

Application of Spatial Information Observations to the Assessment of Irrigable Land Potential in the N'djili River Watershed

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Abstract

The Democratic Republic of Congo has land and water resources that could ensure food security for its population. However, the country continues to import most of its food. The N'djili River basin has significant potential in terms of water resources, covering an area of over 2000 km². Unfortunately, this watershed, like the Kinshasa region, is facing rapid population growth and accelerated urbanization, putting significant pressure on available water resources. Additionally, climate change significantly impacts water availability in the region, as agriculture relies on precipitation. Irrigation can be an effective solution to ensure sufficient and stable food production while preserving the water resources of the N'djili River basin. It is therefore important to assess the potential for irrigable land in this region to identify the most suitable areas for implementing efficient and sustainable irrigation systems. The use of remote sensing and geographic information systems is essential. These approaches allow the use of satellite images as well as spatial data on soil and topography to assess the irrigation potential of a given area. The results of this study include land suitability maps for irrigation, considering various factors such as land use, slope, river proximity, soil texture, soil depth, soil type, and drainage. A comprehensive irrigation suitability map, combining all these factors, was also produced. This investigation provides insights into the potential for irrigable land in the N'djili River basin of the Democratic Republic of Congo.

Keywords: Geographical Information System, Irrigable Land, Irrigation, Watershed, Remote Sensing

1. Introduction

The Democratic Republic of Congo (DRC) is rich in land and water resources that can ensure food security for its population. The country has a potential of 80 million hectares of arable land, 4 million hectares of irrigable land, a diverse climate, and a very dense hydrographic network. However, the country continues to import most of its food from outside [1]. In the face of this, the Congolese government can solve this paradox through the development of an agricultural revitalization program that includes irrigation programming as one of the strategies to optimize the use of water and energy resources and hence reduce dependence on predominantly rain-fed agriculture that is vulnerable to climate change. The watershed of the N'djili River has a significant potential for supplying water for various uses; it covers an area of over 2000 km²; a length of 30 km; a maximum flow rate of 107 m³/s and a minimum observed flow rate of 22.3 m³/s; Real Evapotranspiration (ETR): 700 mm/year; average flow: 47% [2,3]. However, this watershed, like the entire Kinshasa region, is experiencing rapid

population growth and accelerated urbanization, which has put strong pressure on the water resources.

This rapid growth requires land expansion for agricultural production and traditional water use practices do not contribute to food security and promote water waste and soil degradation, thus leading to a decline in agricultural productivity [4]. Furthermore, the practiced agriculture being rain-fed, climate change significantly impacts water availability in the region. Climate change leads to modifications in the rainfall pattern (water cycle) and the intensification of evapotranspiration rates (ET) [1,5-7]. Droughts and consecutive floods are becoming more and more frequent, making water management for agriculture more complex. However, due to the decrease in productivity in rainfed agriculture and the need to double food production in the coming decades, it has been recognized that water is the most important factor for transforming unproductive rainfed agriculture into more efficient and effective irrigated agriculture [8]. In addition, water

is an essential element contributing to the generation of income and the economic growth of society [9].

Improving water management in the agricultural sector offers numerous potential benefits to reduce vulnerability and increase productivity. In the DRC's agricultural development strategy, it has been highlighted that it is essential to develop irrigation to improve the living conditions of smallholder farmers by increasing their agricultural productivity, diversifying their crops, and extending the agricultural seasons [10]. Irrigation can be an effective means of ensuring sufficient and stable food production while preserving water resources in the N'djili River basin. Expansion of irrigation is widely recognized as an essential means to stimulating economic growth and rural development; it is considered the foundation of food security and poverty alleviation in developing countries [11].

To assess whether the land is suitable for irrigation, it is essential to conduct a thorough evaluation of soil characteristics, land use and land cover (LULC), and topography (slope) of the watershed [12]. Our study focused on assessing the potential for irrigable land in the N'djili River watershed using spatial observation information with the help of ArcGIS software to provide answers regarding the potential resources of irrigable land in the watershed. The watershed of the N'djili River was chosen as the study area due to its high potential for water resources, but it suffers from limited irrigation. However, no prior assessment of land resources has been conducted to determine the potential of these irrigable land resources.

To address this gap, we used the ArcGIS software in its environment using the Weight Overlay tool which is widely used in assessment processes of irrigable land potential of watersheds. The main objective of this study was to evaluate the potential and suitability of irrigable lands to design a resilient irrigation system and ensure food security in the N'djili River basin. More specifically, our study sought to identify and assess lands suitable for irrigation; produce an irrigation potential map that will be used for planning and developing future irrigation projects; and finally, propose appropriate irrigation systems in the N'djili River watershed.

2. Materials and Methods

2.1 Description of the Study Area

The Congo River basin, which is the second largest basin in the world after the Amazon, with an area of 3.7 million km², is located in the watershed of the N'djili River where this study was conducted. The Congo basin is also distinguished by its average flow, which reaches 41,000 m³/s, the highest of all hydrographic basins after the Amazon [13]. The N'djili River watershed is bordered to the west by the Congo River basin, to the south and southwest by the Inkisi River watershed, and to the east by the N'sele River watershed (Figure 1). It is composed of several tributaries such as Lukaya, Luzumu, Didingi, Nshimi, Funda, Lususa, Wau, Mangoe, Musinga, Matete, Munfie, and Ludisa. These watercourses have varying importance and are fed by small indigenous streams, which can be permanent or seasonal. Their flow varies depending on the seasons, being higher during the rainy season [3].

