MAPPING THE GROUNDWATER POTENTIAL IN SUB-SAHARAN AFRICA: THE CASE OF LOUMBILA COMMUNE, BURKINA FASO

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Key-words: Geomatics (Remote sensing-GIS), AHP, groundwater potential, Loumbila (Burkina Faso).

Abstract. The objective of this study is to identify and map potential groundwater resource areas in the rural commune of Loumbila in order to assess the potential water accessibility in the area. A spatial data analysis was applied to identify potential groundwater resource areas for drilling. To this end, geomatics tools (Geographic Information Systems and Remote Sensing) and a multi-criteria analysis using the Analysis Hierarchy Process (AHP) technique were deployed. A total of eight (decision) factors with a strong influence on the groundwater storage potential (i.e., soil types, fracture network density, land use, slope, hydrogeology, alterity thickness and drainage density, precipitation) were selected and mapped. An appropriate weight has been assigned to each factor, which were further normalized using the Analytical Hierarchy Process (AHP). Based on the analysis, the rural commune of Loumbila was qualitatively classified into five groundwater potential zones: very low, low, medium, high and very high groundwater potential. The results obtained show that 9.80% (14.75 km^2), 22.02% (33.16 km^2), 30.68% (46.19 km^2), 18.47% (27.81 km^2) and 19.03% (28.65 km^2) of the rural municipality of Loumbila have very high, high, medium, low and very low groundwater potential, respectively. The groundwater potential mapping aims to identify the areas with the highest potential for the sustainable management of groundwater resources, enabling informed decisions to be taken for its management and conservation.

1. INTRODUCTION

Groundwater is a major resource for rural populations in the sub-Saharan area, as surface water is not sustainable due to high evapotranspiration rates or poor quality. It is the only source of water that can be of drinking quality without prior treatment, and it also influences the population's food security (Ouattara, 2016). Accessibility to drinking water is one of the major objectives of development projects worldwide. In developing countries, groundwater is a primary resource for supplying drinking water to the population because it is of relatively good quality and low cost *(Yao et al.*, 2016). In Burkina Faso, the drinking water supply in rural and semi-urban areas is mainly provided by modern wells, boreholes and standpipes (Ministry of Water and Sanitation, 2016). The geological context of Burkina Faso is characterized by a large coverage of the territory over nearly 80% by crystalline rocks, making it difficult to obtain underground water in sufficient quantity and quality (Koussoubé, 1996). According to a study by the Office of Mines and Geology of Burkina Faso (OMGBF)[2], knowledge of Burkina Faso's

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[2] http://www.bumigeb.bf/BUMIGEB/images/info/40j2_resource_eau_souter.pdf.

groundwater resources is very inadequate because there has been no real in-depth research, particularly on the functioning of the deep-water table and its alteration.

The rural commune of Loumbila, which is the subject of our study, is faced with numerous problems in the operation and sustainability of boreholes, with a non-functional rate of 15.7% compared to 11.2% nationally in 2017 (Ouédraogo, 2019). Additionally, 78% of boreholes are in a poor state, the rate of abandonment is 32.58% and the rate of breakdowns is 11.23%, the flow rate of the water supplied and the accessibility at the level of some boreholes not meeting national standards (Ouédraogo, 2019). The groundwater potential of the commune of Loumbila is not well known. Nevertheless, this water is mobilized through boreholes and large diameter wells (PCD, 2021). The most important water resource is Loumbila dam, which is used for hydro-agricultural purposes and makes a major contribution to the supply of drinking water to the city of Ouagadougou, with a capacity of 42.200.000 m^3 (PCD, 2021). The Loumbila dam, whose main purpose is to supply with drinking water the rural commune of Loumbila and the city of Ouagadougou, is used for market gardening and fishing, as well as for construction and public works (BTP) activities, thus threatening its existence and potability because of fertilizer use in agriculture (Sabi Bou Gnon Kanni, 2022). However, the population's need for drinking water is constantly increasing due to the growing population. The population of the commune is 36,465 inhabitants, i.e. a density of 195 inh/km^2 (INSD, 2019). From the above, it is clear that one of the major challenges of the rural commune of Loumbila in terms of water is the knowledge, management and mobilization of this precious resource for life.

Therefore, the objective of this study is to identify and map the groundwater potential zone. For this purpose, geomatics tools combined with a multi-criteria analysis using the Analytic Hierarchy Process (AHP) were used for the prospection and evaluation of potential groundwater areas in the rural commune of Loumbila in order to facilitate the management of drilling facilities. Previous studies have proven the effectiveness of this approach for the assessment of potential groundwater areas, such as: Selvam *et al.*, 2015; Haile, 2022; Hyann, 2015; Vaddadi Natraj *et al.*, 2023; Shuhang Li, Mohamed Abdelkareem, 2023; Avdullahi & Hajra, 2023; Priya *et al.*, 2022. With the help of the literature review, as well as data availability for the region, the following natural factors have been selected and used as decision criteria in the studies mentioned above, thus guiding the analysis in the current paper: precipitation, soil types, fracture network density, land use, slope, hydrogeology, alterity thickness and drainage density.

2. METHODOLOGY

2.1. Study area

The commune of Loumbila is located in the province of Oubritenga, in the Central Plateau region of Burkina Faso. It is one of the eight communes of the province, 25 km from the capital city of Ouagadougou, and 13 km from Ziniaré, the capital of the province to which it belongs. It covers an area of approximately 177 km^2, i.e. 6.16% of the total area of the province of Oubritenga, and has 31 villages with a population of 36,465 inhabitants [3] (11,59% of the total number of inhabitants of the province).

According to the political and strategic orientation document for the rural commune of Loumbila (Municipal Development Plan, 2017–2021), the characteristics of the commune's natural environment are as follows: a peneplain relief, a tropical Sudano-Sahelian climate (600 mm and 900 mm isohyets), temperatures ranging from 21°C (minimum) to 45°C (maximum), with an annual mean of 33°C, the harmattan (a cool, dry wind) as the prevailing wind. The plant cover is essentially characterized by grassy savannahs, shrub savannahs and gallery forests, the three types of soil encountered are poorly developed soils on gravelly materials (erosion-induced soils), lithosols (skeletal soils) and hydromorphic soils and, last but not least, the hydrographic regime consists of a few dams and reservoirs with a tropical rainfall regime.

