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Identification of Optimal Dam Sites in Guinea Using a Digital Elevation Model (DEM)

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Abstract

Rural electrification in Guinea remains constrained by limited energy access, despite the country's substantial and largely untapped hydropower potential, particularly in the upper catchments of major West African river systems. This study develops a GIS-based morphometric screening framework to identify and prioritise candidate hydropower dam sites in the Guinean headwaters of the Senegal River basin. A 30 m Shuttle Radar Topography Mission (SRTM) digital elevation model was hydrologically conditioned and used to derive drainage pathways, flow accumulation, catchment boundaries and terrain attributes. Thirty-four sub-basins were characterised using key morphometric and topographic indicators, including contributing area, elevation range, total head difference, stream-segment length and mean slope. The relief structure proved highly heterogeneous, with slopes ranging from approximately 1% to more than 25% and elevation differences reaching 329.70 m. This geomorphic variability creates favourable conditions for localised hydraulic-head development, particularly in elevated sectors where drainage convergence, valley confinement and steep gradients coincide. Thirty-four candidate dam sites were identified, mostly distributed between 800 and 1500 m above sea level. Among the sub-basins analysed, BV2, BV3, BV4, BV7 and BV13 exhibit the strongest preliminary potential, combining relatively large contributing areas with pronounced altitudinal amplitude and favourable channel gradients. The findings demonstrate the value of remote-sensing-derived terrain analysis for early-stage hydropower reconnaissance in data-scarce regions. The proposed sites should nonetheless be regarded as pre-feasibility targets rather than final engineering locations, since detailed hydrological, geotechnical, environmental and socio-economic assessments remain necessary. The framework provides a reproducible spatial basis for prioritising field investigations and for supporting sustainable small- to medium-scale hydropower planning in Guinea.

Keywords

Hydropower Potential, GIS-Based Screening, Morphometric Analysis, SRTM Digital Elevation Model, Senegal River Basin, Rural Electrification, Guinea

1. Introduction

Guinea sits atop one of the richest freshwater systems in West Africa, yet millions of its rural inhabitants have never had reliable access to electricity. Although the country's hydroelectric potential is estimated at several thousand megawatts, its electrification rate remains among the lowest in the region, and rural communities still rely on wood fuel and kerosene for their everyday energy needs [1]. This paradox of abundant water and scarce power is the starting point of the present work: the challenge is not the resource itself, but the lack of systematic information on where that resource can realistically be harnessed.

The Fouta Djallon massif, often called the water tower of West Africa, gives rise to the Senegal, Niger and Gambia rivers [2]. Its rugged relief, dense drainage network and high seasonal rainfall make it a natural setting for decentralised micro-hydropower, a technology particularly well suited to remote communities thanks to its low unit cost, limited environmental footprint and modular scalability [3]. Turning this broad potential into concrete projects, however, first requires pinpointing the reaches where topographic and hydrological conditions converge most favourably.

Locating such sites has traditionally relied on costly and time-consuming field campaigns. The wide availability of free, global digital terrain models notably the 30 m Shuttle Radar Topography Mission (SRTM) dataset has changed this picture profoundly. SRTM-derived DEMs are now used routinely for basin delineation, watershed morphometry and hydraulic-head estimation, even where ground surveys are sparse [4] [5]. Building on the quantitative geomorphology introduced by Horton [6] and Strahler [7] and later adapted to GIS by Moore *et al.* [8] and Maidment [9], terrain analysis alone can now provide a rigorous and reproducible basis for ranking candidate dam sites [10] [11].

We apply this framework to the Guinean portion of the Senegal River basin. The primary aim is to identify and spatially prioritise sites suitable for small-scale dam construction through a systematic DTM-based analysis, thereby providing a scientific foundation for hydraulic planning in a territory where the Senegal River Development Authority (OMVS) has long acknowledged an untapped micro-hydropower potential [12] [13]. Beyond this applied objective, the study offers a reproducible methodological template that can be transferred to other data-scarce basins across the West African Sahel.

2. Materials and Methods

2.1. Study Area

The study domain corresponds to the Guinean headwaters of the Senegal River basin, in the Fouta Djallon highlands of Middle Guinea (**Figure 1**). It lies between latitudes 10˚20' and 12˚30' N and longitudes 8˚50' and 12˚20' W, covering roughly 33,000 km^2 across three principal sub-basins: the Bafing (≈19,500 km^2), the Bakoye (≈7900 km^2) and the Falémé (≈5600 km^2) [12] [14]. Together, these tributaries supply more than 80% of the mean annual discharge of the Senegal River, which underscores the pivotal hydrological role of Guinean territory at the basin scale.