The watershed of the N'djili River is located in the western region of the Democratic Republic of Congo between latitudes - 4° 21' to - 4° 55' and longitudes 15° 07' to 15° 36'. It covers an area of approximately 2097 km² and is situated between two districts of the city of Kinshasa, the Tshangu district to the east and the Mont Amba district to the southwest [14]. The N'djili River is the main tributary of the Congo River, stretching over approximately 30 km. It flows through the eastern part of the Kinshasa plain and originates from the hills of the Bas-Congo province. It flows towards the city of Kinshasa, crossing the region from south to north with an average flow rate of 22 m³/s [14,15].

The watershed of the N'djili River has altitudes ranging from 269 to 728 m with an average of 420 m. While the slopes of the N'djili River basin have been determined, they range from 0 to 100%, with an average of 10.5%. According to Goy, the precipitation rate in the N'djili basin is evenly distributed throughout the basin [14]. The average annual precipitation is approximately 1470 mm. A tropical climate is characteristic of the basin, with 8 months of rainy season and 4 months of dry season. The minimum and maximum temperatures observed in the N'djili River basin are, respectively, 16 - 21°C and 28 - 38°C.

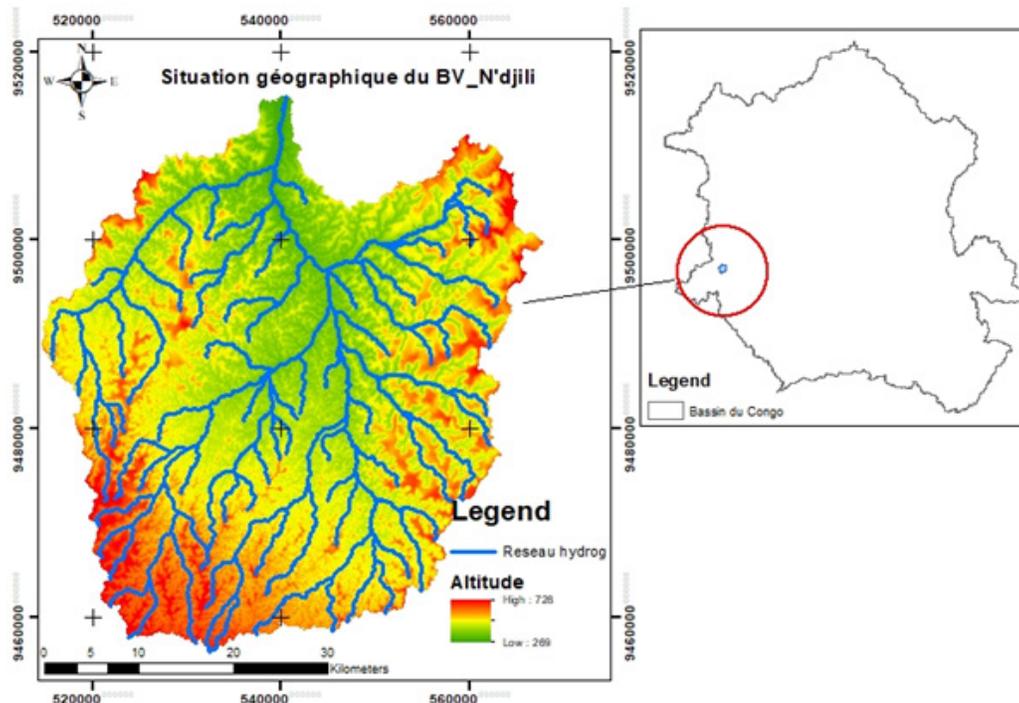


Figure 1: Map of the Hydrographic Network of the N'djili River Watershed

2.2 Data Collection

2.2.1 Soil

Soil data of the N'djili River watershed was obtained based on the soil parameter estimation map by Soil and Terrain for World Information Soil for Central Africa (SOTWIS-caf, version 1.0) on <http://www.isric.org>. This database provides estimates of soil parameters for the central region of Africa, including the DRC, on a scale of 1:2,000,000. The collected field data includes soil type layers, soil drainage, depth, and texture of the N'djili River watershed.

2.2.2 Satellite Imagery for Land Use and Land Cover (LULC)

The Landsat 8 satellite images for the year 2019/2020 with a resolution of 30 m x 30 m were obtained from the USGS website of NASA (<http://earthexplorer.usgs.gov/>). These images have been selected considering their adequate spatial resolution and low cloud cover.

2.2.3 The Data of the Topography and Proximity of the Rivers: Digital Elevation Model (DEM)

As part of this study, we used the Digital Elevation Model (DEM) with a resolution of 30 m x 30 m available on the USGS website of NASA (<http://earthexplorer.usgs.gov/>) to delimit the watershed, determine the slope, and map the distances to the rivers in the catchment area of the N'djili River.

2.3 Methods

Two main steps were followed to assess the potential suitability of land for irrigation in the N'djili River watershed, namely:

- (i) Delimitation of the N'djili River watershed using ILWIS 3.3 academic software
- (ii) Analysis and evaluation of irrigable land suitability were carried out using ArcGIS 10.5 tools based on Multi-Criteria Evaluation (MCE) decision-making techniques and considering soil factors such as drainage, type, depth, and texture; topography; proximity to rivers; and land use. The FAO framework for land suitability classification was adapted to conduct this analysis FAO's [16].

