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RESEARCH ARTICLE

AT THE CROSSROADS OF NATURAL AND HUMAN SCIENCES: THE EVALUATION AND PROSPECTS FOR THE DEVELOPMENT OF THE GEOSITES OF BAKEL CITY (TAMBACOUNDA REGION, SENEGAL)

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Abstract

Bakel, located in the Tambacounda region, is the capital of the department of the same name. It lies in the far east of the country on the left bank of the Senegal River, which separates it from Mauritania. The relief is generally flat but dotted with a few hills and small depressions formed by streams. The exposed geological formations date from the Paleoproterozoic to the Pliocene epochs. The presence of the river has facilitated settlement in the area since the Late Pleistocene, and navigation has furthered the arrival of colonists since the early 19th century. It is connected to National Route 2 (RN2) by a 5 km stretch and is located 65 km from Kidira. This study aims to identify and assess the geosites within the municipality and propose strategies for their development. Based on our observations and the results of previous work, we carried out an evaluation of the criteria used by the authors for the creation of geosites in this municipality. Thus, the scientific, cultural, ecological, aesthetic, and economic values were assessed for nine geosites, eight of which were anthropogenic and one hydrological. To promote geodiversity as a support for biodiversity and geoheritage as a tool for sustainable local human and socio-economic development in the region, some of these geosites deserve to be valued and protected. This could allow for the delimitation of a geopark within the municipality and contribute to promoting geotourism.

Introduction:-

Bakel is the capital of the department of the same name. It is located in the Tambacounda region, in the far east of the country, on the left bank of the Senegal River, which separates it from Mauritania (Fig. 1). It is connected to National Road 2 (RN2) by a 5 km stretch and is 65 km from Kidira, a town crossed by National Road 1 (RN1) and the Dakar-Niger railway. The presence of the river has facilitated human settlement in the area since the Pleistocene (Chevrier & al., 2016).The Ndiaye aristocrats, who came from Djolof, settled in an area they named Ndiayega in the village of Bakel. This latter name also originates from them (Diallo, 2021; Cissokho, 2017; Willane, 2019). This

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departure of the Ndiaye from Djolof is linked to the collapse of the Djolof Empire, which occurred between 1549 and 1575 (Boulègue, 2013). Their settlement in Bakel took place before the official French presence in 1818, although their presence has been documented since the 17th century (Diallo, 2021). Logically, the Ndiaye settlement in Bakel falls within the period from 1549 to 1818. This territory was under the control of the Bathily family when they settled within the Kingdom of Galam (Bathily,1989). The relationships between Bathily and Ndiaye, Ndiaye and Kébé, Ndiaye and the French, French and the inhabitants of Modinkané, French and Bathily, among many others, testify to a multitude of interactions, beginning before the official French settlement and continuing with their arrival to the present day, with other forms of adaptation, the most striking of which is the tendency towards emigration. The desire to reduce Bakel's heritage to the colonial period alone stems from an unsuccessful attempt at ideological manipulation and coercion. Relationships that sometimes converged with the interests of the colonizers, and sometimes diverged, sometimes exhibiting resistance, are visible in the spatial configuration.

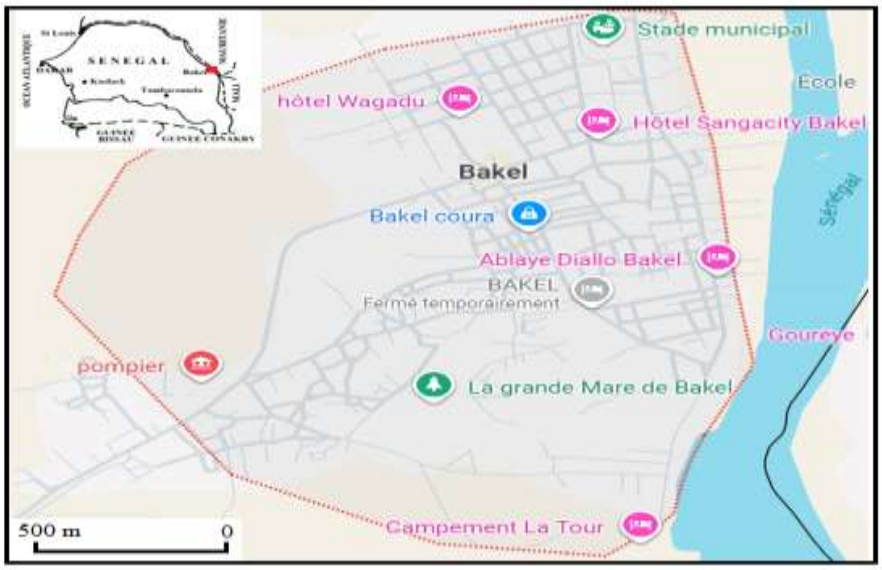

Fig. 1:Location map of the municipality of Bakel

Among the older neighborhoods of Bakel are Ndiayega, Guidimpale ("behind the stones or hills"), and Liberté-Faidherbe, while those of HLM (Habitations à Loyer Modéré – low-income housing), Bakel Coura, Darousalam, and Fandale date from after 1960 (Diallo, 2021). Bakel was established as a municipality in 1960. The area boasts a rich geological and geomorphological diversity (geodiversity), which, through its varied ecosystems, supports significant biological diversity (biodiversity) and a rich cultural heritage based on archaeological sites, places of worship, and traditional ceremonies. The preservation and enhancement of this natural and cultural wealth requires the establishment of several geosites within this municipality. According to Reynard (2004) and Skibiński et al. (2021), "geosites are defined as portions of the geosphere that are of particular importance for understanding Earth's history, geological or geomorphological features that have acquired scientific, cultural/historical, aesthetic and/or social/economic value due to human perception or exploitation." Geosites are therefore key elements in the development of geotourism and education, and inventorying and assessing them is the first step towards establishing a geopark (Skibiński et al., 2021).

Another key concept is geoheritage (geosites and geomorphosites), which must be assessed (Brilha and Reynard, 2018), managed (Erikstad, 2013), subject to conservation (Brocx& Semeniuk, 2019), promoted through geoparks (Xu & Wu, 2022; Zouros, 2004), and be central to geotourism (Ehsan et al., 2012; Hose & Vasiljevic, 2012), geoscience museums, and mapping (Coratza et al., 2021). Preserving geoheritage means safeguarding the natural diversity of elements within major geomorphological and geological sites, that is, geoheritage sites, also called geosites (Mariotto et al., 2020). According to Lima et al. (2010), most geosite assessment methods use scientific value, which can be subdivided into four sub-criteria: representativeness, integrity, rarity, and also the degree of scientific knowledge about the geosite, as evidenced by the number and quality of scientific publications focused on it (Brilha, 2016). In addition to scientific value, other, so-called "complementary" values (Coratza& Giusti, 2005) can be identified and assessed: cultural, ecological, economic, aesthetic, and educational (Mariotto et al., 2023).

