجودة وجودتها كوسيلة للحماية ضد التدهور. في هذا السياق، هدفنا هو دراسة جودة النباتات كوسيلة لحماية التربة من التدهور. للقيام بذلك، قمنا بحساب أربعة مؤشرات فرعية باستخدام نظام المعلومات الجغرافية :(GIS) مؤشر مخاطر الحرائق(FR) ، ومؤشر مقاومة الجفاف(DR) ، ومؤشر حماية التآكل(EP) ، ومؤشر كثافة غطاء النباتات .(VC) من خلال تراكب هذه المؤشرات الفرعية الأربعة باستخدام وظيفة Map Algebra، حصلنا على مؤشر جودة النباتات .(VQI) تظهر نتائجنا أن 81٪ من المساحة الإجمالية لحوض الأم الربيع مغطاة بنباتات ذات جودة منخفضة جدًا.

الكلمات المفتاحية: جودة الغطاء النباتي، تدهور التربة، حماية التربة، حوض أم الربيع.

Introduction

Vegetation cover plays an essential role in protecting against land degradation, making it more resilient to degradation factors such as erosion, drought, and anthropogenic activities. Additionally, it reduces evaporation by providing shade, allowing the soil to maintain its moisture content.

On the contrary, this vegetation constitutes the major natural source of soil water extraction. It contributes to the onset and spread of deep-seated drought within soils. Its water-extraction capabilities are linked to its root system (T. TESSIER et al., 2008).

Therefore, the effect of vegetation on soil protection can vary depending on the vegetation formations; it may depend on the type of vegetation or land use (F. Rey et al., 2004). In other words, the role of this vegetation in soil protection will differ based on the type of vegetation cover and its quality in relation to the risk of fire, drought resistance, erosion control, and density within a given territory.

The Oum Er-Rbia watershed (Ouled Sidi Driss upper) serves as the study area for this research. It covers various topographical entities, making it inhabited by vegetation formations that vary from one entity to another.

In this study, we aim to demonstrate the quality of vegetation in protecting the soil against degradation, with a primary focus on land use in the study area. Subsequently, the results obtained in this research are presented.

1. Presentation of the study area

The Oum Er-Rbia watershed (Ouled Sidi Driss upper) covers an area of 11,152 square kilometers with a perimeter of 628 kilometers. Its main river flows generally from northeast to southwest. It is bounded to the north by the Ain Louh plateau, to the south by the Atlas Mountains of Béni Mellal, to the west by the central plateau, and to the east by the Moulouya watershed.

Furthermore, this watershed encompasses three main geographical entities: the Middle Atlas Mountains, the Phosphate Plateau, and the Tadla Plain, which results in varied vegetation cover and land use across these entities.