2.3.1 Soil Suitability Assessment

The fundamental physical properties of the soil in the N'djili River watershed, such as soil drainage, texture, type, and depth, were used to assess their relevance to irrigation. Soil parameter layers downloaded were imported into ArcGIS and specifically, the N'djili River watershed area was extracted for each considered parameter. The parameter layers were rasterized using the Conversion Tools tool in ArcToolbox and resampled using the Resampling tool in ArcToolbox to achieve a spatial resolution of 30m x 30m. Finally, suitability maps for irrigation for each parameter were produced based on FAO's (1999) classification system for irrigable land suitability [8].

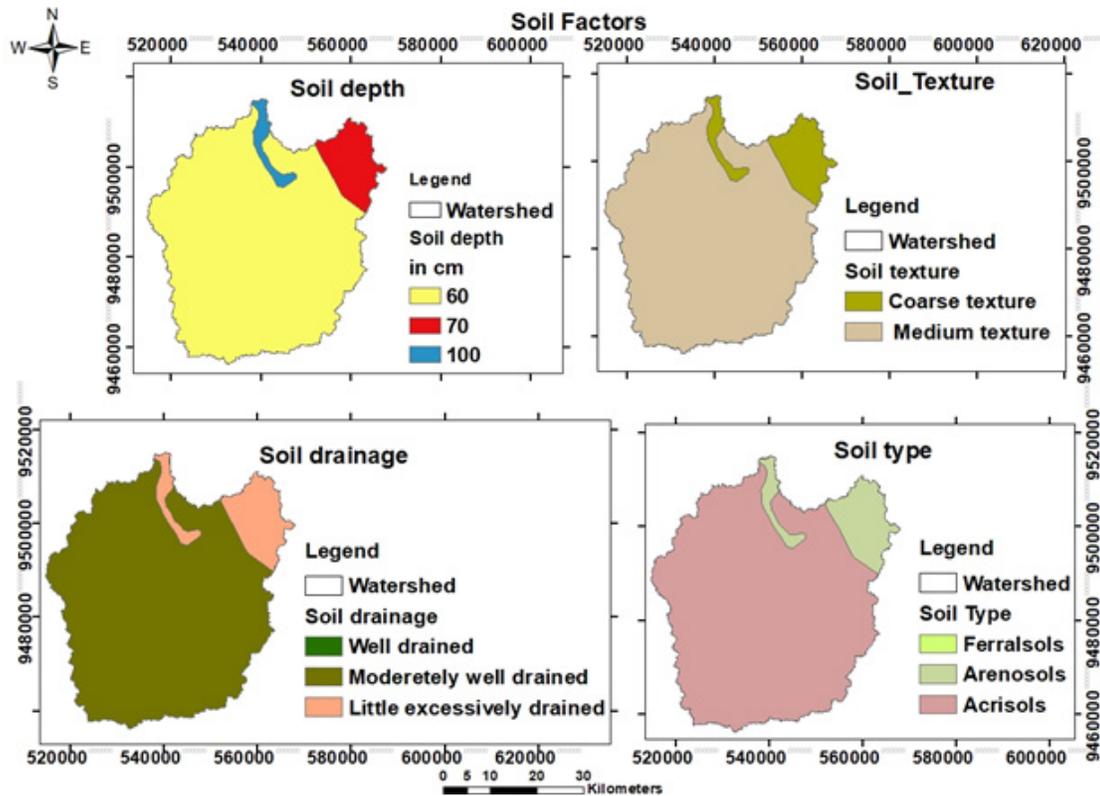


Figure 2: Soil Factors

2.3.2 Slope Suitability Analysis

To create the slope map of the N'djili River watershed, the Digital Elevation Model (DEM) was downloaded from the USGS NASA website with a resolution of 30 m x 30 m. Using the "Slope" tool in Arc ToolsBox, the slope for each cell of the DEM was calculated. Finally, an adequacy slope map of the N'djili River watershed was developed using the "Reclassify" tool in ArcGIS

2.3.3 Rivers Proximity Suitability Analysis

Using the "Distance" tool from the Arc ToolsBox, the distances between each cell of the DEM and the nearest river were calculated and the distances were measured in meters. Once the calculated and classified river distances were obtained, a thematic map to visualize the suitability of the distances to the rivers for irrigation in the N'djili River watershed was generated.

2.3.4 Analysis of Land Use

Using Landsat 8 satellite images for the year 2020 with a resolution of 30m x 30m and a cloud cover of 10%, the ArcGIS tool was used to carry out Land Use analysis. The satellite images were pre-processed to correct any radiometric and geometric distortions. Atmospheric corrections were also performed to reduce the effects of atmospheric variations on the data. The supervised classification method was chosen and used to assign a land cover class to each pixel of the image and the land cover classification map of the N'djili River watershed for the year 2020 was obtained. The identified land cover classes included six (6) classes: urban areas, forest formations, agricultural lands, rivers and water bodies, grass formations, and savannah.