Relief within the area is strongly contrasted. Elevation rises from about 132 m on the lowland periphery to more than 1400 m a.s.l. in the Labé-Mamou highlands, producing a dense and deeply incised drainage network. Annual precipitation ranges between 800 and 1800 mm under a humid tropical, Sudano-Guinean climate with a sharply defined wet season [15]-[17]. Steep gradients, high rainfall and abundant streamflow are precisely the conditions that make small hydropower viable, and they have already drawn the attention of development planners and prompted earlier reconnaissance by OMVS [12]. The resident population is largely rural and agro-pastoral, with livelihoods closely tied to seasonal water availability [13] [18].

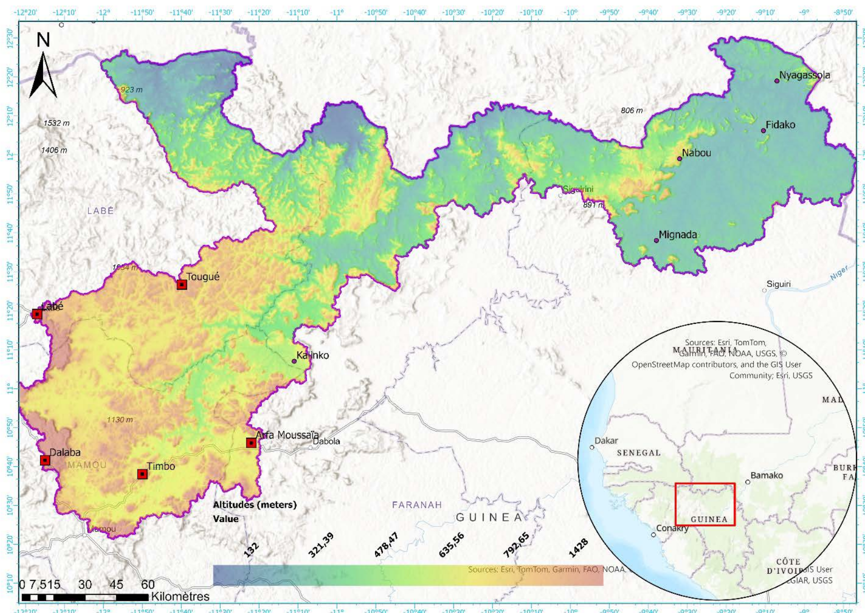

Figure 1. Geographic location, relief and hydrographic network of the study area.

2.2. Data and Pre-Processing

We used the SRTM Version 3.0 DEM at 30 m spatial resolution, obtained from the NASA Earthdata portal and mosaicked to cover the entire study domain. Before any hydrological analysis, the raw DEM was conditioned by filling artificial sinks with the Fill tool of ArcGIS Pro 3.0 [19], a step that is essential for obtaining a hydrologically consistent surface across which flow paths can be traced without interruption [20]. The suitability of the SRTM dataset for this purpose is well established, its accuracy and consistency across West African landscapes having been documented in several comparative studies [5].

2.3. Hydrological Modelling and Network Extraction

Flow direction was derived from the conditioned DEM using the D8 algorithm, which routes water from each grid cell to the steepest of its eight neighbours [4] [20]. Flow accumulation was then computed to map hydrological convergence across the basin, and the drainage network was extracted by applying an accumulation threshold calibrated to basin size and drainage density [9] [10]. The resulting channel network was segmented into homogeneous longitudinal reaches, following the quantitative geomorphology of Moore *et al.* [8] and the stream-ordering schemes of Horton [6] and Strahler [7].

For each reach, we extracted four altimetric attributes from the DEM: maximum elevation (Max Z), minimum elevation (Min Z), total elevation change (ΔZ = Max Z − Min Z, used as a proxy for available hydraulic head) and reach length. Mean slope was calculated as ΔZ divided by reach length and expressed as a percentage. Reaches were then ranked by ΔZ within each sub-basin, and the highest-ranking sections provided they carried perennial flow, as inferred from accumulation thresholds and network continuity were retained as candidate dam sites [4] [9] [10].

Three limitations are inherent to this approach. First, the 30 m DEM resolution smooths fine-scale terrain features that may matter at the engineering stage. Second, the geometry of the extracted network depends on the chosen accumulation threshold and may not reproduce the actual hydrographic network exactly. Third, no field discharge measurements were available to validate the hydrological modelling. The outputs should therefore be treated as a preliminary screening layer, to be confirmed through field survey and hydrological monitoring [4] [5].