[3] File of Localities of the 5th RGPH, June 2022.

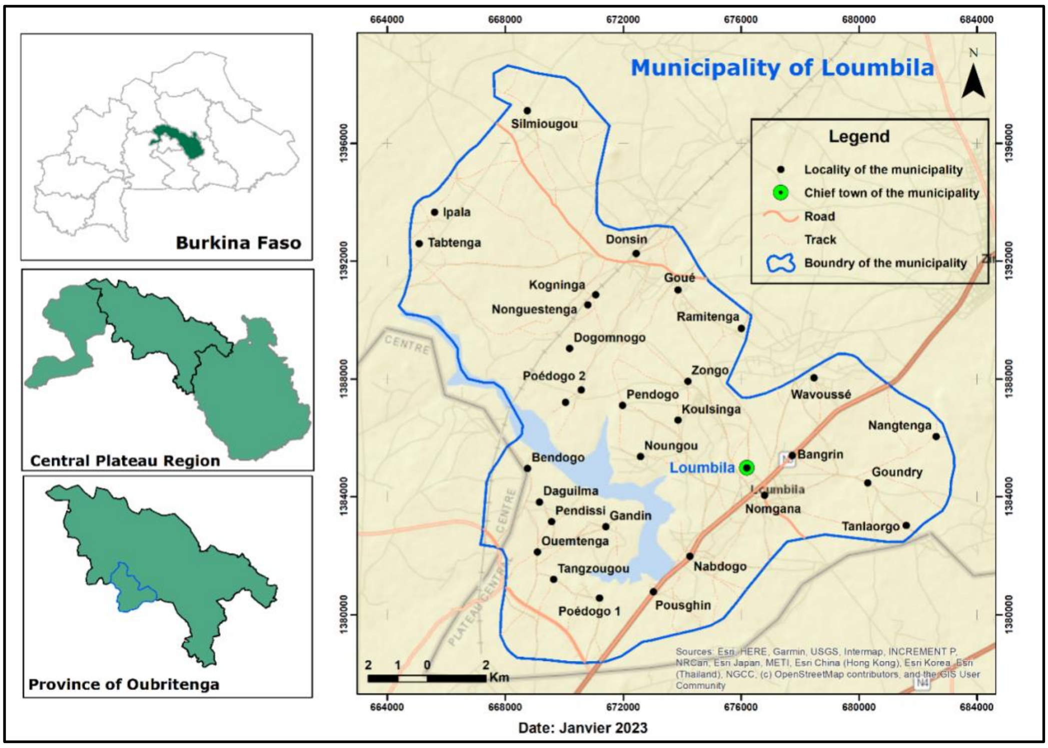

Fig. 1 – Location of the rural commune of Loumbila.

2.2. Data and tools

Several data sources and tools were used to carry out this study. These include satellite data, data from the state institutions, as well as data collected in the field.

2.2.1. Satellite data

The satellite data used belong to Landsat 7 and 8 missions[4]. Landsat 7 ETM+ (bands 7,4,2) involved corrected and ortho-rectified optical satellite images of the year 2000 of the scene 195/051, acquired on 12/08/2000, while Landsat 8 OLI (bands 7,5,3) referred to the corrected and ortho-rectified optical satellite images of the year 2020 of the scene 195/051, acquired on 28/10/2020. Additionally, DEM (Digital Elevation Model) data with a resolution of 30 m from the SRTM (Shuttle Radar Topography and Mapping) mission were used. Finally, precipitation data were retrieved from the Climate Hazards Group InfraRed Precipitation with Station Data (CHIRPS) using Google Earth Engine.

2.2.2. Data from state institutions

Data from the national archives were acquired from the Burkina Geographical Institute (BGI) and National Soil Office (NSO) in shapefile format. These comprised hydrogeological data, soil data, and the National Topographic Data Base (NTDB) in the same format. The technical data of the hydraulic structures were obtained from the General Directorate of Water Resources/Directorate of Water Studies and Information (GDWR/DWSI) in an excel file.

[4] The Landsat 7 and 8 data were kindly provided by the Permanent Secretariat of the National Council for Sustainable Development (PS/NCSD) of Burkina Faso.

2.2.3. Field data

The GPS points indicating the geographical position of the boreholes and wells in the study area were taken during a fieldwork undertaken in July 2020. A Garmin 72H Global Positioning System (GPS) was used for this purpose. Around 123 borehole water points were collected.

2.2.4. Data processing and analysis software

Data processing and analysis was performed using Envi 5.4 (supervised and unsupervised classification and NDVI for a LULC map), Geomatica PCI 9.1 (for the lineament extraction), QGIS 2.18 (spatial database creation, management, mapping and AHP modelling), and Excel 2016 (database creation and management, calculations).

2.2.5. AHP method

The methodological approach in this study consists in a multi-criteria decision support mapping based on the use of the AHP method. The method, developed in 1977 by Thomas L. Saaty, allows the decomposition of a complex problem into a hierarchical system. This method essentially consists of three major steps: the identification of decision criteria, the classification and normalization of these criteria, and the weighting of the criteria and their aggregation. This approach makes use of a multi-source and multi-format data in a GIS. Figure 2 below shows the general methodological framework of the study, based on a method already used by several researchers and applied in studies on mapping the suitability of groundwater (Inaytoulaye *et al.*, 2023; Bebi *et al.*, 2021; Yıldırım, 2021; Djilali *et al.*, 2019; Ake *et al.*, 2018; Al-Bakri & Al-Jahmany, 2013).