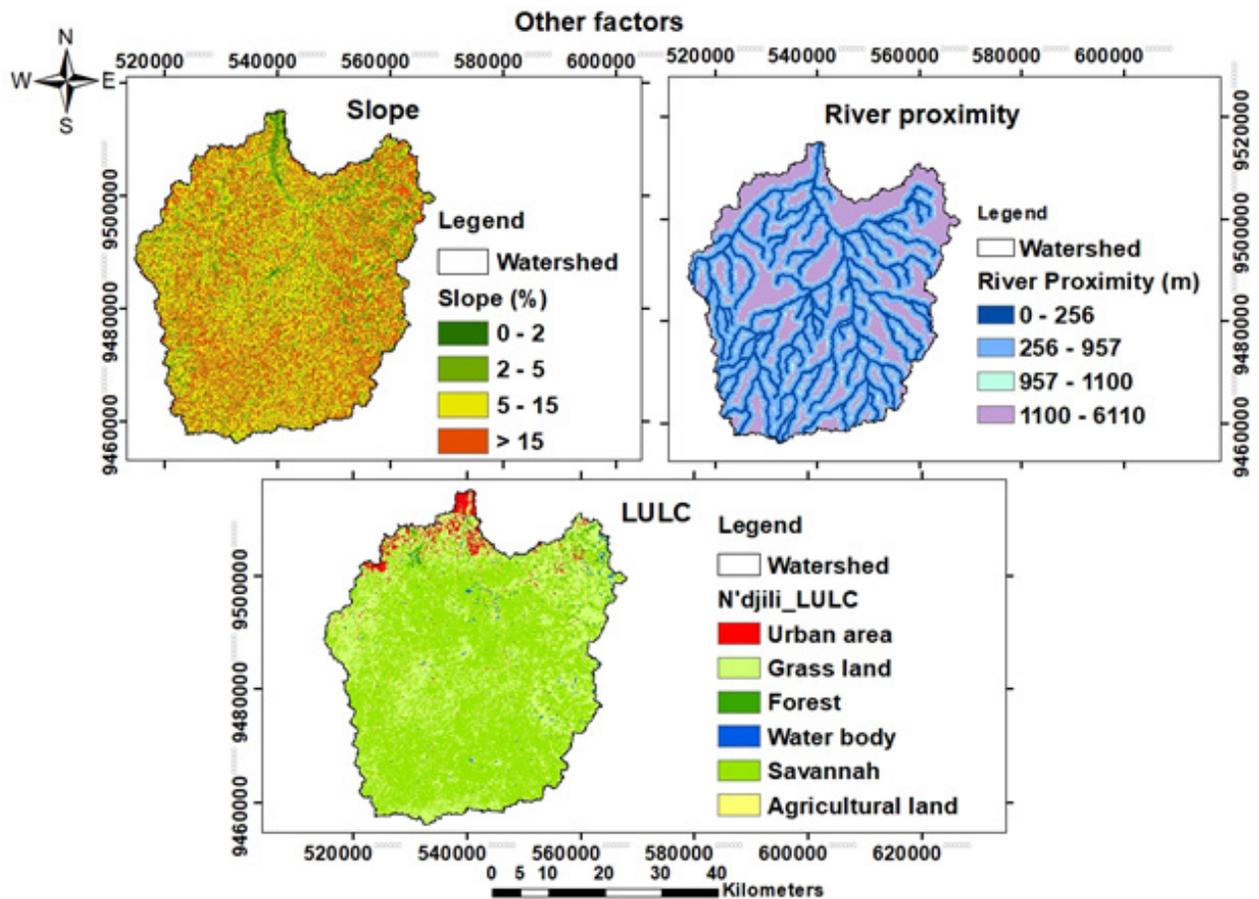


Figure 3: Other Factors

2.3.5 Weighting Factors to Assess Potentially Irrigable Areas

Each parameter was assigned a suitability level based on the FAO land suitability classification system, the suitability levels used included highly suitable (S1), moderately suitable (S2), marginally suitable (S3), and not suitable (N) [17]. After evaluating the relevance of irrigation for each parameter and creating an irrigation suitability map layer for each criterion individually, an overlay

analysis to generate a single suitability map for irrigable lands in the N'djili River watershed was conducted. This was done using the "Weighted overlay" tool in the Arc ToolBox in ArcGIS.

The steps followed in the framework of this study are summarized in Figure. 4.

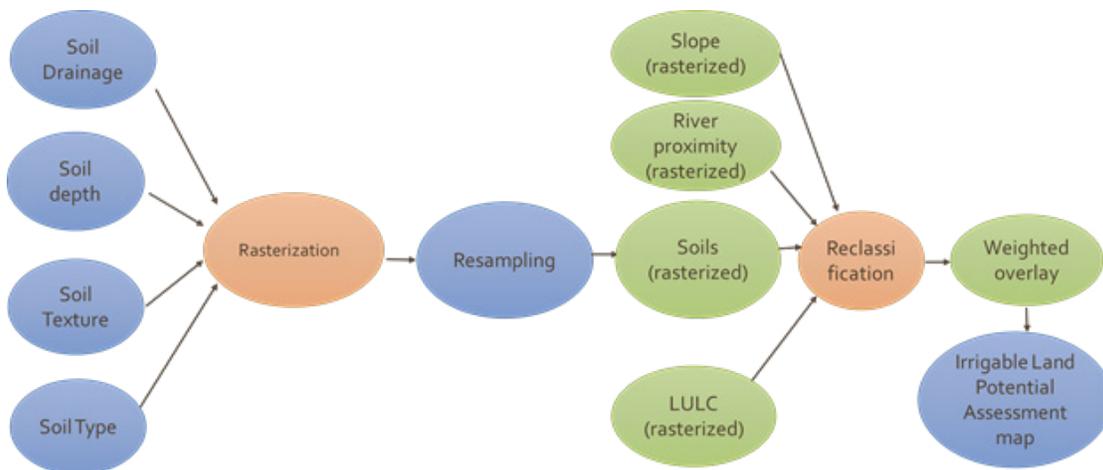


Figure 4: Conceptual Framework

3 Results and Discussion

3.1 Slope Suitability of the N'djili River Watershed

Among the factors that influence the suitability of land for irrigation, the slope is a key one. After conducting slope analyses of the N'djili River watershed, different classes of land suitability for irrigation were obtained. The first class, which corresponded to slopes from 0 to 2% was classified as very suitable and covered approximately 3% of the total area, which is about 68.04 km². The second class, which corresponds to slopes from 2 to 5%, was considered moderately suitable for irrigation and covers approximately 19.28%, which is about 399 km² of the watershed. The third class, which corresponds to slopes from 5 to 15%, is marginally suitable and covers approximately 46% of the total watershed, which is about 963 km². Finally, the fourth class, which is considered unsuitable and corresponds to slopes greater than 15%, covers only 30% of the total watershed area, which is about 637 km² (Figure 3).