This study is a continuation of a large-scale, multidisciplinary research program currently underway in Senegal to promote geodiversity. It follows on from the work carried out by Youm et al. (2018) in the Dindéfélo Community Nature Reserve (RNDC), Youm et al. (2022) at Lac Rose, and Gueye et al. (2023) in the Bamboung Community Marine Protected Area, located 700 km, 30 km, and 150 km from Dakar, respectively. The present study aims to identify and assess the geosites in the area and propose strategies for their development.

Geographical, geomorphological, and geological context of the study area:-

The geographical context:-

The commune of Bakel is located in the east of the country, on the border with Mali and Mauritania, more than 500 km upstream from Saint-Louis on the left bank of the Senegal River and nearly 800 km from the capital, Dakar. Situated at the mouth of a bend in the Senegal River, the town of Bakel lies between latitudes 14°53' and 14°55' North and longitudes 12°26' and 12°27' West (Gassama, 2025). The climate is Sudano-Sahelian, characterized by a dry season (November to June) and a wet season (July to October). Temperatures are high, with an annual average of approximately 27°C. The average annual rainfall is approximately 539.9 mm. The town of Bakel is traversed by the Senegal River, which forms a natural border with Mauritania. This river is formed by the confluence of the Bafing (its main branch) and the Bakoye at Bafoulabé. It originates in Guinean territory in the high altitudes of the Fouta Djallon highlands, within the Guinean climate zone, which is very rainy. Near Aroundou, it is joined by the Falémé, a powerful tropical river. At Bakel, the Senegal River flows over a hard bedrock composed of quartzite sandstone and schist. It drains a catchment area covering 218,000 m², and its average annual flow is 648 m³/s. It's very gentle gradient at Bakel (0.03on average) results in a very small drainage network, which limits erosion and sediment deposition (Gassama, 2025). During the winter, temporary backwaters called "Kharé", formed in the schist lowlands, are flooded by the river.

The distribution and density of vegetation are linked to geology, topography, rainfall, and soil type (Diakité, 2018). Thus, the commune of Bakel is located in the Guinean savanna region, characterized by the appearance of pre-forest species. In the valleys, homogeneous stands of fan palms and sometimes bamboo appear. The presence of water allows for crops such as rice. The streams and rice paddies harbor aquatic and semi-aquatic fauna typical of humid Sahelian environments, potentially including fish, amphibians, and water birds. The presence of water near the town may also attract fauna adapted to Sahelian conditions from the surrounding areas. The town of Bakel owes the beginnings of its urbanization to the establishment of a military post.Indeed, a former river port, the town is situated on a system of rocky hills around which the entire urban fabric was organized. According to the 2023 census, the population of the commune of Bakel was estimated at 18,939 inhabitants, covering an area of 5.858 km², resulting in a population density of 3.233/km². Women represent 54.6% of the population. The Soninke, comprising 52% of the population, are the dominant ethnic group in the commune. The other ethnic groups present in the town are primarily the Toucouleur (20%), the Wolof, the Fulani, and the Bambara (Gassama, 2025). Bakel is full of vestiges from the colonial era.A visit reveals magnificent sites worthy of admiration. This is the case with the René Caillé Pavilion, the Faidherbe Fort, the three military towers, and the circumcised cemetery, which were listed as historical monuments and represent a treasure capable of bringing this town out of obscurity. Unfortunately, all this heritage, which could have made Bakel a true destination for historical and cultural tourism, is being left to decay. Its disappearance could constitute a major loss of a part of the collective memory. The town has a high rate of emigration, particularly of men to Europe. This phenomenon primarily affects the Soninke people, followed by the Halpulaar.

In addition to its role as an administrative center, Bakel is also the economic hub of a vast geographical area. Agriculture and livestock farming remain the main economic activities within the municipality. In each neighborhood, more than a third of the inhabitants are engaged in agriculture. This sector has experienced significant growth with the development of land in the river valley by SAED (the local agricultural development agency). Cultivated crops include millet, corn, market garden produce, and to a lesser extent, peanuts (Gassama, 2025). Livestock farming is, in many respects, an activity that engages the majority of the population. Urban livestock farming is extensive, encompassing the main breeds of domestic ruminants. Poultry farming, primarily practiced by women, provides a supplementary source of income. Support is provided by the departmental livestock service and a private veterinary clinic (Gassama, 2025). The city offers real potential for cultural tourism and exploration. Indeed, the available attractions include the Bakel Cultural Days and historical sites and monuments such as the René Caillé Pavilion and the Bakel Fort. Despite these opportunities, the tourism sector has not benefited from large-scale promotional campaigns. In fact, the lack of dynamism in this sector limits Bakel's appeal as a destination. Three accommodations are available to visitors: the Hotel Islam, the Djikké Camp, and the guesthouses

run by the delegation of SAED (Société d'Aménagement et d'Exploitation des Terres du Delta du fleuveSénégal - Senegal River Delta Development and Management Company) and CFPE (Centre de Formation Professionnelle de l'Entreprise - Business Professional Training Center)(Gassama, 2025). In addition, you will find the hotels of Sangacity, Wagadu, the "La Tour" camp and "Villa La Vallée". Remittances accompanying these international migrations are a crucial component of Bakel's economy. The allocation of these remittances to meet household needs appears to be a deliberate and premeditated strategy undertaken by the migrant in consultation with their family and community (Cissé, 2023). The emigrant is concerned with the well-being of their loved ones. The sums of money sent by emigrants generate significant changes in the socio-spatial configuration of Bakel. The acceleration of urbanization and the development of housing in Bakel's urban area are inextricably linked to the migratory phenomenon (Cissé, 2023).

The geomorphological and geological framework:-

The relief of the municipality of Bakel:-

The relief is generally flat but dotted with a few hills overlooking the Senegal River and small depressions formed by streams and ponds. Specific hills named Grimpalé Montagne, Ndiayega, Dar Es Salam, Bakel Coura, Modinkané, and Yaguiné are present in the landscape.