2.4. Composite Suitability Score

Each candidate reach is rated by a composite suitability score that combines three morphometric drivers of run-of-river potential: reach gross head H^g, mean channel gradient G, and contributing area A. These variables are expressed in different units and cover very different ranges—head in metres, gradient in m km^{-1}, area spanning three orders of magnitude—so they are first placed on a common 0~1 scale by min-max normalisation. For a variable x across the 34 retained reaches:

$$xnorm = \frac{x - x\min}{x\max - x\min} \tag{1}$$

Contributing area is highly right-skewed (a few basins exceed 10^3 km^2 while the median is ≈ 183 km^2), so it is log-transformed before normalisation; head and gradient are normalised on their linear scale:

$$Anorm = \frac{\log 10A - \log 10A\min}{\log 10A\max - \log 10A\min} \tag{2}$$

The composite score S (0 - 100) is the weighted sum of the three normalised drivers:

$$S = 100 \times \left(wH \cdot Hg, norm + wG \cdot Gnorm + wA \cdot Anorm \right), wH + wG + wA = 1 \quad (3)$$

with weights summing to unity. The weights reflect the physical hierarchy of controls on small run-of-river schemes, in which available energy scales directly with head and steep gradients concentrate that head over a short, low-cost conveyance line, whereas contributing area acts only as an indirect, unvalidated proxy for discharge in the absence of flow records [21]-[24]. Head is therefore given the largest weight, gradient the second, and area a deliberately modest weight so that a large but low-head basin cannot dominate the ranking on size alone.

3. Results

3.1. Topographic Structure of the Basin

The Guinean Senegal headwaters display a strongly differentiated altitudinal organisation (Figure 2). Elevations range from 132 m at the basin margin to 1428 m a.s.l. in the south-western highlands, tracing a gradient that broadly governs the architecture of the entire drainage system. The Labé-Mamou uplands act as the engine of the basin: steep slopes, high relief energy and abundant rainfall combine to generate rapid runoff, drive channel incision and sustain active headwater drainage. North-eastward, elevations fall progressively into the 250 - 650 m range, where drainage lines converge and widen into the principal river channels.

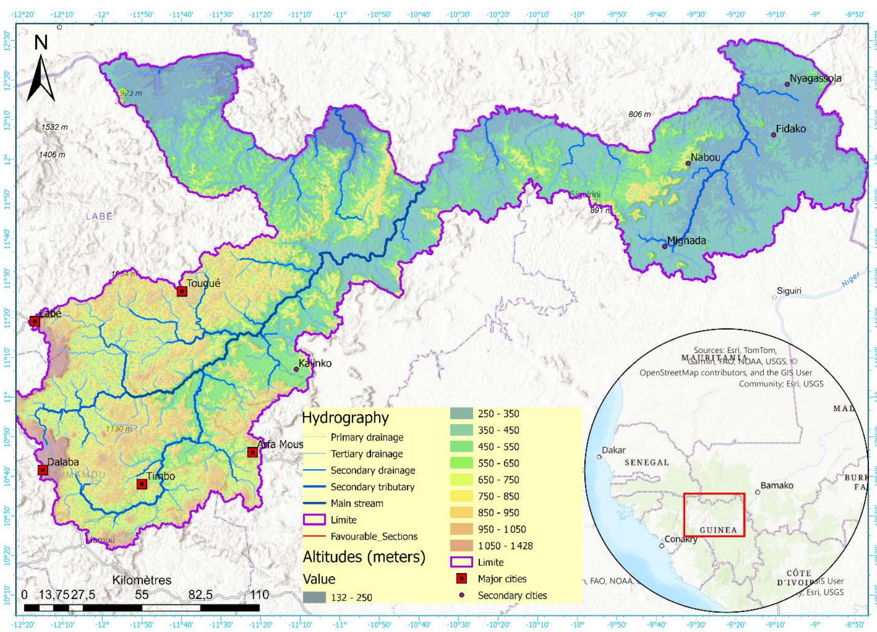

Figure 2. Spatial distribution of elevation classes and the hydrographic network. Elevation spans approximately 132 to 1428 m a.s.l. The south-western highlands form the main runoff-generation zone, whereas the northern and eastern sectors act as downstream transfer corridors. Highlighted reaches indicate sections identified as potentially suitable for hydraulic development.

Between these extremes, an intermediate belt (550 - 850 m) is of particular interest for planning. Here, upstream runoff has already concentrated into coherent channel networks, yet valley gradients remain steep enough to yield exploitable hydraulic head. It is in this transitional zone where relief, drainage convergence and valley confinement align that conditions most favour water-retention structures.

3.2. Slope Distribution and Its Implications for Favourable Dam Location

Slope analysis adds a second layer of discrimination to the topographic picture (**Figure 3**). Gentle to moderate slopes characterise valley floors, alluvial corridors and the lower reaches of the main tributaries—settings where flow velocity decreases, sediment settles and surface water accumulates. These are the zones where dam construction is physically feasible, provided hydraulic head is sufficient. Transitional hillslopes form the lateral boundaries of the drainage corridors and act as conduits for hillslope-channel connectivity, feeding the stream network rapidly during heavy rainfall [25] [26].