The suitability of land for irrigation is influenced by slope, as it affects the ability of the land to retain water. Land with slopes between 0 to 2 % (very suitable) may have better water retention capacity than land with higher slopes. The slope plays also a crucial role in soil erosion, as steeper slopes tend to have higher erosion rates [18]. The moderately suitable class (slopes from 2 to 5%) may face challenges related to erosion control, and this discussion could focus on the potential erosion risks in this class and ways to mitigate them. It could also explore erosion prevention strategies, such as terracing or contour plowing, to maintain soil fertility and prevent sedimentation in irrigation systems.

3.2 Suitability of River Proximity

Optimal plant in irrigation agriculture is achieved by relying on a sufficient water supply [19]. Analysis of distance from rivers in the N'djili River watershed has allowed for the identification of different land suitability classes for irrigation (Figure 4). The results show that a class of 0-256m is considered highly suitable, covering approximately 20% of the total area, which is around 429 km². This finding aligns with the general understanding that proximity to water sources is beneficial for irrigation as it allows for easier access to water for crop cultivation. A class of 250-957m is classified as moderately suitable for irrigation, representing approximately 45% of the watershed area, which is around 935 km².

Another class of 957-1100m is considered marginally suitable, covering approximately 6% of the watershed, which is around 136

km². Lastly, a class of 1100-6110m is classified as not suitable, covering only 27% of the watershed area, which is around 566 km². These classes are based on the proximity of land to rivers and can provide valuable insights for irrigation planning and management in the region. This raises questions about the factors contributing to the unsuitability of these areas.

Overall, the analysis of river proximity and land suitability for irrigation in the N'djili River watershed provides a foundation for scientific discussions on the relationship between water availability, proximity to river, and agricultural practices. These discussions can contribute to the development of sustainable irrigation strategies in the region, taking into account the different land suitability classes identified.

3.3 Land Use Land Cover (LULC) Suitability Assessment

The analysis of Land Use Land Cover (LULC) in the N'djili River basin enabled identification of the different land suitability classes for irrigation (Figure). The first class, considered highly suitable, consists solely of agricultural areas and covers an area of approximately 1% of the watershed or about 21 km². While this class presents excellent potential for irrigation, further investigation is necessary to identify specific crops or farming practices that can be optimized in these areas. Additionally, potential challenges such as soil quality, water availability, and infrastructure development need to be considered to ensure efficient and sustainable irrigation in this class. The second class, classified as moderately suitable, is mainly composed of grassy areas. It represents approximately 33% of the total area of the watershed or about 690 km². This class exhibits potential for irrigation, but additional measures may be required to maximize its use. Conducting soil and water quality assessments, considering suitable irrigation techniques (e.g., sprinkler or drip irrigation) and implementing water conservation practices can enhance the irrigation suitability in these areas.

Collaboration with local communities and farmers to implement best practices and improve water management can also contribute to optimizing irrigation in this class. Although this class presents an interesting irrigation potential, additional measures may be necessary to optimize its use. The third class, considered marginally suitable, is composed of savannahs and covers approximately 61% of the watershed or about 1275 km². While the suitability for irrigation in this class may be limited, it is essential to explore potential strategies for sustainable agriculture practices. This could involve the introduction of drought-tolerant crops, soil conservation techniques, or rainwater harvesting systems.