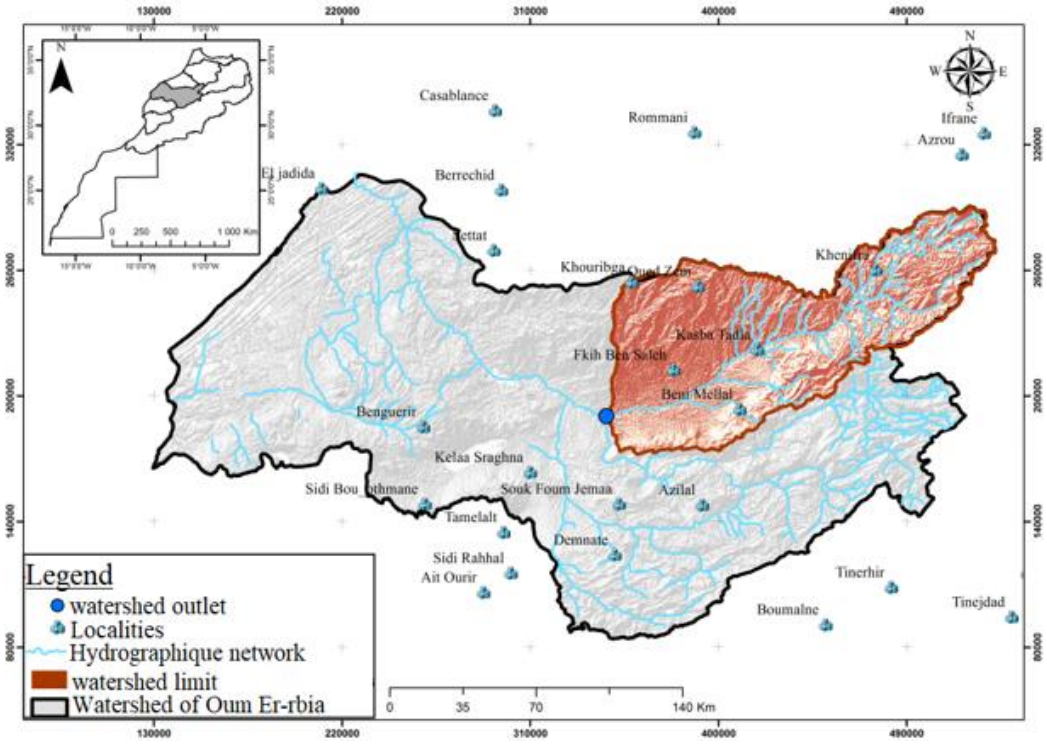

Figure 1: Geographic location of the watershed.

2. Material and methods

The Vegetation Quality Index (VQI) is an index that is part of the MEDALUS approach (Mediterranean Desertification and Land Use). It is one of the necessary indices for assessing desertification sensitivity. The development of the VQI is based on the determination of four sub-indices, namely: The Vegetation Fire Risk Index (RI), the Vegetation Drought Resistance Index (DR), the Vegetation Erosion Protection Index (ER), and the Vegetation Cover Index (VC).

The determination of these four sub-indices relies on the use of two LANDSAT 8 satellite images with a spatial resolution of 30 meters, as well as a map of vegetation cover types. Once each index is obtained, it is classified according to the established standards in the method.

2.1 Elaboration of the Fire Risk Map (FR)

Table 1: Vegetation Fire Risk Standards

Classes	Description	Values
Low	Bare soil (including roads, uncultivated land)	1
Moderate	Agriculture, Resinous Reforestation, Deciduous Reforestation, Mixed Other Deciduous, Other Deciduous	1,33
High	Holm Oak, Mixed Holm Oak, Mixed Junipers, Heathland, Arborvitae, Mixed Arborvitae	1,66
Very high	Cedar, Mixed Cedar	2

2.2 Elaboration of the Drought Resistance Map (DR)

Table 2: Vegetation Drought Resistance Standards

Classes	Description	Values
Very high	Cedar, Mixed Cedar	1
High	Holm Oak, Mixed Holm Oak, Mixed Junipers, Heathland, Arborvitae, Mixed Arborvitae	1,33
Moderate	Agriculture, Resinous Reforestation, Deciduous Reforestation, Mixed Other Deciduous, Other Deciduous	1,66
Low	Bare soil (including roads, uncultivated land)	2

2.3 Elaboration of the Vegetation-Based Erosion Protection Map (EP)

Table 3: Vegetation Erosion Protection Standards

Classes	Description	Values
Very high	Cedar, Mixed Cedar, Arborvitae, Mixed Arborvitae	1
High	Cedar, Mixed Cedar, Heathland	1,33
Moderate	Deciduous Reforestation, Mixed Other Deciduous, Other Deciduous, Mixed Junipers	1,66
Low	Bare soil (including roads, uncultivated land), Agriculture	2

2.4 Elaboration of the Vegetation Cover Density Map (VC)

Regarding this index, and since our basin does not have a very high density, we did not mention the 'very high' class which has a value of 1.