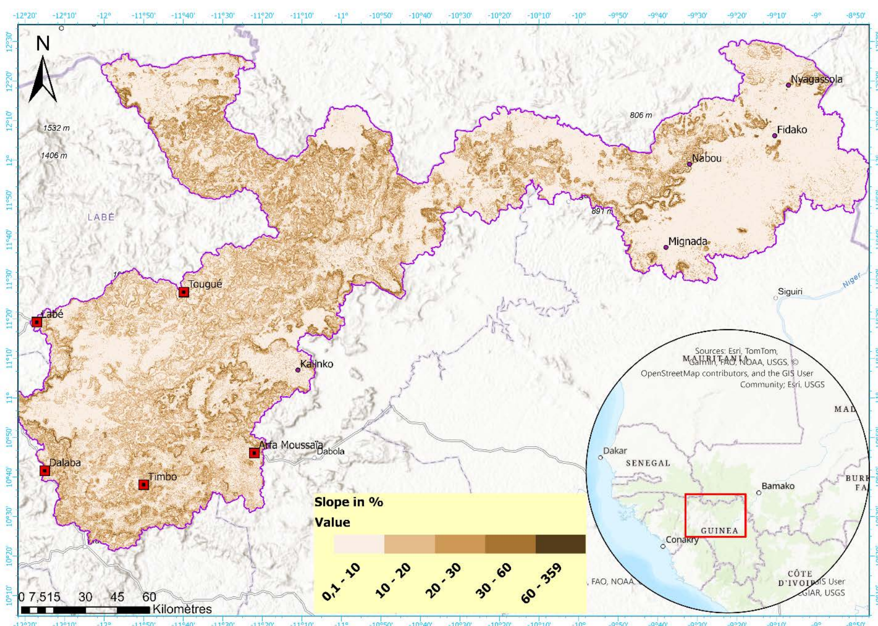

Figure 3. Slope classification and drainage network. Five slope classes are mapped against the hierarchical drainage network. Low-gradient valley corridors emerge as the most suitable zones for hydraulic structures, whereas steep upland sectors, despite their energy potential, present significant engineering challenges.

Steep terrain is widespread in the dissected headwaters and along fault-controlled escarpments. Such slopes signal high relief energy, and therefore high hydraulic potential, but they also impose serious engineering constraints: elevated erosion rates, bank instability and heavy bedload transport all raise the risk of rapid reservoir siltation and infrastructure damage [27]-[29]. The most promising dam locations therefore lie not in the steepest terrain but in the transitional reaches immediately downstream, where gradients remain meaningful while valley geometry becomes manageable.

3.3. Candidate Dam Sites and Drainage Hierarchy

Overlaying the drainage hierarchy on the morphometric ranking produces a clear spatial pattern (**Figure 4** and **Figure 5**). The 39 candidate sites cluster along the mid-elevation reaches of the principal tributaries, between 800 and 1500 m altitude, precisely where contributing area, hydraulic head and valley confinement reach their most favourable combination. No sites were retained in the flat lowland reaches, where hydraulic head is insufficient.

The distribution also mirrors drainage hierarchy: candidate sites are disproportionately associated with second- and third-order streams, where accumulated flow is already substantial but channel gradients have not yet flattened. Confluence zones are especially well represented, since they combine large contributing areas with morphological constraints that naturally favour impoundment. The composite screening score (0 - 100), which integrates gross head, channel gradient and contributing area, ranks these locations consistently; the ten leading candidates are summarised in **Table 1**, and the full inventory of the 34 highest-ranked sites is given in **Table 2**.

Each of these locations should be treated as a first-pass target rather than a confirmed engineering site. Before any construction decision, thorough investigations are required: multi-year streamflow records, geological mapping, geotechnical assessment of foundation soils, slope-stability analysis, sediment-budget estimation, reservoir-capacity modelling, and a full environmental and social impact assessment.