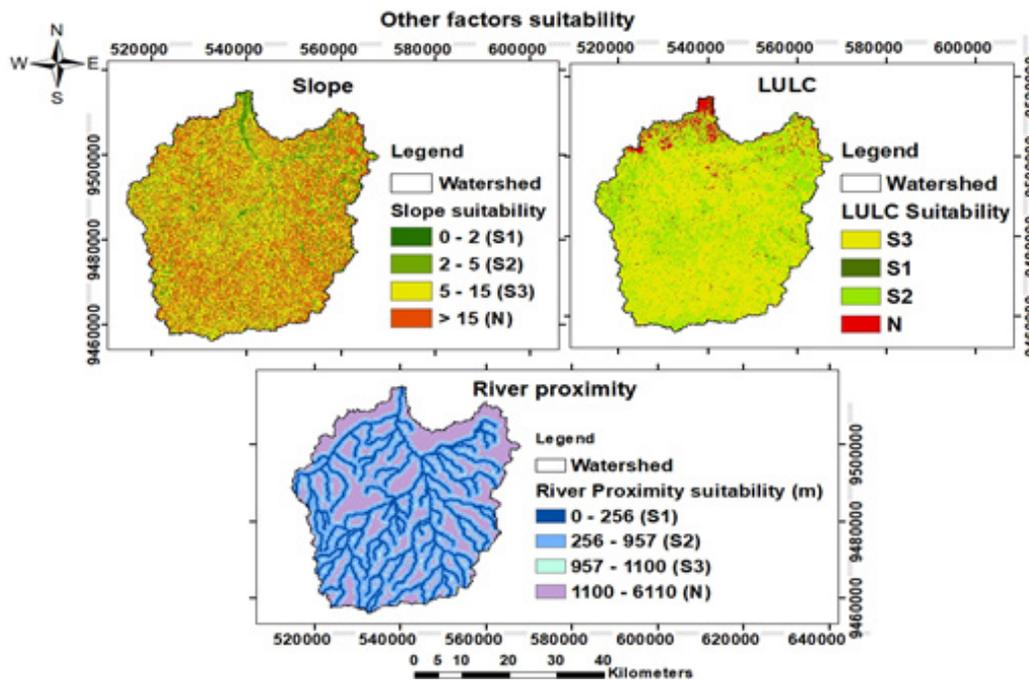


Figure 5: Evaluation of Another Factors Suitability

3.4 Soil Depth Suitability

The analysis of soil depth suitability in the N'djili River watershed has provided valuable insights into the potential for irrigation in the region. The presence of two distinct classes of land suitability based on soil depth, namely moderately suitable and marginally suitable, highlights the variability in soil conditions across the study area.

The first class, classified as moderately suitable for irrigation with a soil depth of 100 cm, covers a relatively small proportion (2%) of the total study area, approximately 49 km². This suggests that only a limited portion of the watershed may be favorable for intensive irrigation practices. However, these areas could still serve as important locations for targeted irrigation interventions, as they offer relatively deeper soils that can support more extensive root systems and potentially higher crop yields [20].

On the other hand, the second class, classified as marginally suitable for irrigation with a soil depth ranging from 60-70 cm, covers a significant majority (97%) of the total area of the watershed, approximately 2018 km². This indicates that most of the N'djili River watershed has relatively shallower soils, which may pose challenges for sustained and efficient irrigation practices. The limited soil depth in these areas may restrict root development and water holding capacity, potentially impacting crop productivity and water management strategies.

3.5 Soil Drainage Suitability

Analysis of soil drainage in the N'djili River watershed led to the classification of lands into three suitability classes for irrigation (Figure 7). A well-drained soil class was identified as highly

suitable, representing 0.003% of the total area of the watershed or approximately 0.60 km². A moderately well-drained soil class was classified as moderately suitable, covering approximately 89% of the total area of the study zone, or approximately 1848 km². Finally, a class of excessively poorly drained soil was classified as marginally suitable for irrigation, covering over 10% of the total area of the watershed or approximately 219 km².

For successful irrigation, well-drained soils allow for efficient water infiltration and root development, ensuring proper moisture levels for crop growth. Moderately well-drained soils may have some limitations but can still support irrigation to a certain extent. Excessively poorly drained soils, on the other hand, can pose challenges such as waterlogging, reduced oxygen availability, and nutrient leaching.

3.6 Soil Type Suitability

Analysis of soil type in the N'djili River watershed enabled classification of lands into three categories of suitability for irrigation (Figure). The Ferralsol class, which is considered highly suitable, covers only a small portion of the total area of the watershed, accounting for only 0.01% or 0.35 km². This highlights the scarcity of high-quality land for irrigation in the region. This finding raises concerns about the availability of suitable land for expanding agricultural activities and potential limitations in achieving sustainable irrigation practices. On the other hand, the Acrisol class, classified as moderately suitable, represents approximately 88% of the total area, which is about 1824 km². This suggests that there is significant potential for irrigation in this soil class. This soil class provides a substantial opportunity for agricultural development. However, further investigation and

analysis are necessary to understand the specific characteristics and limitations of Acrisols in the N'djili River watershed. The Arenosol soil class, classified as marginally suitable for irrigation, covers more than 11% of the total watershed area, approximately 243 km². This indicates that this land may require improvements and appropriate management practices to be effectively used for irrigation. Although classified as marginally suitable, this soil type still holds potential for irrigation if proper measures are taken to enhance its suitability. Strategies such as soil amendments, erosion control, and water management techniques may be necessary to mitigate the limitations of Arenosols and maximize their productivity for irrigation purposes.

3.7 Soil Texture Suitability

The soil texture suitability analysis conducted in this study provides valuable insights into the suitability of the land for irrigation purposes. Two distinct classes of land suitability were identified based on soil texture characteristics. The first class, which represented approximately 89% of the total area of the

watershed, was characterized by a medium texture and is classified as moderately suitable; it covers an area of approximately 1848 km². This means that the soils in this class have properties that make them reasonably suitable for irrigation. Medium textured soils typically have a balanced composition of sand, silt, and clay particles, allowing for good water retention and drainage. The fact that this class covers a large area of approximately 1848 km² indicates the potential for extensive irrigation development in this region. The second class, which represented more than 10% of the total area, was characterized by a coarse texture and classified as marginally suitable; it covers an area of approximately 219 km². Coarse textured soils are composed primarily of sand particles and have relatively low water holding capacity. They tend to drain quickly, which can result in water and nutrient leaching. Due to these characteristics, irrigation on such soils may be challenging as they may require more frequent and careful water management. The fact that this class covers an area of approximately 219 km² indicates that while irrigation is possible, it may be less efficient or require additional measures to optimize water use.