Table 4: Vegetation Cover Standards

Classes	Description	values
High	Cedar, Mixed Cedar, Agriculture	1,33
Moderate	Arborvitae, Mixed Arborvitae, Mixed Other Deciduous, Other Deciduous, Mixed Junipers	1,66
Low	Bare soil (including roads, uncultivated land)	2

The VQI (Vegetation Quality Index) is obtained by combining the four indices: FR (Fire Risk), DR (Drought Resistance), ER (Erosion Protection), and VC (Vegetation Cover), according to the following equation:

$$VQI = (FR \times DR \times ER \times VC)^{1/4}$$

Table 5: Vegetation Quality Index Standards (VQI)

Classes	Description	Values
1	Moderate quality	<1,13
2	Low quality	1,13 – 1,38
3	Very low quality	>1,38

3. Results and discussion

3.1 Land use of the Oum Er-Rbia watershed

Based on the analysis of the land use map, we can divide our watershed into three types of land use located within the three topographic units as follows:

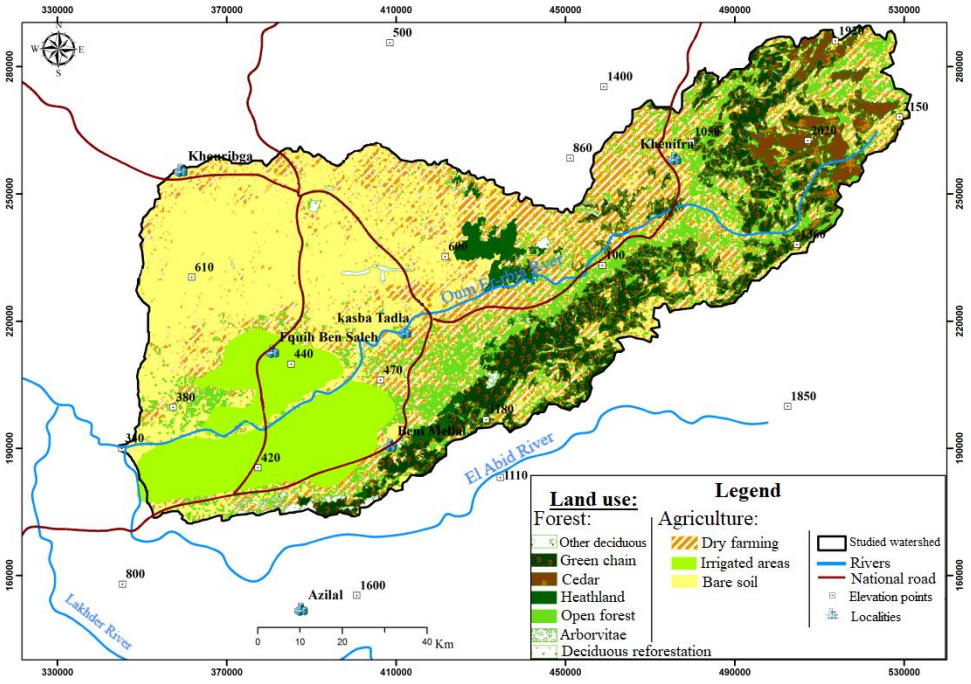

Figure 2: Land use in the watershed of the Oum Er-rbia (Ouled Sidi Driss upper)

Forests are located in the Middle Atlas Mountains, with the main tree species being holm oak, covering an area representing 11.81% of the total basin area, and cedar, covering an area of 3.25% of the total basin area, located at higher altitudes. As altitudes decrease, overgrazing becomes evident in the semi-arid zone covering all the foothills of the Middle Atlas, resulting in the spread of a relatively sparse forest covering an area of 12.32%. Moving towards the Tadla Plain, it is heavily dominated by agriculture, primarily irrigated agriculture (such as the irrigated areas of Beni Moussa and Beni Amir), with the presence of various types of crops, especially cereals.

Around the phosphate plateau, the dominance of bare soil is more noticeable and covers the largest percentage in the watershed, accounting for 35.16% of the area.

3.2 Elaboration of the Vegetation Quality Index

The superposition of the four maps, namely the fire risk map, the drought resistance map, the erosion protection map, and finally the vegetation cover density map, allowed for the development of the vegetation quality status map in the basin.