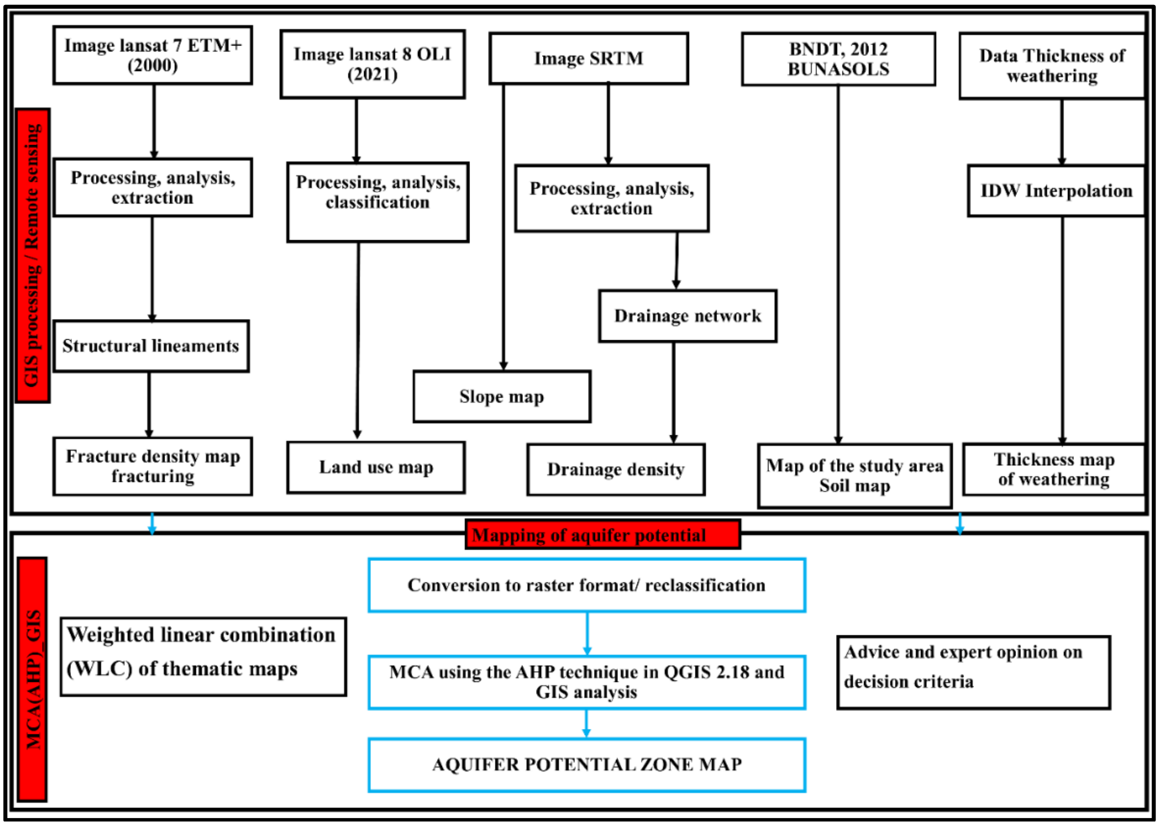

Fig. 2 – Methodological stages of the study.

2.3. Selection of decision factors

The literature review (Koudou *et al.*, 2013; Khodaei & Nassery, 2013; Kanohin Fulvie Epse Otchoumou, Saley Mahaman Bachir, Aké Gabriel Etienne, 2013; Oscar *et al.*, 2016; Essahlaoui, 2016; Sidi Mohamed *et al.*, 2017; Djilali *et al.*, 2019; Allafta *et al.*, 2021; Inaytoulaye *et al.*, 2023) allowed the researchers to select and evaluate a number of criteria for making the different thematic maps of potential indicators with an influence on groundwater resources. The decision criteria used in these studies include soil type, fracture network density, land use, slope, hydrogeology, weathering thickness and drainage density, rainfall, geological formations, distance to river, depth of water table, effective infiltration, etc. It should be noted that the number of criteria is not limitative and depends on the availability of data and the environmental settings of the study area.

Following an expert knowledge approach, the criteria considered important and relevant in the case of the current study are: fracture network density, drainage density, hydrogeology, slope, alteration thickness, pedology, land use/cover and precipitation. Their selection was triggered also by their availability for the case-study area.

2.4. Mapping of decision factors

a. The fracture network density factor

The interpretation of lineament densities for hydrogeological purposes relies on the idea that a much higher intensity of lineaments in relation to the bedrock probably generates faulted zones that conduct groundwater. The analysis of the structural lineaments in the study area reveals that the area has a low fracturing. The fracture density varies from 0 m/Km^2 to 2,593 m/Km^2 and this means that the zone is not faulty enough. The lineament density is classified into five (5) major groups, by reclassifying the image in QGIS.

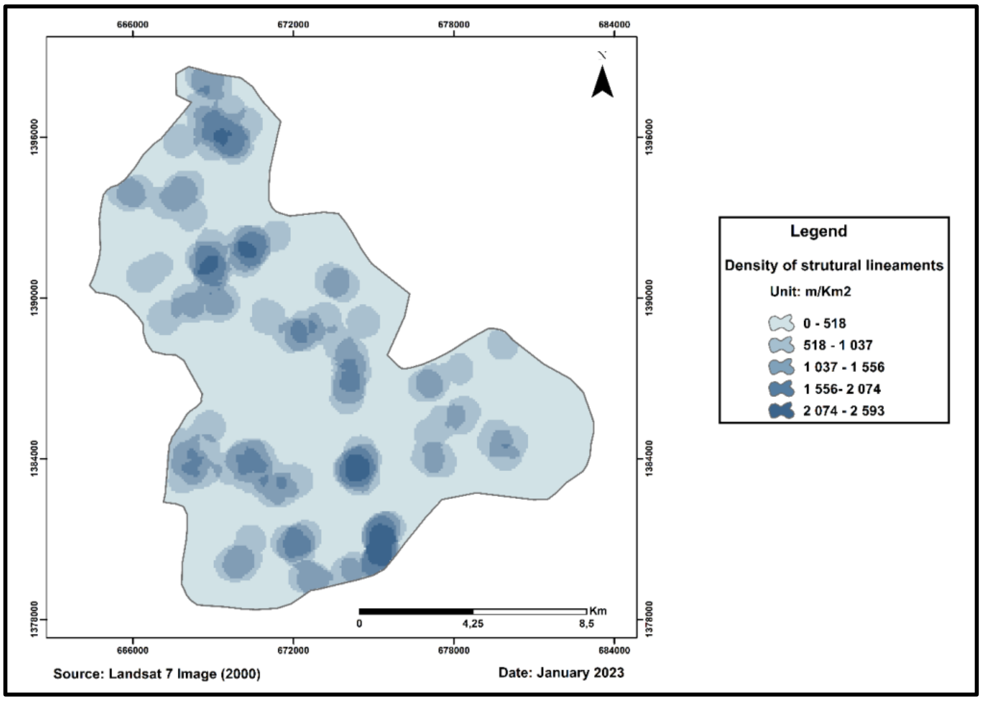

Fig. 3 – Density of the fracture network in the rural commune of Loumbila.

b. The drainage density factor

Drainage density is the cumulative length of stream segments of all orders in a region divided by the area of the region. Drainage density is a good indicator for predicting infiltration rates and their relationship with surface runoff (Allafta *et al.*, 2021). The drainage density in the study area is obtained after the pre-processing and processing of the SRTM image in ArcGIS 10.8. The drainage density map shows a low drainage density in the rural commune of Loumbila. The drainage density was split in five density classes ranging from lowest to highest value. The density values vary from 0 m/km^2 to 0.55 m/Km^2 in density. The 5 classes occupy, in ascending order, 34.80%; 23.32%; 22.53%; 14.20% and 5.13% (Fig. 4) of the communal territory in terms of drainage density.

