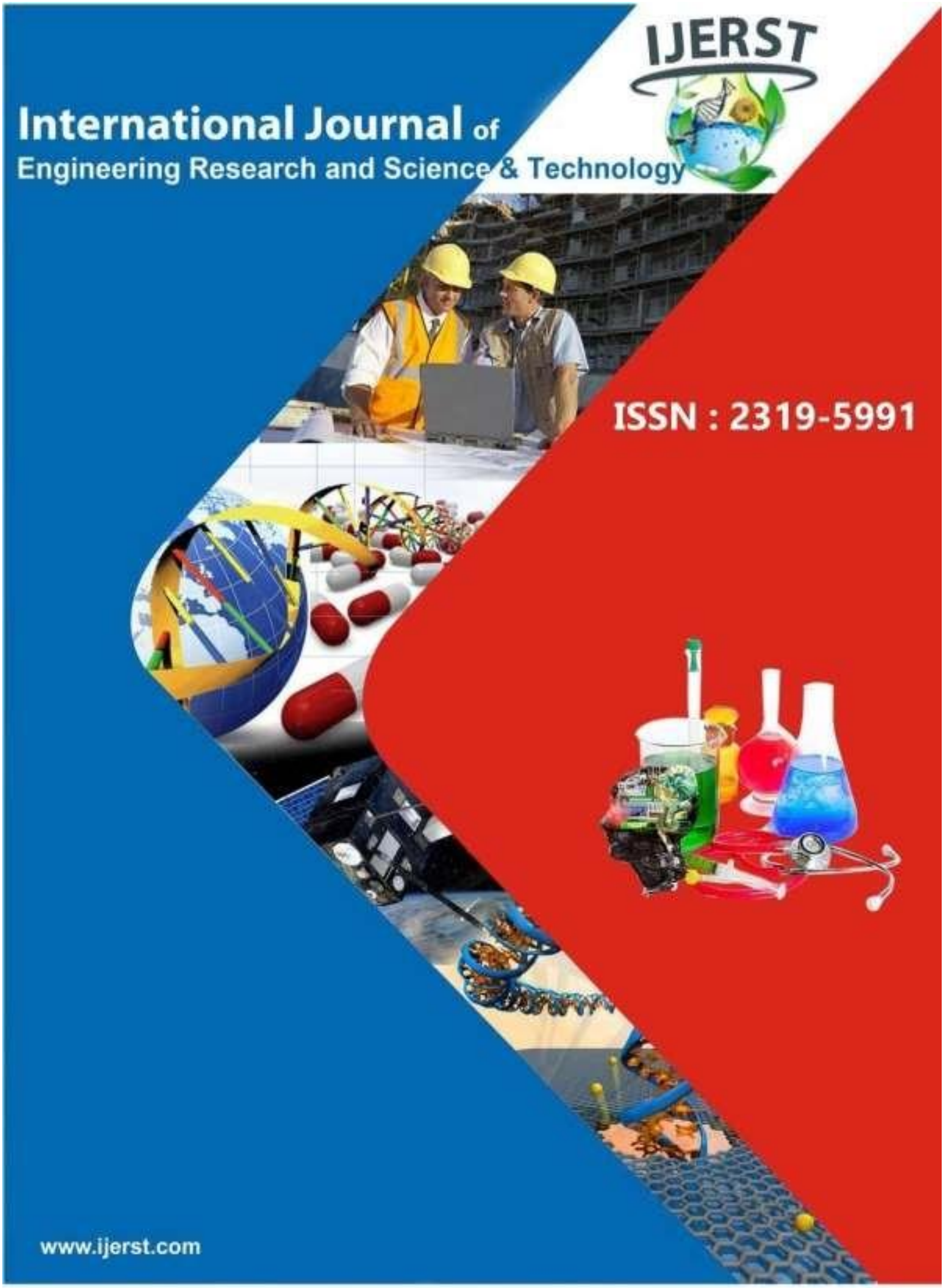

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CONTRIBUTION TO THE IDENTIFICATION AND EVALUATION OF THE HYDROELECTRIC POTENTIAL OF DEVELOPABLE WATERFALLS IN MIDDLE GUINEA