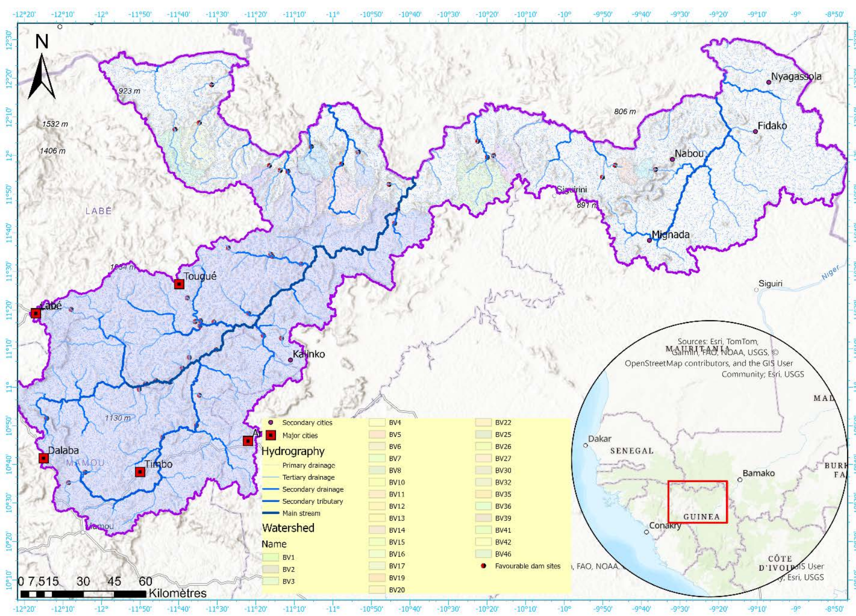

Figure 4. Candidate dam sites plotted against the drainage network of the Guinean Senegal River basin.

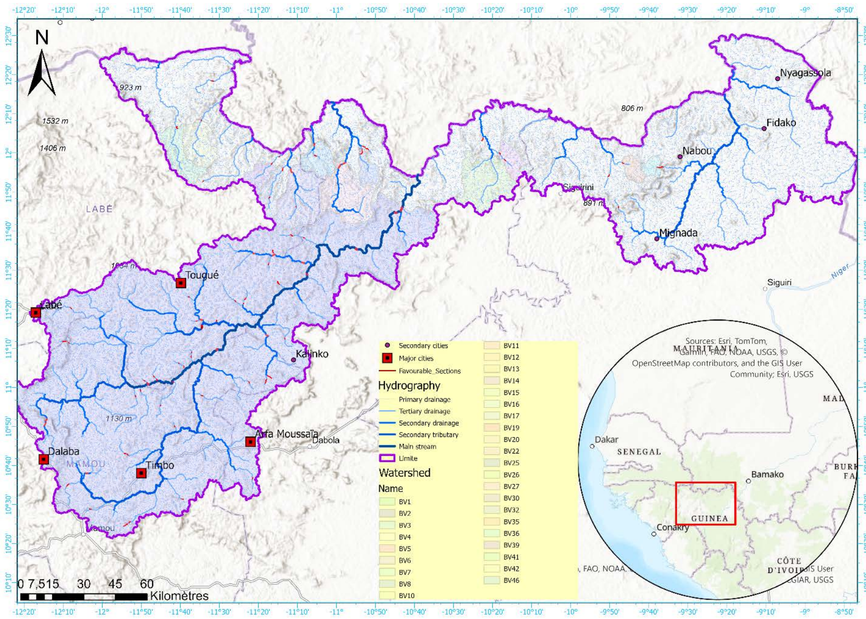

Figure 5. Favourable river sections identified through the morphometric screening.

Table 1. The ten highest-ranked candidate dam sites, ordered by composite screening score. The score (0 - 100) integrates gross head, channel gradient and contributing area.

Rank	Site	Catchment	Suitability class	Score
1	**HPP_012**	BV4	Very high priority	**88.8**
2	**HPP_019**	BV12	Very high priority	**80.6**
3	**HPP_005**	BV42	Very high priority	**75.1**
4	**HPP_008**	BV30	High priority	**62.8**
5	**HPP_006**	BV41	Moderate priority	**60.4**
6	**HPP_016**	BV8	Very high priority	**58.8**
7	**HPP_009**	BV32	High priority	**53.6**
8	**HPP_034**	BV2	Moderate priority	**52.0**
9	**HPP_002**	BV48	High priority	**49.9**
10	**HPP_011**	BV3	Preliminary interest	**46.2**

3.4. Morphometric Parameters of the Studied Sub-Basins

Table 2 summarises the morphometric and topographic attributes of the 34 highest-ranked candidate sites. The data confirm the extreme range of conditions already apparent from the maps: ΔZ spans from below 25 m in the flattest basins to 329.70 m in BV2, BV7 and BV13, while slopes vary by an order of magnitude across the dataset. This heterogeneity is not random; it traces the underlying geomorphological zonation of the massif and provides the empirical basis for the three-tier classification developed in the Discussion.

Table 2. Morphometric and topographic attributes of the 34 highest-ranked candidate dam sites derived from the SRTM DEM. Coordinates are in UTM (m); Head denotes gross head (ΔZ) and Gradient is the mean channel slope. Suitability classes follow the composite screening score.