Principaux critères	Sub-critères	Poids	Influences (%)	Adéquation	Superficie (ha)	Superficie (%)
Pente (%)	0 – 2	0.30	35	S1	6804.40	3.28
	2– 5			S2	39898.06	19.28
	5– 15			S3	96357.89	46.58
	> 15			N	63777.64	30.83
LULC	Z. urbaines	0.3	30	N	5506.66	2.66
	Z. agricoles			S1	2179.62	1.05
	Forets			N	1052.22	0.50
	Rivières/Plans d'eau			N	1522.31	0.73
	Savanes			S3	127565.89	61.67
Z. Herbeuses	S2	69024.76	33.36			
Proximité aux rivières (m)	0 – 256	0.25	20	S1	42916.11	20.74
	256 - 957			S2	93579.95	45.23
	957 - 1 100			S3	13668.69	6.60
	1 100 - 6 110			N	56694.07	27.40
Types de sol	Ferra sol	0.075	7.5	S1	35.32	0.01
	Acrisol			S2	182457.55	88.70
	Arenosol			S3	24342.06	11.27
Texture du sol	Texture moyenne	0.025	2.5	S2	184882.99	89.37
	Texture grossière			S3	21975.91	10.62
Drainage du sol	Bien drainé	0.025	2.5	S1	6.64	0.003
	Modérément bien drainé			S2	184882.99	89.37
	Peu excessivement drainé			S3	21967.90	10.61
Profondeur du sol (cm)	100	0.025	2.5	S2	4920.24	2.37
	70			S3	17065.38	8.24
	60			S3	184882.91	89.37

Table 1: Evaluation of Factors for Irrigation Suitability

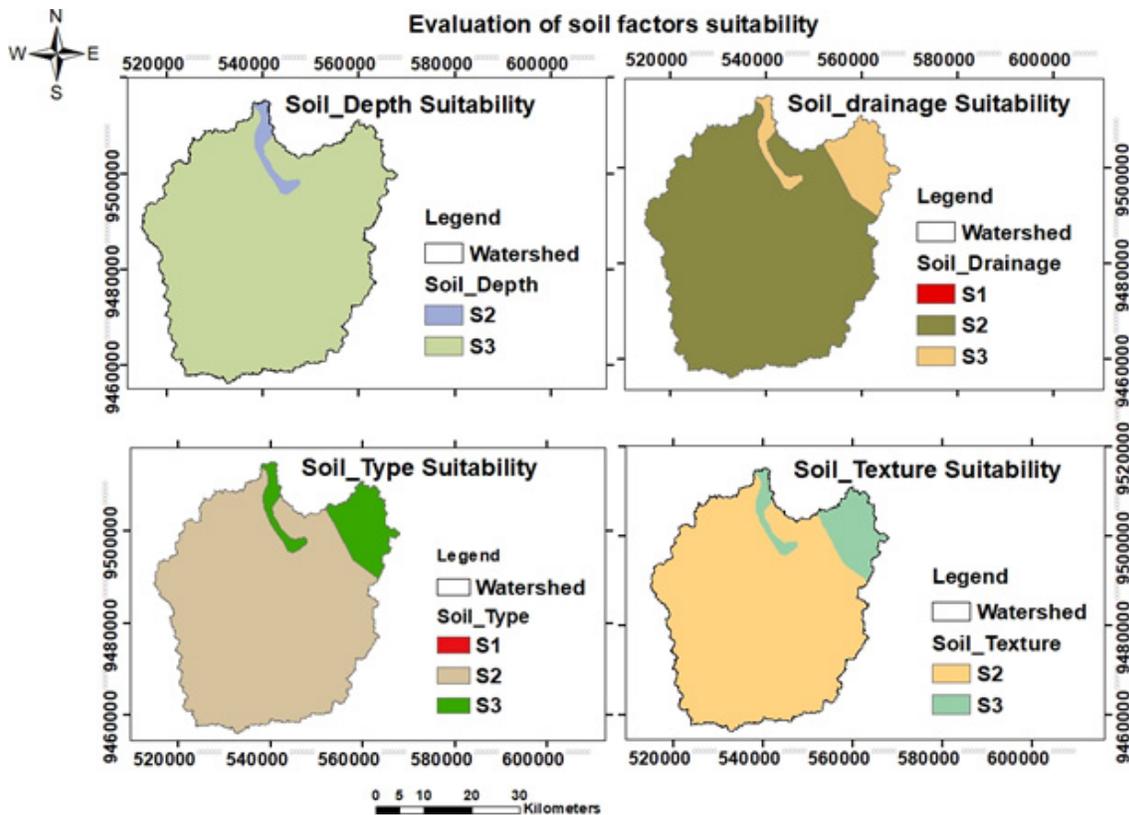


Figure 6: Evaluation of Soil Factors Suitability

3.8 Evaluation of Irrigable Land Suitability in the N'djili River Watershed.

Several factors such as slope, land use, proximity to rivers, soil type, soil drainage, and soil texture and soil depth were taken into account in evaluation of irrigable land suitability in the N'djili river watershed. By overlaying these factors, a model for assessing the potential for irrigable land in the N'djili River watershed was created (Figure 10). The results show that only about 1% of the total area of the watershed was classified as highly suitable for irrigation, which represents an area of 26.65 km². Approximately 39% or more than 804 km² of the area was considered moderately suitable, while 58% is marginally suitable, approximately 1203 km², and 1% is not suitable for irrigation, corresponding to about 26 km².

The land suitability analysis for irrigation in the N'djili River watershed involved the consideration of several factors such as slope, land use and land cover, proximity to river, soil type, soil drainage, soil depth and soil texture. By overlaying these factors, as a model was developed to assess the potential for irrigable land in the watershed. The findings of this study indicate that only a small portion of the total area of the N'djili River watershed, approximately 1 %, was classified as highly suitable for irrigation. This highly suitable land cover an area of 26.65 km². The majority of the area, around 39 % or more than 804 km², was considered moderately suitable for irrigation. Additionally, 58 % of the land,

approximately 1203 km², was classified as marginally suitable, while only 1 % or approximately 26 km² was deemed unsuitable for irrigation.