The geological context of the municipality of Bakel:-

The outcropping rocks in the commune of Bakel belong primarily to the Mauritanides Supergroup, which is composed of Precambrian and Paleozoic formations deformed and metamorphosed during the Pan-African and Hercynian orogenies (Lécorché, 1980; Lécorché et al., 1989; Le Page, 1983). This north-south trending chain forms the western boundary of the geological formations of the West African Craton and the Taoudeni Basin. It disappears in its western part beneath the sedimentary formations of the coastal basins of Western Sahara, Mauritania and Senegal. The Mauritanides have been subdivided into three structural zones: the northern section located north of the Aouker River, the central section from the Aouker to the Senegal River, and the southern section, south of the Senegal River (Dia, 1984; Lécorché, 1980; Le Page, 1983; Lille, 1967). Our study area is located on the southern branch. The latest updates carried out by Lahondère et al. (2010), which we refer to below, have allowed us to distinguish four major geological domains: autochthonous to parautochthonous, allochthonous in an external position, a Central Complex, and an allochthonous unit in an internal position. The Bakel rock outcrops belong to the Bakel and Moudéri Group (Fig. 2), both of which are part of the allochthonous unit in an internal position.

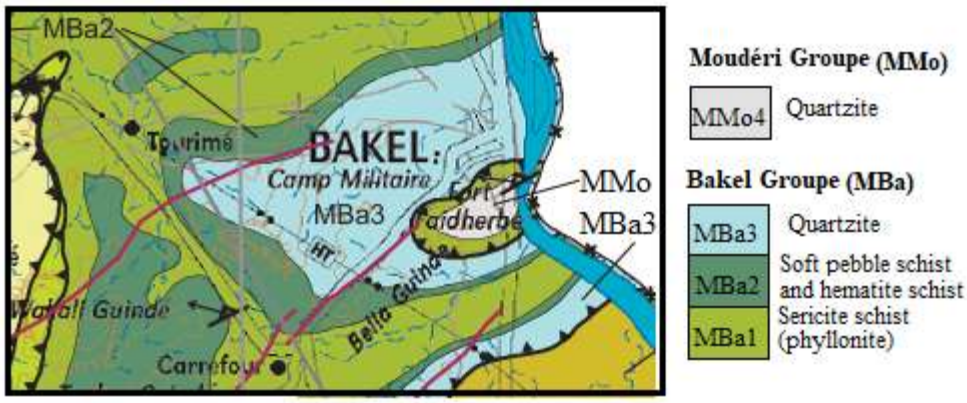

Fig. 2: Geological map of the study area (after Fullgraf et al., 2010, modified)

The Bakel Group (MBa) corresponds to a vast unit that constitutes, in and around the town of Bakel, numerous hills reinforced by sandstone-quartzite bars. It corresponds to the southern continuation of the El Harach Group defined in Mauritania (Pitfield et al., 2004). The quartzites of the Bakel Group are affected by a penetrative foliation of locally protomylonitic to mylonitic nature. This foliation is generally associated with an elongation lineation, sometimes highlighted by long fibrous quartz crystals. Measurements show that the S1 foliation has a generally shallow dip (< 40°) towards the West or Northwest. The elongation lineation is always close to the line of steepest descent (Lahondère et al., 2010). The Bakel Group is divided by Lahondère et al. (2010) in three formations: - MBa3 consisting of white quartzites with mauve patches on which the old agglomeration is built; MBa2 represented

by schists with soft pebbles and hematite schists located below and surrounding the white quartzites and - MBa1 consisting of sericite schists (phyllonite) surrounding, in the locality, the MBa2 and MMo4 Formations (Fig. 2).
The Moudéri Group (MMo) is composed of conglomerates, greenschists, quartz-sericitic schists, ferruginous schists, meta-arenites, and quartzites, forming a sedimentary stack whose stratigraphy remains largely unknown. The distinction between the MMo1 to MMo4 Formations within the group is therefore based primarily on the predominance of certain facies within each unit (Lahondère et al., 2010). In the municipality of Bakel, only the MMo4 Formation outcrops as an ENE-WSW trending quartzite hill overlooking the river (Fig. 2). In thin section, these quartzites consist of heterogranular quartz grains, very tightly interlocked, without any preferred orientation. Iron oxide veins, sometimes folded, appear to be associated with micro-shears. The recrystallization of quartz is subsequent to the folding of the iron oxide veins. These Precambrian and Paleozoic formations are partly covered by superficial formations represented by some lateritic crusts.

Methodology for evaluating geosites:-
We conducted a quantitative and qualitative evaluation using the criteria proposed by Lima et al. (2010) and Mariotto et al. (2020). According to Lima et al. (2010), most geosite evaluation methods use scientific value, which can be subdivided into four sub-criteria: representativeness, integrity, rarity, and also the degree of scientific knowledge about the geosite, as evidenced by the number and quality of scientific publications focused on it (Brilha, 2016). Each of these sub-criteria is evaluated independently with a numerical score ranging from 0 (none) to 1 (very high) in 0.25 increments; the final scientific value of the geosite is obtained by averaging the four criteria. In addition to scientific value, other, so-called "supplementary" values (Coratza& Giusti, 2005) can be identified and assessed: cultural, ecological, economic, aesthetic, and educational (Mariotto et al., 2023). Like scientific value, these additional values are established by a score ranging from 0 to 1 in increments of 0.25. A table is created in which the average values obtained are entered, along with the overall average value, which is the mean of the data, with the scientific value weighted twice. The data used comes from our observations and surveys conducted among the population, notably Mr. Abdoulaye Diallo, Curator of Bakel's heritage. It is supplemented by work carried out in previous programs based primarily on geology, biodiversity, history, archaeology, and tourism.

Geosites in the Municipality of Bakel: Prospects for Development:-
Based on our observations and the results of previous studies, we evaluated the criteria used by authors for the creation of geosites in this municipality. Thus, the scientific, cultural, ecological, aesthetic, and economic values were assessed for nine geosites, eight of which were anthropogenic and one hydrological (Table 1, Fig. 3). Of these identified geosites, only four obtained a score greater than 0.50 and will be described in detail. These are, in descendingorderof score: Pavillon René Caillé (René Caillé Pavilion), Fort de Bakel (Bakel Fort), « Tour Brue » or Tour du « Mont aux Pigeons » (Tower of Pigeon Hill) and Tour Descennet (Descennet Tower) or Tour du Mont aux Singes (Monkey Mountain Tower). All are colonial remains falling under the category of anthropogenic geosites, which, according to Rădulescu et al. (2019), encompass historical, cultural, archaeological, artistic, sporting, and economic geosites. They have all been listed as historical monuments of Senegal (Willane, 2019).