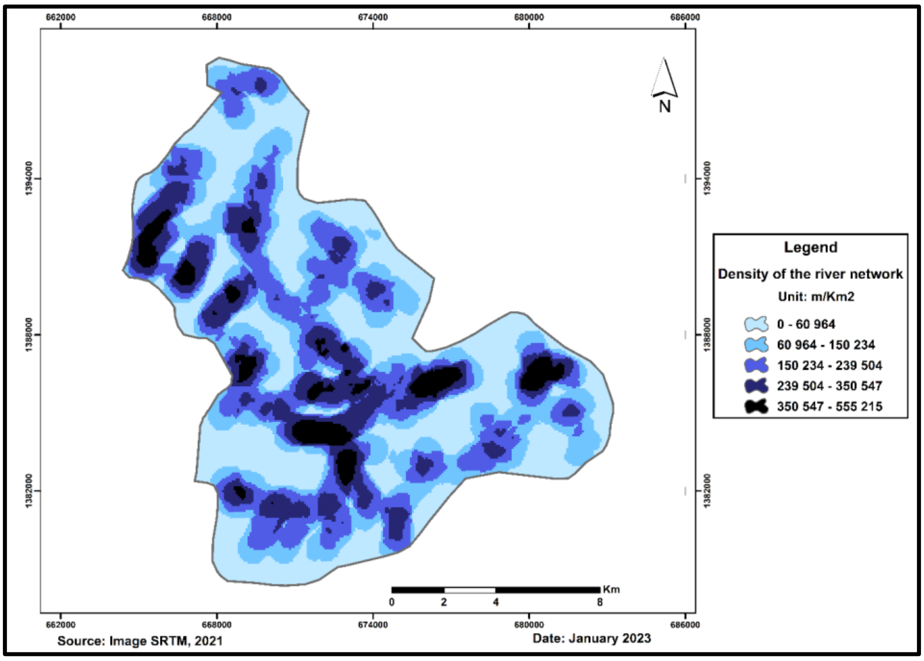

Fig. 4 – Drainage density factor.

c. The hydrogeological factor

The hydrogeological units were obtained by digitizing the hydrogeological map of Burkina Faso. In the rural commune of Loumbila, the hydrogeological system is based on a geological layer of ante-Birrimian granites with highly cultivated ferruginous soils over a surface area of 36.24 km^2 (19.40% of the commune), on the one hand, and on ante-Birrimian granites with degraded ferruginous soils over a surface area of 150.52 km^2 (80.59% of the commune), on the other hand (Fig. 5).

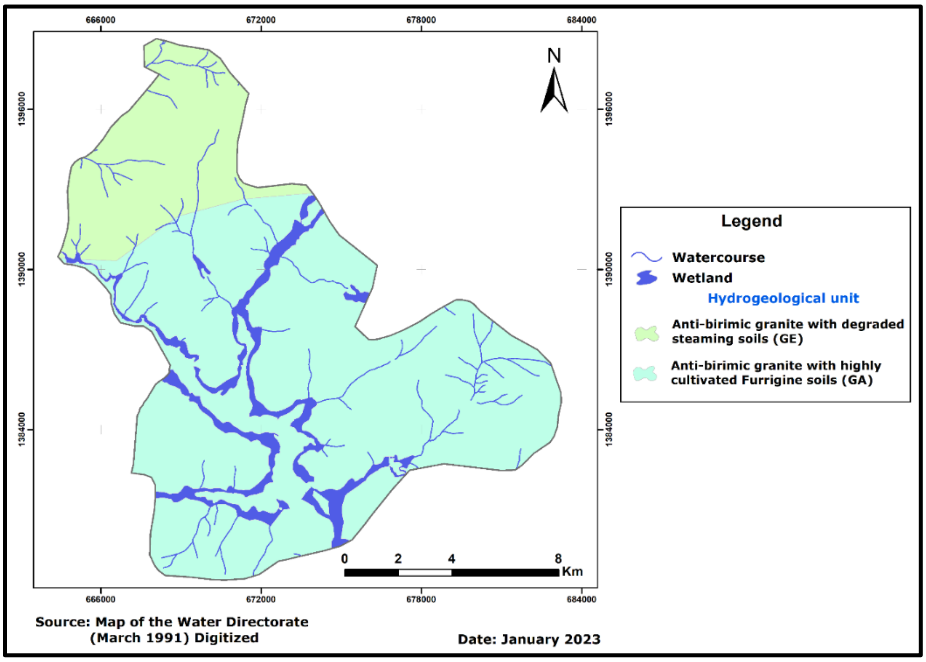

Fig. 5 – The hydrogeological factor.

d. The slope factor

The slope is taken into account to integrate the influence on the water transfer paths and their distribution between runoff and infiltration components (Fig. 6). The slope data were derived using the DEM/SRTM raster at a resolution of 30 m. Areas with low slope are considered favourable to infiltration and, therefore, to groundwater recharge. Steep slopes favour the rapid runoff and drainage of meteoric water.