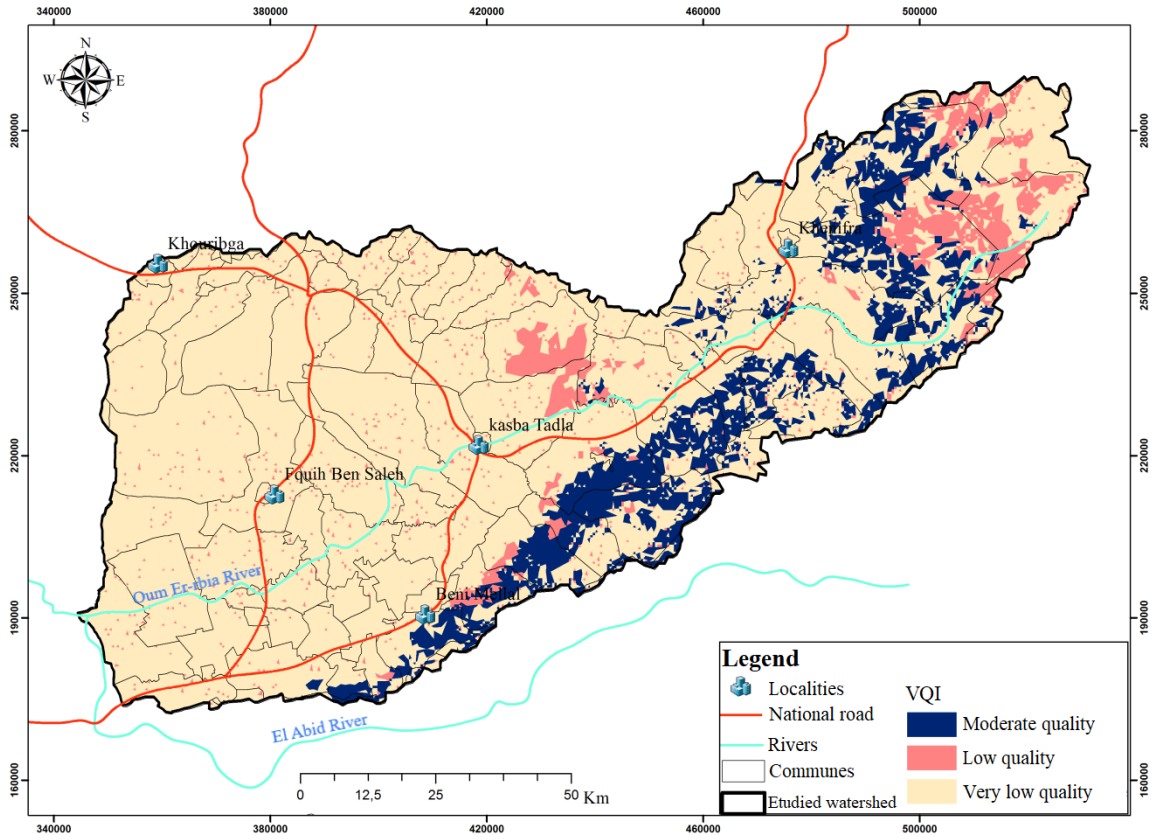

Figure 3 Spatial Distribution of Vegetation Quality in the Oum Er-Rbia Watershed (Ouled Sidi Driss Upper)

The analysis of Figure N°. (3) reveals that the majority of the watershed, 81% or 9072 km², corresponds to very low quality due to the prevalence of bare soil and extensive agricultural land.

However, we observe that the high altitudes of the Middle Atlas are covered by vegetation of moderate quality, accounting for approximately 12% of the total watershed area. This proportion corresponds to "holm oak" vegetation, characterized by high drought resistance and strong erosion protection. On the other hand, areas characterized by low quality cover 7% and correspond to "heathland and cedar" vegetation, possessing high drought resistance and strong erosion protection. Unfortunately, these types of vegetation only occupy 3.6% of the total watershed area.

Conclusion

This study highlights the importance of geographic information systems in geographical research as decision-support tools. The use of ArcMap software in this work enabled us to analyze our subject and assess the quality of vegetation in the studied watershed by determining the necessary indices and classifying them according to their standards, then calculating the final index using the MapAlgebra function.

The results reveal that 12% of the area corresponds to high-altitude zones, which are protected from degradation as they are colonized by holm oak, which obtains high to very high values in each of the four indices. In contrast, the majority of the watershed is highly threatened, especially in the northeastern and central parts of the basin, where vegetation types such as heathland and thuja are found. These two types are characterized by a high fire risk index, high drought resistance, and high erosion protection, but they exhibit moderate density on the ground.

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