The Pavillon René Caillé (Fig. 4).:-
The building is perched on a hill offering a picturesque view of the entire town and the Senegal River. It is the highest point in all of Bakel. It served as a sanatorium for patients from French Sudan (Cissokho, 2017). The French explorer René Caillé, during his voyage to Timbuktu in 1824, is said to have stayed there as a patient, and the building, although older, eventually came to bear his name. The pavilion's location was later used as a training ground for adults in the area when the number of learners grew significantly. Initially, classes were held at Fort Faidherbe, and it was later, with the increasing number of students, that the area around the pavilion was used by the French to train tax collectors (Willane, 2019). It was also used as a rear base and lookout point by the Senegalese military during the Senegal-Mauritanian conflict of 1989 (Cissokho, 2017; Willane, 2019). This pavilion also served as temporary housing for refugees from Mauritania during the conflict. It was also used, in turn, as accommodation for the district chief, the Gendarmerie, and the deputy prefect. It was converted into a reading center in 1997 by the town hall, but this did not have the desired effect due to a lack of readers (Cissokho, 2017). The site is currently used as a children's playground, a garbage dump, and also as a public urinal and defecation area. Geologically, it is located on a hill composed of quartzites from the MMo4 Formation and sericite schists from the MBa1 Formation.

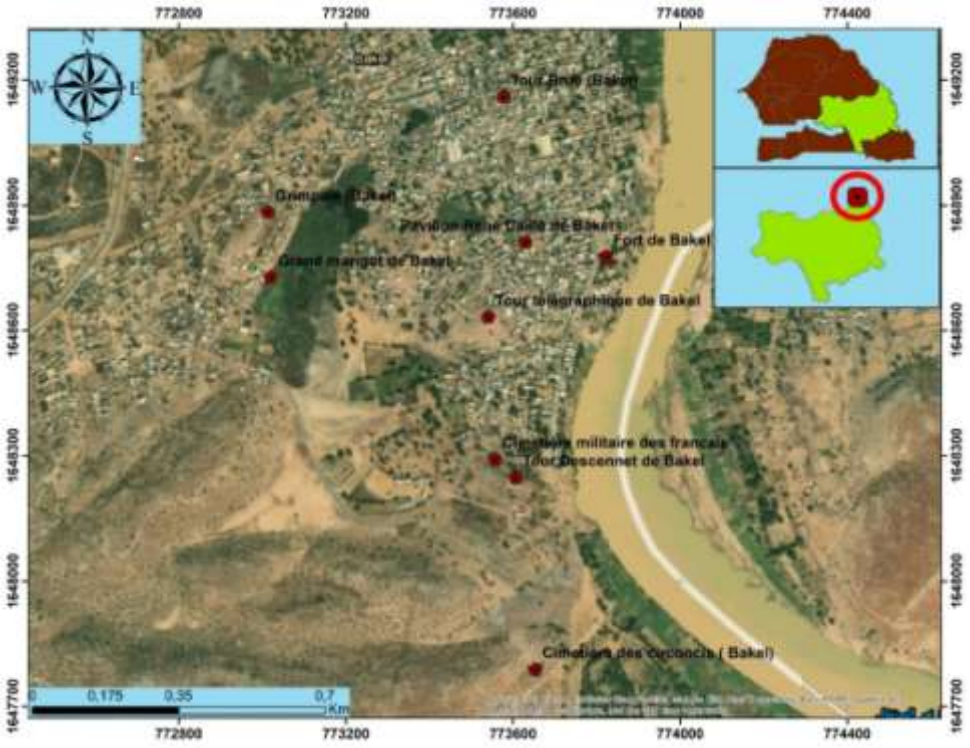

Fig. 3: Location map of the geosites identified in the municipality of Bakel

Table 1: Geosites identified in the municipality of Bakel, classified by type and in descending order of score.

N°	Geosite	Geographic coordinates	Scie	Cult	Ecol	Aest	Econ	Moy
A1	Pavillon René Caillé of Bakel	X = 773629.9 ; Y = 1648812.2	0,75	0,67	0,13	0,88	0	0,69
A2	Fort of Bakel	X = 773823.3 ; Y = 1648777.6	0,8	0,5	0,63	0,5	0,25	0,66
A3	Tour Brue (Bakel)	X = 773577.2 ; Y = 1649160.4	0,75	0,5	0,13	0,88	0	0,63
A4	Tour Descennetof Bakel	X = 773606.2 ; Y = 1648249.5	0,75	0,5	0,13	0,88	0	0,63
A5	French Military Cemetery (Bakel)	X = 773556.9 ; Y = 1648293	0,5	0,5	0,25	0,75	0	0,5
A6	Telegraph Tower of Bakel	X = 773540.5 ; Y = 1648633.3	0,55	0,5	0,13	0,5	0	0,45
A7	Cemetery of the Circumcised (Bakel)	X = 773653.3 ; Y = 1647789.5	0,65	0,13	0,13	0,63	0	0,44
A8	Grimpalé (Bakel)	X = 773013.6 ; Y = 1648884.8	0,3	0,13	0,13	0,63	0	0,29
H1	Large marsh of Bakel	X = 773020 ; Y = 1648728.6	0,4	0,13	0,13	0,63	0	0,36

Scie = scientific value; Cult = cultural value; Ecol = ecological value; Aest = aesthetic value; Econ = economic value; Moy = average value; A = anthropogenic geosite; H = hydrological geosite.

The highest score for this geosites is its aesthetic value (0.88), followed by its scientific (0.75) and cultural (0.67) value. The high aesthetic value is due to the site's open layout, its visibility from afar, and its expansive size. The high scientific value is linked to its rarity, with exceptional characteristics unique within the reference area, and its international recognition. The cultural value is a combination of its international historical importance and its lack of religious importance. Ecologically, the site has very low biodiversity and receives no protection. The site also generates no income.

Fort de Bakel (Fig. 5).:-

Fort de Bakel (also called Fort Faidherbe) was founded between 1818 and 1820 by the French (Diallo, 2021) and primarily served to supply "DouaïchMaures gum," gold, and ivory to merchants in Saint-Louis (Bah, 1981). It is built on the quartzite hill of the MMo4 Moudéri Formation, bordering the left bank of the Senegal River. The basic building materials came from the same hill. It offers a panoramic view of the landscape (the Senegal River and the surrounding plain) and the city, with cannons aimed towards the river. The Compagnie du Galam was the main trading company, followed by merchants representing the trading houses of Saint-Louis. The fort underwent modifications in the 1850s under Faidherbe. It served political, administrative, legal, commercial, and military purposes. It currently serves as the prefecture. The fort currently serves as the prefecture. It also served as a school for adults in its early years, around 1919-1920. The construction of three towers near the fort between 1855 and 1860 made Bakel the most important military post in all of Upper Senegal. This is what led to the failure of Mamadou Lamine Dramé's attack in 1886 (Bah, 1981). The three watchtowers, built on hills, allowed for control of the surrounding area.