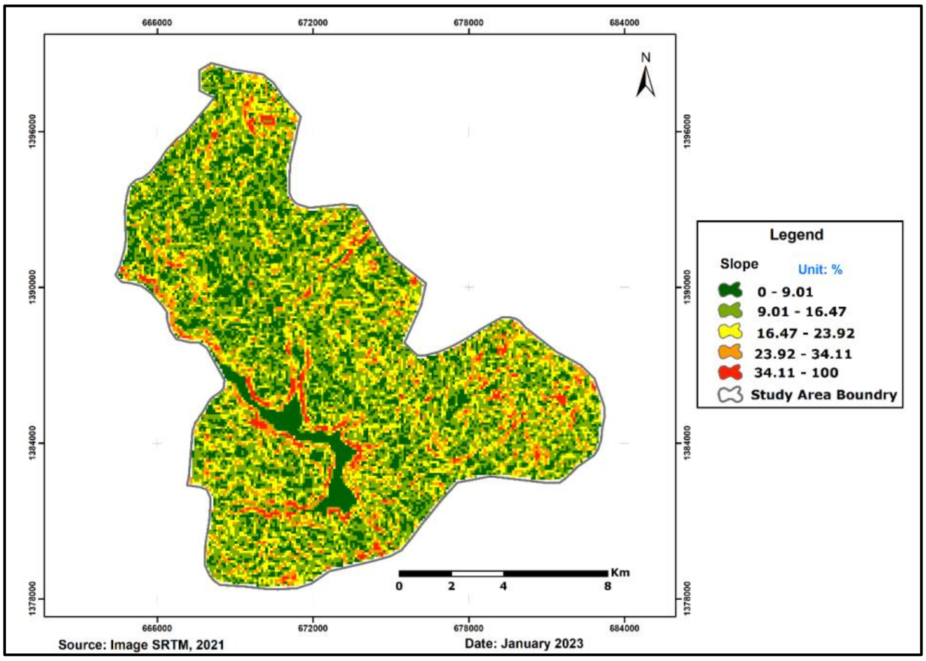

Fig. 6 – The slope factor.

e. The weathering thickness factor

Alterites are residual surface formations resulting from the weathering and fragmentation of the parent rock and they form water underground reservoirs called alterite aquifers (Koudou *et al.*, 2013). The thickness of alterites is retrieved from the data sheet of the Directorate General for Water Resources (DGWR). This parameter shows variable values over the study area. Areas with high alteration thickness are likely to indicate the presence of reservoirs in the aquifers, unlike areas with low alteration thicknesses. The generalization of the extent of the weathering cover over all formations indicates the importance of fracturing. The average thickness of the weathering layer is 19.88 m, the maximum is 53 m and the minimum thickness is 3 m in a sample of 114 boreholes. Using IDW interpolation, the weathering layer thickness has been calculated and divided into five thickness zones: (1) 0.98 to 9.68, (2) 9.69 to 15.02, (3) 15.02 to 19.75, (4) 19.75 to 24.17, and (5) 24.17 to 37.89 (Fig. 7).

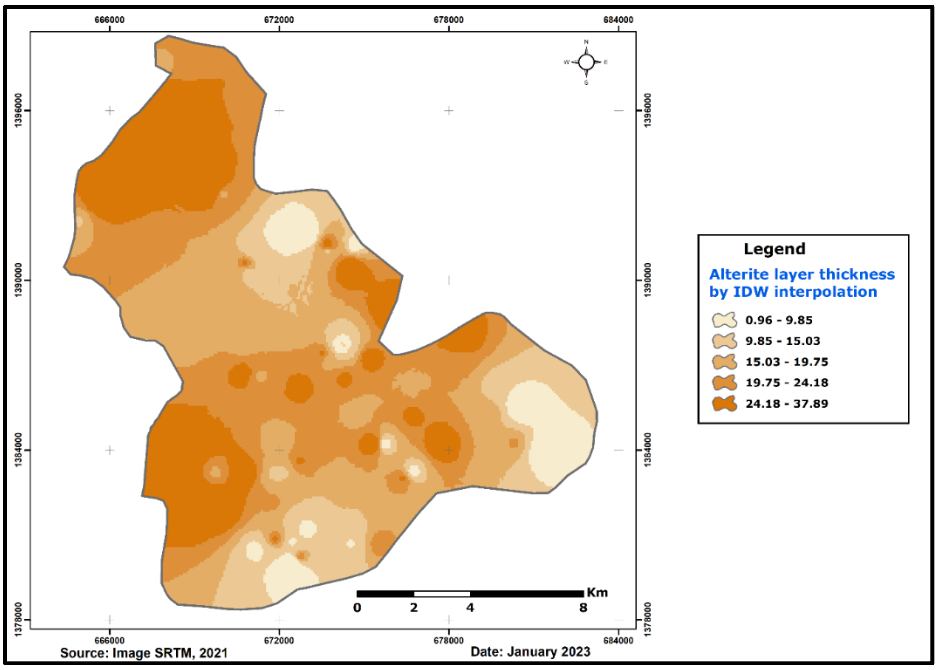

Fig. 7 – The thickness of weathering layers' factor.

f. The land use/ land cover factor

Knowledge of the land use categories provides information on the terrain permeability to allow rainwater to infiltrate. According to the rate of vegetation cover, 3 types of land use have been derived using Landsat 8 OLI images: a grassy savannah, a shrubby savannah and a gallery forest at the edge of watercourses (Fig. 8). Moreover, it should be mentioned that the presence of crops is a sign of strong demographic pressure. These are: Mangifera indica (Mango tree), Psidium guajava (Guava tree), Borasus aethiopum (Rônier) and Eucalyptus glonulus (Eucalyptus).

g. The soil factor

Soil plays a major role in groundwater recharge (Haile, 2022). Because the infiltration rate is determined by the permeability of the soil and its water retention capacity (Lee *et al.*, 2014). The main types of soil in the study area are poorly developed soils on gravelly materials (erosion soil) covering approximately 142 km², i.e. 80.13% of the municipal territory. Lithosols (skeletal soils) are mainly made up of ferruginous cuirasses on residual relief (lithosols on cuirasses) or outcrops of various unaltered or slightly altered rocks (lithosols on rocks) characterised by the absence of any pedogenetic evolution. They cover 4.7 km², i.e. 2.65% of the municipality. Hydromorphic soils are made up of sandy materials and have evolved under the influence of a temporary or permanent excess of water. These soils cover 30.46 km², that is, 17.21% of the municipality (Fig. 9).