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ABSTRACT: Guinea's energy potential is immense and diverse: hydraulic power, biomass, solar and wind energy. With a very dense hydrographic network, over 1100 water ways. Guinea has a hydroelectric potential estimated at more than 6000 MW for guaranteed energy of 19300 GWh/year. To date, certain site of pico, micro and small hydroelectric power stations of developable waterfalls in Guinea still remain unidentified and evaluated by researchers and services of the National Energy Directorate. The present study is part of this dynamic, its objective is to identify and evaluate the hydroenergetic potential of unstudied developable waterfalls. The methodology adopted in this present work consists of: identifying the different developable waterfalls, evaluating the hydrological regimes and their hydroenergetic characteristics. To this end, a certain number of criteria are taken into account, which are: the criterion of proximity of the site to electrified localities; the theoretical criterion (flow and head) and the socio-economic criteria. The following results were obtained from this study: 30 sites were inventoried, including 25 sites studied and 18 validated in the region. The total gross power of the sites studied is 810.262 kW, with a minimum of 5.787 kW recorded in the locality of Korbè in Lélouma and maximum of 264 kW in the locality of Kakoni in Gaoual. The development of these waterfalls would significantly improve the energy needs of these rural areas.

Keywords - Hydroelectric power stations, potential, developable waterfall, raw power.

INTRODUCTION

Although security and access to energy remain major challenges for the West African region, important steps are being taken to improve the environment and a growing number of renewable energy projects and energy efficiency projects are being prepared in order to attract investments [1]. More than 200 clean energy mini-grids are already operational, with more on the way. At the same time, more than 130 projects, with an installed capacity of more than 7 GW of power plants connected to the network, managed by public and private actors, are currently under study or in development, several of which are already at an advanced stage. advanced [2].

Guinea's energy potential is immense and diverse: hydraulic power, biomass, solar and wind energy. With a very dense hydrographic network (1165 rivers), Guinea has a hydroelectric potential estimated at 6000 MW for guaranteed energy of 19300 GWh/year [3]. This potential is unevenly distributed across the national territory. Maritime Guinea has 7 large basins representing 2800 MW or 46% of the total potential. Middle Guinea has 7 large basins representing 2600 MW or 43%. Upper Guinea has a potential estimated at 500 MW or 8.9%. Forest Guinea has a potential of 100 MW or 2% [4].

In addition, the country has biomass resources, estimated at 30 million m3 of wood per year; with an average solar potential of 4.8 kWh/m²/day, with a wind farm which offers an average wind speed of 3 m/s and fossil fuels (oil, gas, uranium, etc.) with promising indications . The hydroelectricity sub-sector is very underdeveloped compared to the existing potential. In fact, more than 138 hydroelectric dam sites have been identified. To date, less than 8% of this potential is exploited. These resources are strongly influenced by climatic variations [5].

The Guinean hydrographic network finds its origin mainly in the mountainous regions of Fouta Djallon and Guinée Forestière. It is divided into 19 river basins, 13 of which are shared with neighboring countries. It includes 6 coastal watersheds, made up of 24 large rivers which have their sources on the western slope of the Guinean ridge. The Konkouré is the most important of these coastal basins in the country [6]. The Konkouré basin brings together the most important developable sites. This is why the country's new energy policy has prioritized the exploitation of the hydroelectric potential of the Konkouré basin. There are several sites suitable for hydroelectric development in the Konkouré basin. The most important identified are those of Garafiri, Souapiti, Kaléta and Amaria [7]. This study focuses on the losses of mini, small and micro hydroelectric power stations in Middle Guinea.

Hydroelectric power plants can be classified based on installed capacity. Generally speaking, we are talking about: Micro hydroelectric power stations for powers of less than 100 kW; Mini hydroelectric power stations for powers between 100 kW and 2 MW;

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Small hydroelectric plants for powers between 2 and 50 MW approximately; Hydroelectric power stations for powers over 10 MW.

If some authors use power for this classification, others consider that in addition to power it is important to take into account the diameter of the

Table 1: Classification of small hydroelectric power plants [9].

Types plant	Power	Flow (m^3/s)	Blade diameter (m)
Micro power	< 100 kW	< 0.4	< 0.3
Mini power	100 to 1000 kW	0.4 to 12.8	0.3 to 0.8
Small power	1 to 50 MW	> 12.8	> 0.8

MATERIALS AND METHOD

Presentation of the study area

With an area of 245857 km², the Republic of Guinea has a population of approximately twelve million inhabitants, or a density of 48 inhabitants per km². It is characterized by four large eco-climatic zones: Lower Guinea, Middle Guinea, Upper Guinea and Forest Guinea. Its hydrographic network is very dense, 1166 rivers divided into 23 watersheds including 14 international [10]. It enjoys a humid tropical climate characterized by the alternation of two seasons of unequal duration: the dry season during which the harmattan blows and the rainy season governed by the West African monsoon. The rainy season lasts 5 to 7 months (April-October) from north to south; There is a national average of 1988 mm of precipitation per year, although there are very significant variations depending on latitude, topography and continentality (4000 mm in Conakry,

blade and the equipment flow rate. This is how, in recent years, Canadian researchers have grouped Micro, Mini and Small Hydroelectric Power Plants under the name of Small Hydroelectric Power Plant [8]. Table 1 below gives this classification taking into account these three main characteristics.