Geologically, the dominant facies are the same as those of Pavillon René Caillé, with quartzites from the MMo4 Formation of the Moudéri Group and sericite schists (phyllonite) from the base of the Bakel Group (MBa1 Formation). In front of the prefecture building, brittle faults and associated structures, including tectoglyphs (striations, re-entrant surfaces, crush surfaces, and detachment surfaces), are visible on the quartzites. On the phyllonite, descending the hill, folded quartz veins with long and short limbs and boudinage of the limbs are found. The folds have a curved axis, with the curvature of the axis in the direction of the stretching lineation (Lahondère et al., 2010).

Fig. 4: Pavillon René Caillé. A: Building perched on a hill of sericite schist from the MBa1 formation; B: Detail of the main entrance.

The highest score for this geosite is its scientific value (0.80), followed by its ecological value (0.63). The high scientific value is due to the following: - it is highly representative of the regional geomorphology and exhibits truly exemplary qualities; - it is rare and possesses exceptional characteristics unique within the reference area; - it is of exceptional importance for education and training and - it is internationally renowned. The high ecological value is supported by ecological diversity and protection related to its occupation by the prefecture and its listing as a historical monument. The cultural value is shared between its international historical importance and the absence of religious significance. The aesthetic value is average, and the site does not generate any income.

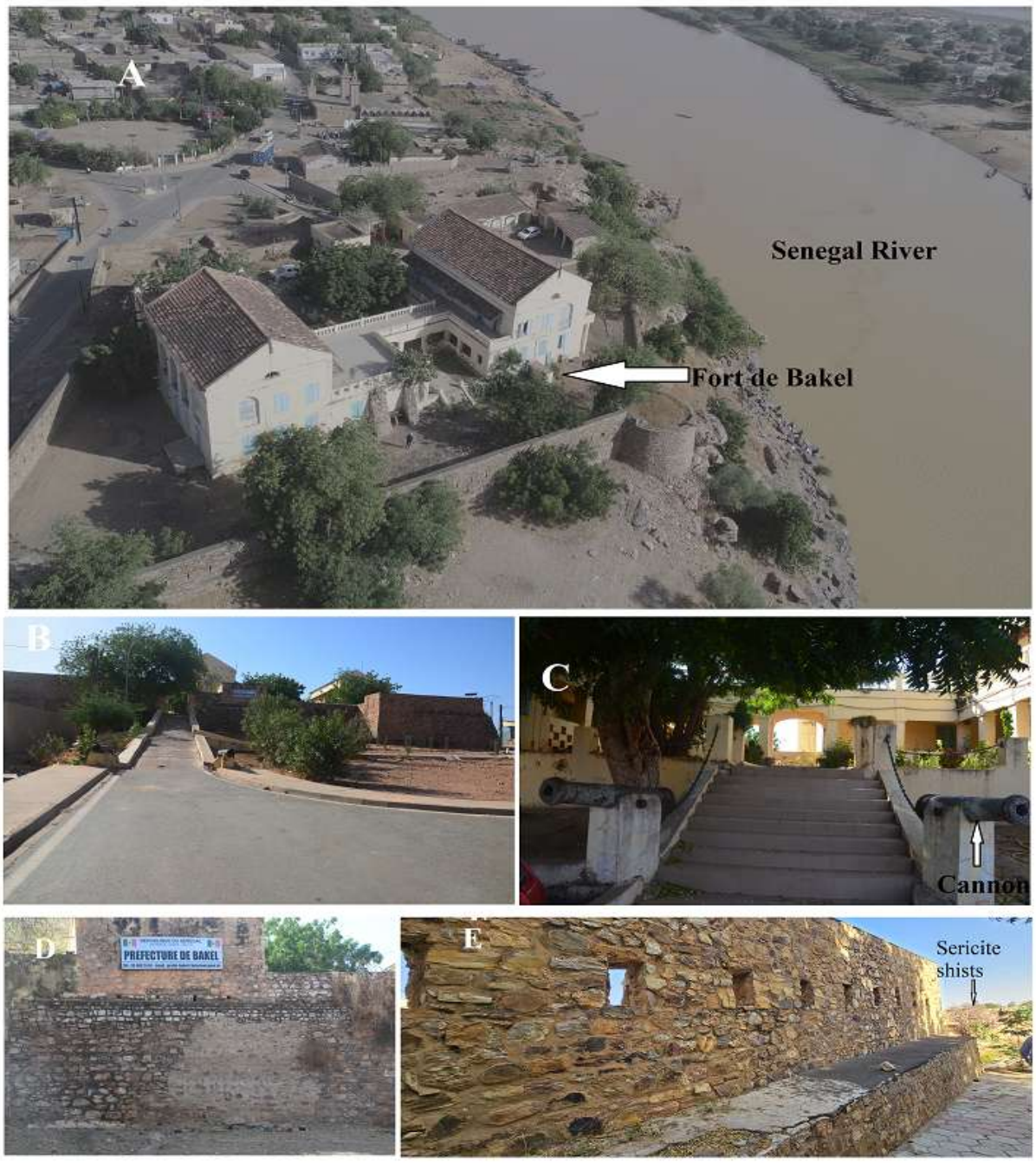

Fig. 5: Fort Faidherbe of Bakel. A: General view; B: view of the main entrance; C: Detail of the main entrance showing the cannons; D = Wall of the fort bearing the plaque of the Prefecture; E = Outcrop of sericite schists of the MBa1 formation visible at the bottom of the wall of the fort which is deteriorating.

Tour Brue or Tour du « Mont aux Pigeons » (Fig. 6).:-

The Tour Brue, or Tour du « Mont aux Pigeons », stands to the north, which is why it is also called "Tour du Nord" (North Tower). It is built on a hill in the DiabéGiddé district (Cissokho, 2017). Construction of this tower dates back to the 1820s. Its purpose was to monitor traffic to and from the villages of Tiyabu and Modinkané. The latter word means "dwellings of the marabouts" (Diallo, 2021). The tower has metal stairs leading to the top. From the summit, one can see the Pavillon René Caillé, the Tour Descennet and the Bakel water tower. It is an excellent vantage point.