Site	Catch.	Area (km²)	X (m)	Y (m)	Head (m)	Grad. (m/km)	Score	Class
HPP_001	BV36	70	425,582	1,321,055	32.5	28.1	**27.5**	Moderate priority
HPP_002	BV48	94.4	409,339	1,315,893	44.5	73.7	**49.9**	High priority
HPP_003	BV47	42.4	350,156	1,333,273	21.8	16.9	**17.6**	Preliminary interest
HPP_004	BV27	128	359,771	1,329,846	22.1	70.3	**38.2**	Preliminary interest
HPP_005	BV42	265	219,550	1,343,331	69.6	158.2	**75.1**	Very high priority
HPP_006	BV41	280	208,298	1,340,549	39.7	108.1	**60.4**	Moderate priority
HPP_007	BV39	117	252,138	1,322,490	31.6	51.0	**36.0**	Moderate priority
HPP_008	BV30	502	263,901	1,321,151	40.4	93.0	**62.8**	High priority
HPP_009	BV32	151	256,994	1,320,422	48.2	75.7	**53.6**	High priority
HPP_010	BV48	224	167,226	1,189,279	15.4	19.7	**19.1**	Preliminary interest
HPP_011	BV3	2461	186,658	1,195,734	17.6	49.6	**46.2**	Preliminary interest
HPP_012	BV4	3534	205,954	1,203,307	69.5	97.4	**88.8**	Very high priority
HPP_013	BV5	162	218,681	1,213,220	24.0	36.9	**28.1**	Preliminary interest
HPP_014	BV6	101	189,981	1,216,184	26.0	83.0	**44.1**	Moderate priority
HPP_015	BV7	3514	166,303	1,258,078	17.1	10.3	**32.1**	Preliminary interest
HPP_016	BV8	47.2	196,214	1,228,011	72.4	62.0	**58.8**	Very high priority
HPP_017	BV10	182	205,159	1,219,749	24.1	28.4	**25.6**	Preliminary interest
HPP_018	BV11	74.5	205,145	1,233,279	20.8	22.9	**19.9**	Preliminary interest
HPP_019	BV12	63.8	216,530	1,236,574	88.6	102.7	**80.6**	Very high priority
HPP_020	BV13	8663	166,303	1,258,078	17.1	10.3	**32.1**	Preliminary interest
HPP_021	BV14	478	224,852	1,278,992	16.6	54.4	**36.9**	Preliminary interest
HPP_022	BV15	1166	184,909	1,273,450	15.7	29.2	**38.1**	Preliminary interest
HPP_023	BV16	659	253,438	1,242,081	21.9	37.6	**37.3**	Preliminary interest
HPP_024	BV17	54.2	257,552	1,240,328	15.8	42.4	**23.8**	Preliminary interest
HPP_025	BV8	292	227,593	1,268,207	29.7	40.7	**34.9**	Moderate priority
HPP_026	BV19	681	245,818	1,288,743	15.6	50.9	**39.2**	Preliminary interest
HPP_027	BV20	174	310,671	1,294,285	15.4	12.6	**15.6**	Preliminary interest
HPP_028	BV22	495	286,325	1,323,012	16.7	33.7	**30.0**	Preliminary interest
HPP_029	BV25	110	293,963	1,329,228	16.6	22.6	**18.4**	Preliminary interest
HPP_030	BV26	513	354,746	1,325,707	15.4	18.7	**24.5**	Preliminary interest
HPP_031	BV35	92.2	419,360	1,324,020	21.6	26.2	**21.8**	Preliminary interest

Continued

HPP_032	BV46	185	272,759	1,331,764	17.1	73.9	**38.1**	Preliminary interest
HPP_033	BV1	95.3	155,794	1,171,861	39.0	62.1	**43.2**	Moderate priority
HPP_034	BV2	15,228	304,744	1,305,170	29.3	49.6	**52.0**	Moderate priority

4. Discussion

4.1. From Favourable Reaches to Preliminary Siting

The screening delineated favourable reaches across the investigated watersheds and, for each of them, defined a preliminary powerhouse location as the geometric midpoint of the reach, computed from its start and end coordinates. This convention gives every site a reproducible spatial reference for mapping, ranking and field planning, but the resulting coordinates are pre-feasibility markers, not final engineering positions. GIS-based screening is now standard practice for identifying hydropower opportunities at basin, regional or continental scales; the consistent message of that literature is that screening must be followed by hydrological modelling, environmental assessment, economic evaluation and field validation before any development decision [23] [24] [30].

4.2. Morphometric Controls on the Candidate Sites

Contributing area varies strongly across the candidate watersheds, from 42.45 km^2 to 15,228.17 km^2, with a mean of 1,202.87 km^2 but a median of only 183.20 km^2. The gap between mean and median reveals a right-skewed distribution dominated by a handful of large basins. Catchment area matters because it conditions runoff production and long-term water availability, yet on its own it is a poor proxy for hydropower potential. Theoretical output depends primarily on discharge and head, $P = \rho g Q H \eta$, where P is power, ρ water density, g gravitational acceleration, Q discharge, H head and η overall efficiency [21] [22]. A small basin with a high head may therefore be more attractive than a large basin with a low one—unless the latter sustains a high flow permanence.