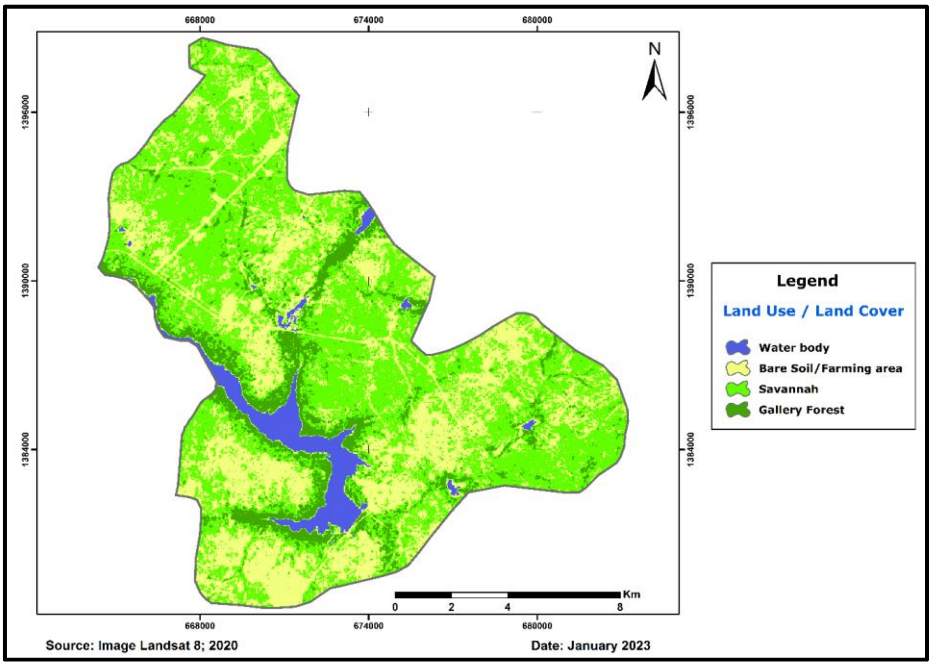

Fig. 8 – The land cover and land use factor.

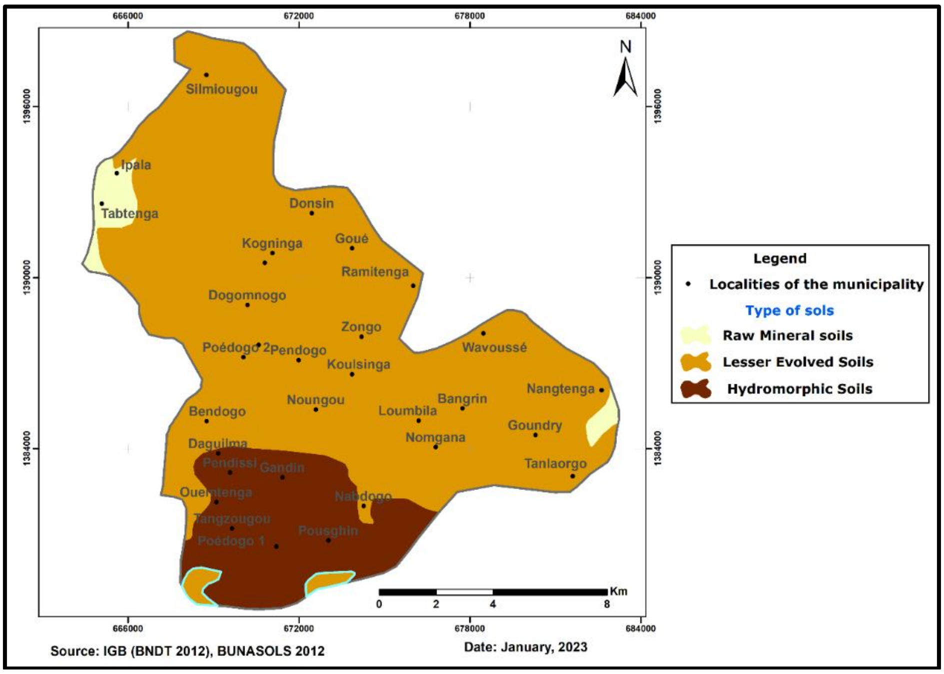

Fig. 9 – The soil types factor.

h. The precipitation factor

Precipitation is essential for groundwater recharge. Rainfall is the main source of groundwater recharge, while irrigation areas, rivers, ponds, lakes, etc. are secondary sources (Vaddadi Natraj *et al.*, 2023). Our study area is located in the Soudano-Sahelian climatic zone of Burkina Faso. It therefore benefits from an average rainfall of 850 mm/year. The rainfall map below was obtained by the Inverse Distance Weighting (IDW) interpolation of rainfall data. A total of 33 homogeneously distributed points were used.

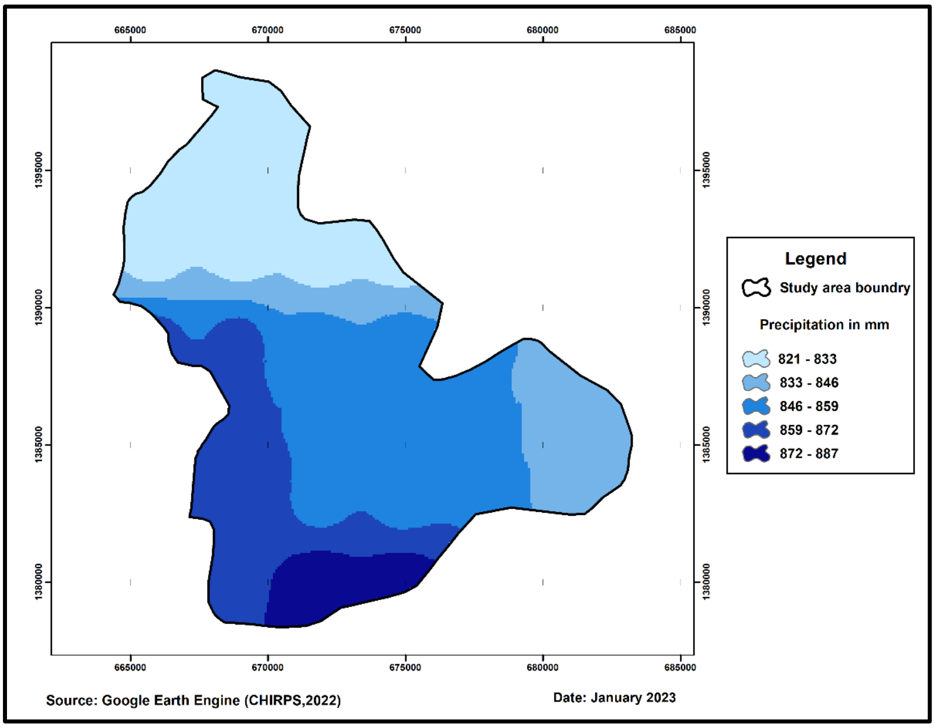

Fig. 10 – The annual average precipitation factor.