930 mm in Koundara). From an administrative point of view, the country is subdivided into 7 regions (Boké, Kindia, Mamou, Faranah, Kankan, Labé, N'Zérékoré) and a Governorate (Conakry), 33 Urban Communes and 304 Rural Development Communities [11, 12].

Middle Guinea or Fouta Djallon is a region of mountains and plateaus. Its relief culminates at Mount Loura (Mali) at 1,538 m. This massif is strongly cut by valleys with interior plains and depressions. Heavily degraded soils are gradually replaced by bowé, which shrinks the extent of agricultural land. The numerous rivers which have their source here make this region the water tower of West Africa. But these watercourses are enclosed in deep valleys, hence the narrowness of the plains which house them, thus leading to difficulties in their hydro-agricultural development. The tropical climate is modified into a mountain microclimate. There is very little precipitation there. It is an area of pasture, citrus and vegetable gardens [13]. Nowadays, the degradation of the environment has pushed herders to extend transhumance as far as Lower Guinea (Boké, Boffa and Forécariah), whereas initially it was practiced between the high plateaus in the rainy season and the depressions in the season. dried. Because of its mountainous terrain and the extent of the degradation of its ecosystem, Middle Guinea is the poorest region from an agricultural point of view [14].

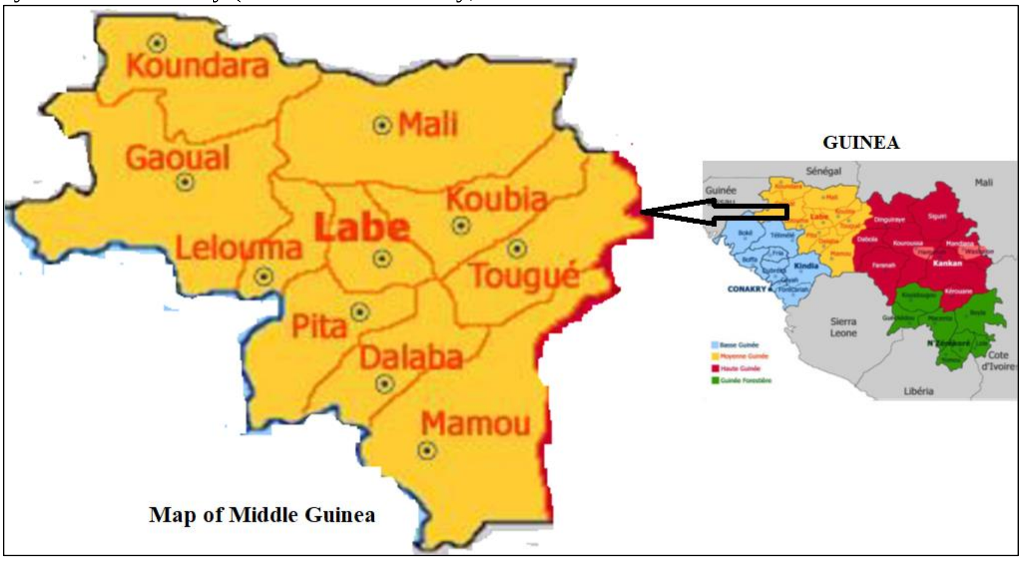

Figure 1: Presentation of the study area

MATERIALS

Several materials and equipment were used during the research, including: survey sheets, databases of the National Directorates of Energy and Meteorology, a rope (string), a tape measure or GPS, telescope (level), propeller current meter (reel), Magnetic current meter, Charts, etc.

METHODOLOGY

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The methodology adopted in this present work carried out in 2023 consists of: an inventory of sites not studied; identify the different waterfalls that can be developed, evaluate the hydrological regimes of the sites; determine the hydroenergetic characteristics of the sites.

Validation criteria for developable waterfall sites: Proximity criterion: the sites must be within a 5 km radius of the localities to be electrified ; Theoretical criterion (Flow rate - Head): the hydrological regime of the watercourse (number of months of low water) ; Isolation criterion (locality isolated from public electricity distribution networks) ; Socio-economic criterion: control of water created by the development (drinking water, agropastoral water points and irrigation).