Gross head ranges from 15.38 to 88.61 m (mean 30.27 m, median 22.04 m), so the dataset is dominated by low- to medium-head opportunities with a smaller high-head subset. Gross head is a legitimate first-order filter, since available energy grows with head, but it must not be mistaken for net head, which remains only after hydraulic losses in the intake, penstock, conveyance and turbine are subtracted. Because measured or modelled discharge is not yet available, these results identify topographically favourable sites without quantifying installable power—a limitation shared by comparable studies, which stress that dependable feasibility analysis needs both head and flow-duration information, typically the Q50, Q75, Q90 or Q95 values appropriate to the target reliability [24] [30] [31].

Reach gradient is equally variable, from 10.28 to 158.16 m km-1 (mean 51.55, median 45.99 m km^{-1}), the steepest values occurring at HPP_005/BV42, HPP_006/BV41 and HPP_019/BV12. Steep reaches concentrate head over short distances, which suits run-of-river schemes and can shorten the conveyance line; but they also tend to coincide with geomorphic instability, high sediment transport, bank erosion and difficult access for civil works. Gradient is thus best read as both a technical opportunity and a field-verification priority, the same dual role that earlier GIS studies assign to slope, head and network geometry before final selection [23] [24] [32].

4.3. Site Ranking

Four sites stand out as very high priority: HPP_012/BV4, HPP_019/BV12, HPP_005/BV42 and HPP_016/BV8 (**Table 1**), each combining high gross head and/or high gradient. HPP_012/BV4 leads with a score of 88.8/100, a gross head of 69.50 m, a gradient of 97.42 m km^{-1} and a basin area of 3534.38 km^2, a rare pairing of strong topographic energy with a large contributing area. HPP_019/BV12 follows, holding the highest gross head in the database (88.61 m) despite a modest area of 63.79 km^2; HPP_005/BV42 records the steepest gradient (158.16 m km^{-1}); and HPP_016/BV8 couples a high head of 72.43 m with a moderate-to-high gradient of 61.96 m km^{-1}.

A second group: HPP_008/BV30, HPP_009/BV32 and HPP_002/BV48 carries gross heads of 40.39 - 48.19 m and gradients of 73.74 - 92.95 m km^{-1}. These sites merit retention as robust back-ups: they could overtake the leaders if their hydrological reliability, access or environmental setting proves more favourable. Of the seven moderate-priority sites, HPP_034/BV2 warrants particular attention because it drains the largest basin in the dataset (15,228.17 km^2). Its head is only moderate (29.25 m), yet its very large catchment may confer a discharge advantage that the topographic score cannot capture a reminder that prioritisation should not rest on head and gradient alone, and that mature site-selection increasingly blends technical, economic, environmental and social criteria through spatial multi-criteria decision analysis [33] [34].

The remaining sites fall into a preliminary-interest class. Their lower topographic scores do not warrant outright exclusion: low- and medium-head schemes remain relevant for micro-hydropower, rural electrification, multipurpose water infrastructure and decentralised supply where flow permanence and local demand are favourable. Small hydropower is typically run-of-river and can serve remote communities well, but its viability is strongly site-specific, hinging on hydrology, civil-works cost, grid access, environmental constraints and operating requirements [21]-[23].

4.4. What the Score Does and Does Not Capture

The correlation structure confirms that the screening score is driven by morphometry. It correlates strongly with gross head ($r \approx 0.845$) and gradient ($r \approx 0.858$) but only weakly with basin area ($r \approx 0.154$). This is internally coherent, since the database chiefly encodes topographic suitability, yet it also exposes the method's principal blind spot: the highest-ranked sites are not necessarily those with the greatest annual energy production. Sites with moderate head but large, hydrologically reliable catchments could climb the ranking once discharge is modelled. The logical next step is therefore to bring in observed flow series where they exist, rainfall-runoff modelling for the ungauged basins, and flow-duration curves an approach for which coupling GIS with hydrological models such as SWAT has proven effective in estimating flow availability at different exceedance probabilities [24] [31] [32].

4.5. Environmental Considerations

The database is best understood as a first screening layer, not a development plan. Sound hydropower planning must weigh environmental flow, sediment continuity, aquatic habitat integrity and longitudinal connectivity. A large body of ecological work shows that natural flow regimes underpin riverine habitat, biodiversity and ecosystem function, and that flow alteration can cascade through fish, invertebrates, riparian vegetation and floodplain processes [35] [36]. Basin-scale syntheses further show that dams and reservoirs fragment river networks and erode free-flowing connectivity, which makes environmental screening indispensable even for renewable projects [37]-[39].