2.5. Classification, evaluation and normalization of decision criteria

Each identified criterion is subdivided into classes representing either a particular environment or a range of values. For each criterion, five classes were defined (very weak, weak, medium, strong and very strong) in order to improve the interpretation conditions. Furthermore, for a good multi-criteria analysis, the different classes for each criterion are hierarchically ranked according to their influence on groundwater formation. The intermediate classes have an intermediate rating according to an increasing or decreasing linear distribution. Table 1 below illustrates the classification, evaluation and normalization of decision criteria.

Table 1

Classification, evaluation and normalization of decision criteria

Criteria	Units	Sub-criteria	Suitability class ranges and ratings	Suitability class ratings	Weights Normalized through AHP calculation
Soil types	Level	Raw Mineral soils	Very high	9	0.054
		Lesser Evolved Soils	High	7	
		Hydromorphic Soils	Medium	5	
Land use /Land cover	Level	Gallery Forest	Very high	9	0.094
		Savannah	High	7	
		Bare Soil	Medium	5	
		Wetland	Low	3	
Slope	%	0 – 7.13	Very low	9	0.074
		7.13 – 9.9	Low	7	
		9.9 – 17.03	Medium	5	
		17.03 – 35.38	High	3	
		35.38 – 82.54	Very high	1	
Lineament density	m/km²	0 – 518	Very low	1	0.208
		518 – 1,037	Low	3	
		1,037 – 1,556	Medium	5	
		1,556 – 2,074	High	7	
		2,074 – 2 593	Very high	9	
Thickness of weathering layers	m	96 – 9.85	Very low	1	0.039
		9.85 – 15.03	Low	3	
		15.03 – 19.75	Medium	5	
		19.75 – 24.189	High	7	
		24.18 – 37.89	Very high	9	
Drainage density	m/km²	0 – 60,964	Very low	9	0.139
		60,964 – 150,234	Low	7	
		150,234 – 239,504	Medium	5	
		239,504 – 350,547	High	3	
		350,547 – 555,215	Very high	1	
Precipitation	mm	821–833	Very low	1	0.357
		833–846	Low	3	
		846–859	Medium	5	
		859–872	High	7	
		872–887	Very high	9	
Hydro-geology	Level	Ante-birrimian granite, highly cultivated ferruginous soils (GA)	High	7	0.034
		Ante-birrimian granite, degraded ferruginous soils (GE)	Very high	9	

Source: literature review, results of AHP processing in QGIS.

2.6. Thomas Saaty's scale

In order to evaluate the different criteria, Saaty proposed in 1984 a scale of values. Saaty's assessment scale ranging from 1 to 9 was used. A score of 9 is assigned to the class of criteria deemed "very strong", depending on whether it reinforces the presence of reservoirs in the study area. If not, the class is rated 1 – "very weak" (Table 2).

Table 2

Scale proposed by Saaty in 1984

Level of importance	Verbal scale
1	Equal importance of both elements
3	One element is slightly more important than the other
5	One element is more important than the other
7	One element is much more important than the other
9	One element is absolutely more important than the other
2, 4, 6, 8	Intermediate values between two judgements, used to refine the judgement

Source: Thomas Saaty's scale table, 1984.

3. RESULTS AND DISCUSSION

3.1. Pairwise comparisons of decision criteria

The technique for assigning weight to each criterion is based on Saaty's multi-criteria hierarchy method of 1977. The weighting criterion reflects the relative importance of each criterion in the formation of the aquifer reservoir. The weighting values from a series of pairwise comparisons of the selected criteria are listed in Table 3. The weights assigned to each criterion vary between 0 and 1.

Table 3

Pairwise comparisons of identified criteria (AHP)

	P	**Ld**	**Dd**	**Luc**	**Sl**	**S**	**Wt**	**Hydrogeo**	
P	**1**	3	3	5	5	5	7	7	
Ld	0.333	**1**	2	3	3	5	5	5	
Dd	0.333	0.5	**1**	1	2	3	5	5	λ_{max}=8.238
Luc	0.2	0.333	1.0	**1**	1	2	3	3	CI = 0.034
Sl	0.2	0.333	0.5	1.0	**1**	1	3	3	
S	0.2	0.2	0.333	0.5	1.0	**1**	1	2	CR= 0.024
Wt	0.143	0.2	0.2	0.333	0.5	1.0	**1**	**1**	
Hydrogeo	0.143	0.2	0.2	0.333	0.333	0.5	1.0	**1**	

Source: Calculation using the AHP method.

Table reading scale: P = precipitation, S = soil, Dd = drainage density, Wt = weathering thickness, Ld = lineament density, Hydrogeo = hydrogeology, Luc = land use/land cover, Sl = slope.

3.2. Normalized Weight Percentage of each influencing decision criteria

The normalised weight (Table 4) of each decision factor determines the relative importance of that factor in terms of its role in recharging the aquifer in the rural commune of Loumbila. In our context, priority is given to the precipitation factor, followed by the density of structural lineaments and land use/cover.

Table 4

Decision criteria weight

Decision criteria	Weight %
Precipitation	35.7
Lineament density	20.8
Drainage density	3.9
Land use/land cover	9.4
Slope	7.4
Soil type	5.4
Weathering thickness	3.9
Hydrogeology	3.4

3.3. AHP analysis by calculation

To obtain the groundwater potential map, a number of indices have been calculated: eigenvalue, coherence index, coherence ratio and random coherence index. These indicators are calculated using QGIS and its Easy AHP extension.

3.3.1. Calculation of the eigenvalue

The matrix A is multiplied by the elements of the priority vector (x), where x is the eigenvalue of the priority vector (n), and the average of the values found is calculated. The result is called the *max value*; Saaty suggested that the largest max eigenvalue is:

$$\lambda\mathbf{max} = \mathbf{aij}.\frac{\mathbf{Wi}}{\mathbf{Wj}}$$

The eigenvalue calculated using the above formula gives a result equal to λmax = 8.238.