The site is currently inhabited by two men. The tower is built on the quartzite hills of the MBa3 Formation of the Bakel Group. The highest score for this geosites is its aesthetic value (0.88), followed by its scientific value (0.75). The high aesthetic value stems from the site's open layout, its visibility from afar, and its expansive size. The high scientific value is linked to its international recognition and its visibility within the landscape, possessing exceptional, though not unique, characteristics within the reference area. Ecologically, the site exhibits very low biodiversity and receives no protection. Furthermore, the site generates no revenue.

Fig.6: Tour Brue in deterioration

Tour Descennet or Tour du Mont aux Singes (Fig. 7).:-
It is perched on a hill south of the city (in "Montagne Centrale" district). It was built to control the passes leading to Boundou and Kounghanyin order to defend against attacks from these areas. Upon reaching the tower, one can see the Cimetière Militaire des Français on the plain (Cissokho, 2017). A camp is noted near this tower. It is also built on a quartzite hill of the MBa3 formation of the Bakel Group.
The scores are the same as for the Tour Brue.

Geosites with a score of 0.50 or less (Fig. 8).:-
In descending order, we have:
Cimetière militaire des Français (French military Cemetery, Fig. 8A).:-
It is located not far from Fort Faidherbe. It contains the remains of French nationals who succumbed to war or malaria.

Fig.7: Tour Descennet or Tour du Mont aux Singes perched on "Montagne Centrale".

Tour télégraphique (Telegraph Tower, Fig. 8B).:-
The Jauris Tower, or telegraph tower, is located west of Fort Faidherbe. Its ruins can currently be seen in the area known as "Central Mountain" (Cissokho, 2017). It served as a communication relay point for the colonial administration.

Cimetière des circoncis (Cemetery of the Circumcised, Fig. 8C).:-
This is a space where circumcised boys who had died after sucking on tamarind fruit, a forbidden act, were buried. Subsequently, it became a gathering place for boys about to be circumcised. It is an important place for young men of the local ethnic groups before their circumcision, which constitutes an essential step in their passage to adulthood (Interview with Mr. Abdoulaye Diallo, Curator of Bakel's heritage). It is located in a plain at the foot of a quartzite hill of the MBa3 Formation of the Bakel Group. Today, the cemetery has become a garbage dump; the waste is even burned there.

Grimpalé or Sacred Hill of Ngoundéiny (Fig. 8D).:-
It is a historical and cultural site located in the present-day in Darou Salam district. It offers a panoramic view of the entire river. From there, one can see the René Caillé Pavilion, the Descennet Tower, and the SDE water tower. People live in the immediate vicinity of the site, with all the associated risks of rockfalls. It is listed among the historical monuments and sites of the Tambacounda region. It is currently being used as a garbage dump.

Fig. 8: Geosites with a score of 0.50 or less: A: Overview of the Cimetière militaire des Français (French Military Cemetery); B: Tour Télégraphique (Telegraph Tower); C: Cimetière des Circoncis (Cemetery of the Circumcised); D: Grimpalé; E: Grand Marigot de Bakel (Large Bakel marsh).

Grand Marigot de Bakel (Large Bakel marsh, Fig. 8E).:-

It is a temporary pond occupying a clay depression. During periods of high water on the Senegal River, it acts as a retention basin, posing a risk of drowning. Pollution is severe, increasing the risk of contracting diseases. During the rainy season, it shelters aquatic and semi-aquatic fauna typical of humid Sahelian environments. Market gardening activities are practiced all around it. As with the previous geosites, the highest score for this geosite is its aesthetic value, which exceeds 0.50 everywhere, followed by their scientific value. Economically, the site also generates no income.

Discussion:-

The geosites identified in the municipality of Bakel are not very diverse. Only two types were found: anthropogenic (8 geosites) and hydrological (1 geosite). Since the objective of this work was to inventory and conduct a qualitative and quantitative assessment of the geosites in the department, we used the methodology proposed by Brilha (2016). Our approach could not be the same as that of the RNDC (Youm et al., 2018), the Lake Rose (Youm et al., 2022), or the Bamboung Community Marine Protected Area (Gueye et al., 2023), which primarily focused on a single geosite. As Sallam et al. (2018) did on the Fayoum oasis in the Western Desert of Egypt, and Marescotti et al. (2022) in the UNESCO Global Geopark of Beigua (Liguria, Italy), we carried out a quantitative and qualitative assessment of the most representative sites (having a score exceeding 0.50). This allowed us to select four geosites, all anthropogenic (historical) and all listed as historical monuments of Senegal. They are distinguished primarily by their aesthetic and scientific value, followed by their cultural and ecological value. The only hydrological geosite identified is the Grand Marigot de Bakel (Bakel's Great Marsh); its low score (0.36) is dominated by its aesthetic value, followed by its scientific value.

The highest average scores obtained for aesthetic and scientific values across all the studied geosites indicate remarkable natural and geological richness, undeniable scenic beauty, and proven educational value. Conversely, only the Fort de Bakel geosite exhibits low economic value (0.25); all the others have none. This low, or even nonexistent revenue is primarily due to the underdevelopment of tourism activities, linked to insufficient and poor-quality tourist infrastructure. Added to this are the inadequacy and poor quality of transportation routes. Indeed, in the past, navigation on the Senegal River flourished between Saint-Louis in Senegal and Kayes in Mali, over a distance of 948 km. Unfortunately, the severe drought of 1973-1975, along with a lack of dredging, hampered this development, and today only the "Bou El Mogdad" ferry provides regular service, transporting tourists from Saint-Louis to Podor. This disruption of river transport was followed by a slowdown and then a stoppage of the Dakar-Bamako railway line, which crossed the Bakel department. This rich historical, cultural, geological, and hydrological heritage deserves to be preserved, promoted, and made economically viable.

The solution involves several approaches:

(i) Opening up the city through the rehabilitation of the waterway. The SOGENAV (Société de Gestion et d'Exploitation de la Navigation - Navigation Management and Operations Company) of the OMVS (Organisation pour la Mise en Valeur du fleuveSénégal - Senegal River Basin Development Organization) launched a call for tenders in September 2025 for dredging and improvement works of the navigable channel of the Senegal River from Saint-Louis (Senegal), to Ambidédi (Mali). The work is scheduled to take 30 months;

(ii) Preserving the Falémé River environment, threatened by pollution from upstream mining and by flooding; this requires a cooperative and cross-border approach;

(iii) Promoting the rich and diverse geological heritage by emphasizing the close relationship between geology and human history. Examples include historical sites built on geological formations and using subsoil rocks as construction materials. This will allow for the creation of detailed geotourism and road maps and make this heritage more visible;

(iv) Modernization and strengthening of tourist accommodations. These, as mentioned above, are listed in Bakel.