4.6. Implications for Renewable-Energy Planning

These results speak directly to renewable-energy strategy. Hydropower remains a major, dispatchable and flexible source of renewable electricity, well placed to stabilise power systems and complement variable solar and wind; recent assessments confirm that it is still the largest renewable source and that conventional and pumped-storage plants can supply valuable flexibility and storage as systems evolve [40]. That strategic value does not relax the need for strict sustainability safeguards. For the study area, the most defensible reading is that HPP_012/BV4, HPP_019/BV12, HPP_005/BV42 and HPP_016/BV8 are first-order candidates for detailed hydrological and field investigation; HPP_008/BV30, HPP_009/BV32 and HPP_002/BV48 form a robust second tier; and HPP_034/BV2 should be carried forward for hydrological verification, its large catchment potentially offsetting a moderate topographic score.

Taken together, the database offers a reproducible, spatially explicit and publication-ready basis for preliminary hydropower prioritisation. Its strength is the systematic identification of favourable reaches and preliminary plant coordinates; its main limitation is the absence of measured or modelled discharge, which precludes any estimate of installed capacity, annual energy or firm power. A rigorous follow-up should integrate (i) flow-duration curves; (ii) rainfall-runoff modelling for ungauged basins; (iii) net-head correction; (iv) turbine suitability; (v) road and grid access; (vi) protected areas and ecological-flow requirements; (vii) geotechnical stability; and (viii) preliminary cost and social acceptability. This staged logic GIS screening first, detailed technical, environmental and economic feasibility next is exactly the sequence recommended in recent hydropower-planning literature [23] [24] [30] [32] [33].

5. Conclusions

This study set out a reproducible, GIS-based morphometric framework for the early-stage identification and prioritisation of hydropower dam sites in the Guinean headwaters of the Senegal River basin, a region that pairs considerable but largely untapped hydro-energy resources with persistent rural-electrification deficits. Conditioning a 30 m SRTM DEM and deriving drainage networks, flow accumulation, catchment boundaries and terrain attributes allowed 34 sub-basins to be characterised through a coherent set of indicators and 39 candidate dam sites to be delineated, concentrated mainly between 800 and 1500 m above sea level.

The relief proved strongly heterogeneous, with mean slopes from roughly 1% to more than 25% and elevation differences up to 329.70 m. This variability is the primary control on preliminary favourability, because it governs where hydraulic head concentrates in sectors where drainage convergence, valley confinement and steep gradients coincide. On that basis, sub-basins BV2, BV3, BV4, BV7 and BV13 emerge as the most promising first-order targets and should lead subsequent field reconnaissance.

Methodologically, the framework shows that remote-sensing-derived terrain analysis is an efficient, low-cost and transferable basis for hydropower reconnaissance in data-scarce mountainous settings, where in-situ hydrological and topographic records are sparse. Its strength lies in the systematic, spatially explicit and reproducible identification of favourable reaches and preliminary structure locations across an entire basin.

The outcomes remain, nonetheless, pre-feasibility targets rather than final engineering locations. Because the approach rests on topographic and morphometric criteria without measured or modelled discharge, it cannot yet estimate installed capacity, firm power or annual energy. Robust selection will require a staged follow-up covering (i) flow-duration analysis and rainfall-runoff modelling for the ungauged catchments; (ii) net-head correction and turbine suitability; (iii) geotechnical and geomorphic stability; (iv) environmental flow, sediment continuity and longitudinal connectivity; and (v) socio-economic, access and grid-integration constraints.

Within these limits, the study delivers a defensible and publication-ready spatial foundation for guiding detailed field investigations and for informing the sustainable development of small- to medium-scale hydropower in Guinea. More broadly, it shows how open-access remote-sensing data and transparent GIS workflows can support evidence-based, low-carbon energy planning across the wider Senegal River basin and comparable data-scarce regions of West Africa.

Data Availability

The SRTM 30 m DEM used in this study is freely available from the NASA Earthdata platform (https://earthdata.nasa.gov). Additional data supporting these findings are available from the corresponding author upon reasonable request.

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Author Contributions

Conceptualization, M.C. and I.M.; methodology, M.C. and I.M.; software, M.C.; validation, M.C., I.M., S.D. and P.M.N.; formal analysis, M.C. and I.M.; investigation, M.C., I.M. and S.D.; resources, M.C. and P.M.N.; data curation, M.C. and I.M.; writing—original draft preparation, M.C.; writing—review and editing, M.C., I.M., S.D. and P.M.N.; visualization, M.C. and I.M.; supervision, I.M. and P.M.N.; project administration, M.C.; funding acquisition, N/A. All authors have read and agreed to the published version of the manuscript.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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