Characteristics of validated hydroelectric sites : the geographical position: Prefecture and village in which the site was identified ; the number of households in the locality: the number of households in the villages ; the name of the watercourse and the waterfall: the names were provided to us by the populations ; the number of months of low water and flood of the river: this information was collected from wise people due to the lack of hydrological data ; the gross height of fall: is determined using a GPS, telescope and wall (topographic survey) ; the flow of the watercourse: $Q = V \times S$; hydroelectric power: $P_b = g \times \rho \times Q \times H$; $g = 9.81$ N/kg and $\rho = 1000$ kg/m^3.

FALL HEIGHT ASSESSMENT

The heights of falls were determined based on the topography of the site: for gross falls, we used a rope (string), a tape measure or GPS ; for other less rugged sites we used the telescope (level) or GPS.

The gross head (Hb) is the difference in altitude, expressed in meters (m), between the water level at the water intake (free surface level in average water) and the level of the water to the right of restitution. It is determined by relation 1 [15].

$$H_b = H_{am} - H_{av} \qquad (1)$$

With :

Hb: Gross fall height in (m); Ham: Altitude upstream; Hav: Altitude downstream.

HYDRAULIC POWER

Hydraulic power is the power supplied to the turbine by the water which feeds it [16].

$$P_b = \rho \times g \times Q \times H_b \qquad (2)$$

Where: P_h - Hydraulic power in W ; Q - Average flow rate of the watercourse in m^3/s ; H_b - Gross fall height in m; g - Acceleration of gravity in N/kg. Images of some waterfalls studied are illustrated in Figure 2.

Figure 2: Photos of some waterfalls studied

RESULTS AND DISCUSSIONS

During this study, we have 30 sites were inventoried, including 25 sites studied and 18 validated in the region. The characteristics of these sites are given in Table 2.

Table 2: classification of validated sites by prefecture

Prrfecture	Village	Number of households or family	Name of the watercourse	Number of months of low water	Gross height watercourse H_b (m)	Stream flow Q(m^3/s)	Raw site power P_b(kW)
Pita	Donghol-Touma	250	Diounghol	4	35.00	0.329	69.090
Dalaba	Ditinn	460	Ditinnwol	1	6.00	0.865	31.140
	Ditinn	350	Hérico	3	5.00	0.288	8.640
	Kébaly	500	Gilinti	2	2.66	0.693	11.048

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Mamou	Tamagale	250	Karankawol	3	10.00	0.700	42.000
Labe	Noussy	572	Farinwol	3	9.48	0.322	18.323
	Kouramangui	400	Kimbéliwole	1	8.75	0.836	43.890
Koubia	Pilimini	73	Bhoubadian	2	30.00	0.040	7.200
Mali	Téliré	283	Diogomawol	1	30.00	0.045	8.100
	Fougou	700	Nyolo	3	54.00	0.310	100.440
	Dougountouni	210	Wantankoro	1	16.23	0.595	57.952
Lelouma	Thianguel-Bory	336	Görörö	1	6.00	2.000	72.000
	Lafou	283	Bombiwole	1	4.60	0.278	7.673
	Diounti	400	Goubi	3	7.70	0.447	20.651
	Korbè	512	Louguèl	4	11.09	0.087	5.787
	Parawol	148	Botokotowol	2	23.00	0.256	35.328
Gaoual	Kakoni	380	Kakoniwol	1	10.00	4.400	264.000
	Kounsitel	200	Séribawole	6	10.70	0.109	7.000
Total	-	6307	-		-	-	810.262

The diagrams in Figure 3 show the raw powers of the sites in each village.