(v) Rehabilitating and protecting historical monuments. Although four sites in Bakel are listed as historical monuments of Senegal, only the Bakel fort is functional because it houses the prefecture. The others are in a state of advanced disrepair and have sometimes become garbage dumps. The local community bears a heavy responsibility in this management.

The preservation and enhancement of this natural and cultural wealth will allow the erection of several geosites in this city, the first step towards the establishment of geoparks.

Conclusion:-

In the municipality of Bakel, we identified nine geosites, eight of which are anthropogenic and one hydrological. For each geosite, we conducted an evaluation based on the criteria established by the authors for the creation of geosites. These criteria are based on scientific, cultural, ecological, aesthetic, and economic values. For each geosite, we performed a quantitative and qualitative evaluation of the most representative ones (those with a score exceeding 0.50). The highest average scores were obtained for aesthetic and scientific values across all the geosites studied. This indicates remarkable natural and geological richness, as well as undeniable scenic beauty and proven educational value. In contrast, only the Fort de Bakel exhibits economic value, and even then, it is very low. The low

revenue is mainly due to the underdevelopment of tourism activities related to the inadequacy and poor quality of tourist infrastructures, as well as the inadequacy and poor quality of transportation routes.

The enhancement and protection of this rich historical, cultural, geological, and hydrological heritage must involve all stakeholders, both state and community. This requires opening up the area by rehabilitating the railway and river routes; restoring and protecting historical monuments; adopting a cooperative and cross-border approach to protect the Falémé River environment from mining-related pollution; promoting the rich and diverse geological heritage; and strengthening and modernizing tourist facilities. These efforts will enable the city of Bakel to become an attraction that could potentially become a future geopark.

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References:-

1. Bah, T.M.(1981). Les forts français et le contrôle de l'espace dans le Haut-Sénégal-Niger (1855-1898). In: 2000 ans d'histoire africaine. Le sol, la parole et l'écrit. Mélanges en hommage à Raymond Mauny. Tome II. Paris: Société française d'histoire d'outre-mer, 1981. pp. 977-995. (Bibliothèque d'histoire d'outre-mer. Études, 5-6-2); https://www.persee.fr/doc/sfhom_1768-7144_1981_mel_5_2_989.
2. Bathily, A. (1989). Les portes de l'or: le royaume de Galam (Sénégal) de l'ère musulmane au temps des négriers (VIIIe-XVIIIe siècle), L'Harmattan, 379p.
3. Boulègue, J.(2013). Les royaumes wolof dans l'espace sénégambien: XIIIe-XVIIIe siècle. Karthala (Eds). 503p.
4. Brilha, J.(2016). Inventory and quantitative assessment of geosites and geodiversity sites: A review. Geoheritage, 8, 119–134. DOI: 10.1007/s12371-014-0139-3
5. Brilha, J., Reynard E.(2018). Geoheritage and Geoconservation. The Challenges. In Reynard E., Brilha J. (Eds): Geoheritage: assessment, protection, and management. Elsevier, Amsterdam, 433-438. DOI : 10.1016/B978-0-12-809531-7.00025-3.
6. Brocx, M., Semeniuk V.(2019). The '8Gs'—A Blueprint for geoheritage, geoconservation, geo-education and geotourism. Aust. J. Earth Sci. 66, 803–821.
7.Chevrier, B., Rasse, M., Lespez, L., Tribolo, C., Hajdas, I., Fígols, M. G., ... &Huysecom, É. (2016). West African Palaeolithic history: New archaeological and chronostratigraphic data from the Falémé valley, eastern Senegal. Quaternary International, 408, 33-52.
8. Cissé, I.(2023). Migration et développement socio-économique à Bakel (Sénégal). Revue Espace Géographique et Société Marocaine 67: 123-138. DOI : https://doi.org/10.34874/IMIST.PRSM/EGSM/36921
9. Cissokho, M.(2017). Sauvegarde et valorisation du patrimoine historique de la ville de Bakel (Sénégal). Mémoire Master, département Histoire, FLSH, UCAD – Dakar, 80p.
10. Coratza, P., Bollati, I.M., Panizza, V., Brandolini, P., Castaldini, D., Cucchi, F., Deiana, G., Del Monte, M., Faccini, F., Finocchiaro, F.(2021).Advances in Geoheritage Mapping: Application to Iconic Geomorphological Examples from the Italian Landscape. Sustainability, 13(20), 11538; https://doi.org/10.3390/su132011538.
11. Coratza, P., Giusti, C.(2005). Methodological proposal for the assessment of the scientific quality of geomorphosites. Alp. Mediterr. Quat., 18, 307–313. https://amq.aiqua.it/index.php/amq/article/view/500
12. Dia, O.(1984). La chaîne panafricaine et hercynienne des Mauritanides face au bassin Protérozoïque supérieur à Dévonien de Taoudéni dans le secteur clef de Medjeria (Taganet, Sud RIM). Thèse d'Etat, Univ. Aix Marseille, 516p.
13. Diakité, M.M.(2018). Caractérisation de la variabilité hydro-climatique dans le haut bassin du fleuve Sénégal. Thèse FLSH, UCAD, 340p.
14. Diallo, S.D.B.(2021). Wolofs et Français en pays soninké: Bakel (Sénégal) à l'épreuve des intrusions étrangères (XVIe-XXe siècles). L'Harmattan (Eds), 317p.
15. Ehsan, S., Leman, M.S., Ara Begum, R.(2012). Geotourism: A tool for sustainable development of geoheritage resources. Adv. Mater. Res. 622–623, 1711–1715. DOI: 10.4028/www.scientific.net/AMR.622-623.1711
16. Erikstad, L.(2013). Geoheritage and geodiversity management - The questions for tomorrow. Proc. Geol. Assoc. 124, 713–719. DOI: 10.1016/j.pgeola.2012.07.003
17. Fullgraf, T., Ndiaye, P.M., Théveniaut, H., Lahondère, D., Caby, R., Delor, C., Diallo, D.P., Dioh, E., Goujou, J.C., Buscail, F., Le Métour, J., Martelet, G. & Villeneuve, M. (2010). Cartegéologique à 1/200 000 du Sénégal,