The results provide valuable insights into the potential for irrigable land in the N'djili River watershed. The limited extend of highly suitable land highlights the need for careful planning and management of irrigation systems in this region. It suggests that the available of suitable land for irrigation purposes may be limited, and thus, any expansion or development of irrigation schemes should be approached with caution.

The factors considered in this land suitability analysis play crucial roles in determining the suitability of land for irrigation. The slope of the land influences water runoff and erosion, and areas with steep slopes may be less suitable for irrigation due to the risk of soil erosion and water loss. Proximity to river is important as it determines the availability of water for irrigation purposes. Land closer to rivers may have better access to water resources and hence, higher suitability for irrigation. Soil type, drainage, texture, and depth are also crucial factors in assessing land suitability for irrigation. Different soil types have varying water holding capacities and drainage characteristics, which can affect the suitability for irrigation. Soils with good drainage and suitable texture and depth are generally more suitable for irrigation as they allow for effective water infiltration and root growth.

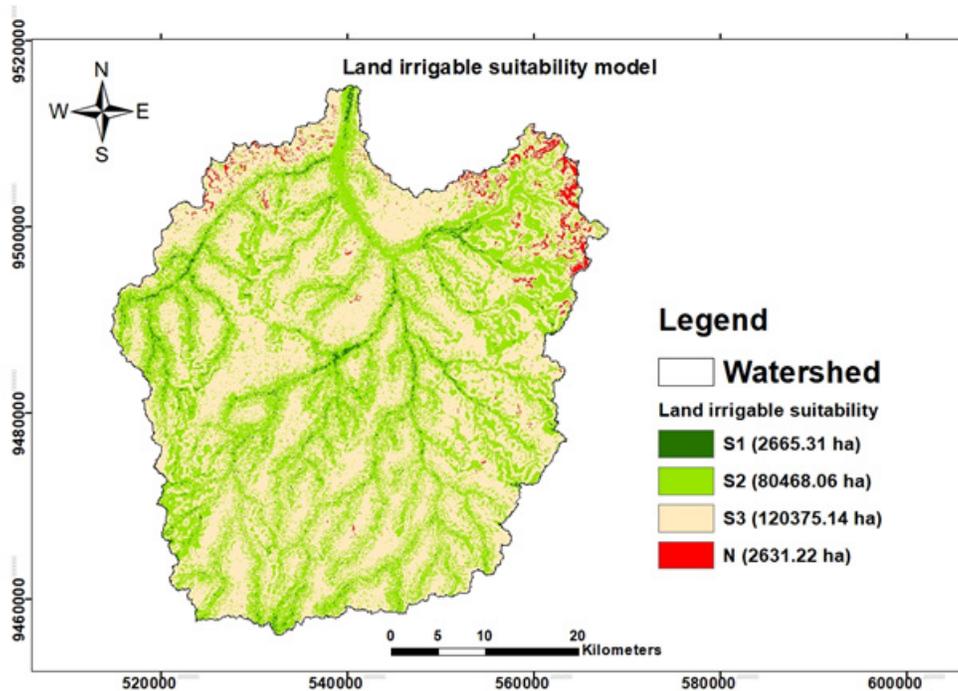


Figure 7: Land Suitability Model for Irrigation By Weighted Overlay

Land suitability	Area (ha)	Area (%)
Very suitable	2665.3182	1.292967
Moderately suitable	80468.0696	39.035686
Marginally suitable	120375.147	58.39492
Non suitable	2631.2253	1.276428
No Data	709.3256	0.343

Table 2: Land Suitability Values in N'djili River Watershed

4. Conclusion and Recommendations

The multi-parameter analysis carried out in the framework of this study has made it possible to define different land suitability classes for irrigation in the N'djili River watershed. The results have shown that land with slopes of less than 2%, located within 256m of the rivers and used for agricultural purposes, is considered highly suitable for irrigation. Land with slopes greater than 15%, grassy areas, forest formations, water bodies and urban areas are considered unsuitable for irrigation. Only land with a soil depth of about 100 cm is classified as moderately suitable, while that with a soil depth of 60-70 cm is marginally suitable. Well-drained soils are considered highly suitable, moderately well-drained soils as moderately suitable and excessively well-drained soils are marginally suitable. Soils with medium texture are classified as moderately suitable, while those with coarse texture are marginally suitable for irrigation. These results provide important information for sustainable and efficient management of water resources and land in the N'djili River watershed for optimal land use for irrigation.

According to the weighted overlay of all the parameters considered, this study has revealed that the potential for irrigable land in the

N'djili River watershed is relatively limited. Only about 1% of the total area of the watershed is classified as highly suitable for irrigation, providing a study area of 26.65 km². Approximately 39% of the area is considered moderately suitable, offering an opportunity for exploitation of over 804 km². However, the largest part of the watershed (about 58%) is classified as marginally suitable and would require special attention to be exploitable, representing an area of approximately 1203 km². Finally, 1% of the watershed area was deemed unsuitable for irrigation, corresponding to a zone of 26 km². These results highlight the need for effective measures to optimize the use of available irrigable land and exploring possibilities for improving marginally suitable areas and to promote sustainable use of water resources and land in the N'djili river watershed.

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