3.3.2. Calculation of the Coherence Index IC

During the judgement explanation stage, redundant comparisons are made to improve the validity of responses, given that decision-makers may be uncertain or make poor judgements when comparing a few elements (Rakotoarivelo, 2015). The coherence index is the ratio of the difference between the max eigenvalue minus the number of comparisons on it minus one. The formula for the coherence index is:

***IC** = average consistency - number of elements / (number of elements -1)*

$\mathbf{IC} = \frac{\boldsymbol{\lambda}\mathbf{max-n}}{\mathbf{n-1}}$ Evaluation of the Global Consistency Index (GCI) of the judgements gave a value of IC=0.034, expressing satisfactory consistency of judgements according to Saaty, 1984.

3.3.3. Calculation of the Coherence Ratio CR

The Coherence Ratio (CR) is the ratio of the coherence index calculated on the matrix corresponding to the decision-maker's judgements and the IA random index of a matrix of the same dimension. If RC ≤ 0.1 or RC ≤ 10%, the matrix is considered to be sufficiently coherent. If this value exceeds 10%, the assessments may need to be revised (Rakotoarivelo, 2015).

RC = Consistency index / random consistency

$\mathbf{RC}=\frac{\boldsymbol{IC}}{\boldsymbol{IA}}$**;** the calculated consistency ratio equal to CR=0.024 or 2.4%, which means that our matrix is sufficiently coherent.

3.4. Integration of decision criteria in a GIS

The weights and normalized values of each criterion make it possible to calculate a Groundwater Potential Zone (GwPZ). The following equation was used to determine the areas of groundwater potential:

$$GwPZ= (Wi) \times (Xi) = (S+0.054) \times (Ld+0.208) \times (Lu+0.094) \times (Sl+0.074)$$
$$\times (hydrogeo+0.034) \times (Wt+0.039) \times (Dd+0.139) \times (P+0.357)$$

where, GwPZ = Groundwater Potential Zone, Wi = the weight of criterion i, and Xi = the normalized value of criterion i.

3.5. Groundwater potential map

The map below (Fig. 10) illustrates the groundwater potential areas in the commune of Loumbila obtained by integrating AHP analysis into GIS environment. This ground water potential was classified into five areas: very low, low, moderate, high and very high.

The use of GIS and AHP multi-criteria analysis led to the production of a groundwater potential map in the rural commune of Loumbila. The multi-criteria analysis method, coupled with GIS, has been used by many authors and has enabled the mapping of areas suitable for boreholes (Akkari, 2022, Oularé *et al.*, 2017, Khan *et al.*, 2022). In fact, this method has proved to be effective in assessing areas with aquifer potential. It also has the advantage of being a low-cost approach to proposing aquifers.

However, the method is not without its limitations. The main difficulty lies in defining the class limits of the factors and the weights assigned to the various factors used in the GIS (Kisiki *et al.*, 2022, Faye *et al.*, 2021). It should be noted that these limitations should not be seen as tangible barriers to the validity of the method.

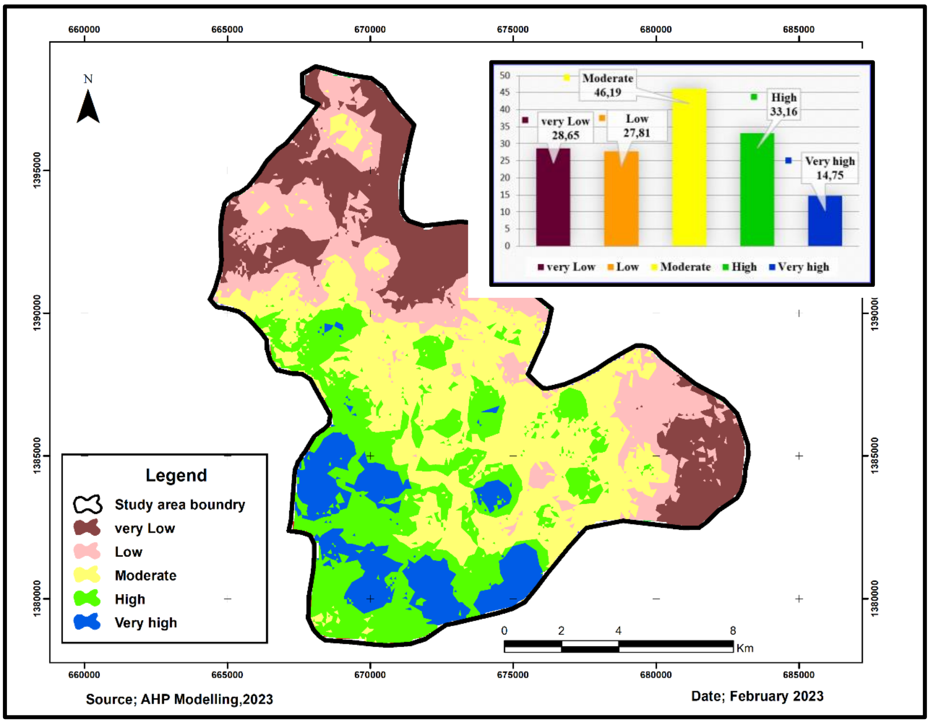

Fig. 10 – The map of groundwater potential of the rural commune of Loumbila.

4. CONCLUSIONS

In this study, the potential of groundwater resources in the commune of Loumbila was mapped. The mapping is obtained by integrating data on soil type, fracture network density, land use, slope, hydrogeology, weathering thickness and drainage density into an AHP multi-criteria analysis and the GIS environment.

The results highlighted the areas most suitable for exploiting the municipality's groundwater resources. The resulting map of groundwater potential areas is classified into five levels of potentiality zones, characterized as very low, low, moderate, high or very high groundwater. The results indicate a generally very low groundwater potential, as only around 9.80% of the commune's territory lies in a very high groundwater potential. The study demonstrates the importance of using advanced AHP mapping and modelling techniques to assess the availability of groundwater resources. However, certain limitations of this study should be noted, in particular the use of available data and its reliability. Further research is needed to refine the results.

This work provides a useful decision-making tool for groundwater resource management strategies, as well as for prospecting borehole sites in a rural area with low access to data and resources. This work contributes to a better understanding of the availability of groundwater resources in Loumbila commune, and provides a solid basis for informed decisions on water resource management. It also paves the way for future research aimed at improving the understanding of groundwater resources, which is important for ensuring sustainable access to water resources. This study is all the more interesting in that we recommend similar studies in other communes in Burkina Faso. To further minimize drilling failures, the results of this study need to be refined by geophysical measurements in the field.

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