feuille Bakel-Semme Sud-Ouest. Ministère des Mines, del'Industrie, de l'Agro-Industrie et des PME, Direction des Mines et de la Géologie, Dakar.
18. Gassama, A.(2025). Commune de BAKEL. http://depbakel.free.fr/?page_id=559.
19. Gueye, A., Sow, I.S., Youm, C.I., Sow, E.H., Doumbouya, M.F., Fofana, C.A.K.(2023). Evaluation of The Bamboung Community Marine Protected Area (Senegal) as a geosite.Int. j. Innov. App. Studies, ISSN 2028-9324, 39(4), 1527-1545. http://www.ijias.issr-journals.org/
20. Hose, T.,Vasiljevi´c, D.(2012). Defining the nature and purpose of modern geotourismwithparticular reference to the United Kingdom and south-east Europe. Geoheritage, 4: 25(43): 25-43. DOI: 10.1007/s12371-011-0050-0
21. Lahondère, D., Théveniaut, H., Ndiaye, P.M., Fullgraf, T., Caby, R., Blein, O.R., Delor, C., Diallo, D.P., Dioh, E., Goujou, J.C., Buscail, F., Le Métour, J., Martelet, G., Sergeev, S., Tegyey,M., Villeneuve, M., Wemmer, K.(2010). Notice explicative de la carte géologique à1/200000 du Sénégal, feuille Bakel-Semme Sud-Ouest. Ministère des Mines, de l'Industrie, del'Agro-Industrie et des PME, Direction des Mines et de la Géologie, Dakar.
22. Lécorché, J.P.(1980). Les Mauritanides face au craton Ouest-africain. Structure d'un secteur-clé: la région d'Irjibiten (est d'Akjout, République Islamique de Mauritanie). Thèse, Université Aix- Marseille III, 446p.
23. Lécorché, J.P., Dallmeyer, R.D., Villeneuve, M.(1989). Definition of tectonostratigraphic terranes in the Mauritanides, Bassarides and Rockelide orogens, west Africa. Geol Soc Am Spec Pap. 230, 131-144. DOI: 10.1130/SPE230-p131
24. Le Page, A.(1983). Les grandes unités des Mauritanides, aux confins du Sénégal et de la Mauritanie. L'évolution structurale de la chaine, du Précambrien supérieur au Dévonien. Thèse de doctorat, Université d'Aix-Marseille (France), 518p.
25. Lille, R.(1967). Etude géologique du Guidimaka (Mauritanie). Thèse et Mém. BRGM, N° 55, 399p.
26. Lima, F., Brilha, J., Salamuni, E.(2010). Inventorying geological heritage in large territories: A methodological proposal applied to Brazil. Geoheritage, 2(3): 91-99 DOI: 10.1007/s12371-010-0014-9
27. Marescotti, P., Castello, G., Briguglio, A., Caprioglio, M.C.,Crispini, L., Firpo, M. (2022). Geosite assessment in the Beigua UNESCO Global Geopark (Liguria, Italy): A case study in linking geoheritage with education, tourism, and community involvement. Land, 11(10), 1667.https://doi.org/10.3390/land11101667
28. Mariotto, F.P., Bonali, F.L., Venturini, C.(2020).Iceland, an Open-Air Museum for GeoheritageandEarth Science Communication Purposes.Resources 9(2), 14; doi:10.3390/resources9020014.
29. Mariotto, F.P., Drymoni, K., Bonali, F.L., Tibaldi, A., Corti, N., Oppizzi, P. (2023).Geosite Assessment and Communication: A Review. Resources, 12(2), 29. https://doi.org/10.3390/ resources12020029.
30. Pitfield, P.E.J., Key, R.M., Waters, C.N., Hawkins, M.P.H., Schofield, D.I., Loughlin, S., Barnes, R.P.(2004). Notice explicative des cartes géologiques et gîtologiques à 1/200 000 et 1/500 000 du Sud de la Mauritanie. Volume 1, DMG; Ministère des Mines et de l'Industrie: Nouakchott, Mauritania. [Google Scholar]
31. Rădulescu, C.C., Grecu, F., Dobre, R. (2019). Sur le concept de géosite, des préliminaires au plateau de Dobroudja du Sud. 147-166. https://www.researchgate.net/publication/336529838.
32. Reynard, E.(2004). Géotopes, géo(morpho)sites et paysages géomorphologiques, in Reynard, E., Pralong, J.-P. (eds.), Paysages géomorphologiques, Compte-rendu du séminaire de 3ème cycle CUSO 2003, Lausanne, Institut de Géographie, Travaux et Recherches, 27, 123-136.
33. Sallam, E.S.,Fathy, E.E., Ruban, D.A.,Ponedelnik, A.A.,Yashalova, N.N.(2018). Geological heritage diversity in the Faiyum Oasis (Egypt): A comprehensive assessment. J. Afr. Earth Sci., 140, 212–224. Article Google Scholar
34. Skibiński, J., Kultys, K., Baran-Zgłobicka, B., Zgłobicki, W.(2021). Geoparks in SE Poland as Areas of Tourism Development: Current State and Future Prospects. Resources, 10(11). https://doi.org/10.3390/ resources10110113.
35. Willane, T.A.(2019). Education au Patrimoine et en archéologie à Bakel (Sénégal), mémoire de master, département d'Histoire, FLSH, UCAD, 85p.
36. Xu, K., Wu, W.(2022). Geoparks and geotourism in China: A sustainable approach to geoheritage conservation and local development: A review. Land, 11(9), 1493. https://doi.org/10.3390/land11091493
37. Youm, C.I., Errami, E., Sow, E.(2018).Neoproterozoic Dindéfélo waterfall geosite (RNCD, Bassari country, Eastern Senegal): biodiversity and geodiversity between conservation and valorization. Journal of Chemical, Biological and Physical Sciences, Section D: Environmental Sciences, 8(3), 197-224. [DOI: 10.24214/jcbps.D.8.3.19724].
38. Youm, C.I., Sow, E., Errami, E, Diédhiou, Y, Gueye, A., Sarr, R. (2022).Le géosite du Lac Rose (NE Dakar, Sénégal): enjeux de la préservation d'un géopatrimoine exceptionnel menacé de disparition », Géomorphologie: relief, processus, environnement, 28(2), 93-104. https://doi.org/10.4000/geomorphologie.16878.
39. Zouros, N.(2004). The European Geoparks Network. Geological heritage protection and local development. Episodes, 27(3), 165–171. https://doi.org/10.18814/epiiugs/2004/v27i3/002.