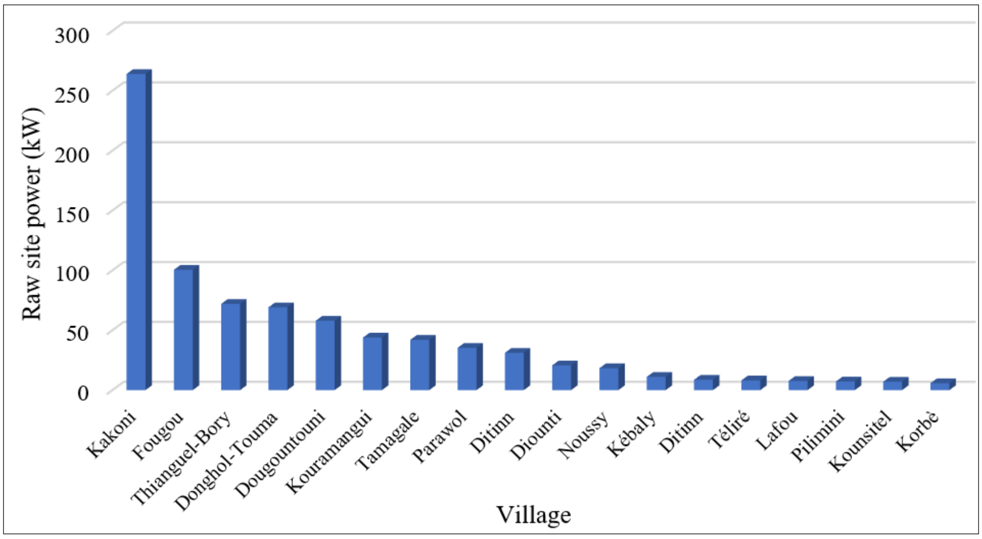

Figure 3: Raw power of each site by each village

The diagrams in Figure 4 show the numbers of households or families per village

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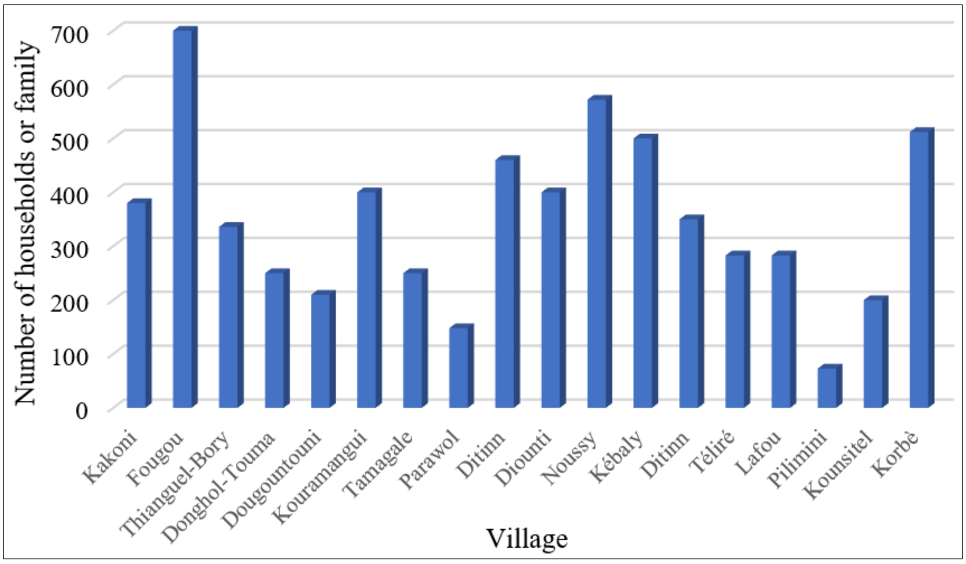

Figure 4: Number of households per village

The results illustrated in Table 1 show the total gross power of the 18 sites studied is 810,262 kW, with a minimum of 5,787 kW recorded in the locality of Korbè in Lélouma and maximum of 264 kW in the locality of Kakoni in Gaoual. The largest number of developable sites was recorded in the prefecture of Lélouma, i.e. five (5) sites, for a gross power of 141.439 kW, followed by the prefectures of Mali and Dalaba with three (3) sites each, for powers respectively of 217.582 kW and 50.828 kW. The results obtained are not exhaustive, the study focused on sites located at a maximum distance of 5 km from the localities to be electrified. Also, these results are a function of the period of study, they vary according to the seasons (dry to rainy), likewise, they depend on the entropic activities in the different regions. This requires ongoing evaluation studies of these sites. In addition to the domestic service of using these energy potentials, we could set up agro-industrial units in these isolated areas.
The diagrams in Figure 4 show the numbers of households or families per village, these numbers of households vary from 73 for the village of Pilimini to 700 for the village of Fougou, the total number of households in the villages for the sites evaluated is 6307 (table 1).

CONCLUSION

The non-existence of databases on hydrology and meteorology constitutes a handicap for an exhaustive study of the various sites of developable waterfalls. However, from a perspective of using the numerous sites available throughout the territory, a method for estimating potential and evaluating the technologies to be used remains an essential necessity. It is in this sense that the results obtained are of capital importance for the sustainable development of Guinea.

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