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Research Article

Potential of Hydropower-Based Renewable Energy in Cipunegara Watershed

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ABSTRACT

Developing new and renewable energy (NRE) is a sustainable solution to the current complexity associated with population growth and environmental problems. Some developed countries have recognized renewable energy development as a substitute for non-renewable energy such as coal, petroleum, and natural gas. Therefore, this study employed the geospatial approach scheme to identify the NRE potential in the Cipunegara watershed. This was achieved using regional research with a spatial approach and considering five locations in the upstream area of the Cipunegara watershed. Data were collected through observation, consultation with experts, and map interpretation, and analyzed using descriptive statistics. The results showed that only location 2 had a significant potential to be used in building a dam to generate electrical energy. This study was based on several aspects such as hydrology, morphology, topography, meteorology, erosion, geology, and land use. The results were derived from empirical data and geospatial modeling, and expected to serve as a significant reference for the central government in developing EBT as the tangible manifestation of the Sustainable Development Goals 2030 program and the implementation of the national research master plan 2017-2045.

Keywords : Renewable Energy; Hydropower; Geospatial Models; Cipunegara Watershed

INTRODUCTION

The depletion of fossil fuel and concerns about environmental pollution have led to extensive global discussion on the shift from non-renewable to eco-friendly renewable energy such as hydropower, geothermal, biomass, solar, and ocean currents (Erinofiardi et al., 2015; Erinofiard et al., 2017). The World Bank ranked Indonesia as the 14th country in the world discharging CO2 emissions into the air in 2010 with 433,989,000 tons and CO2 emissions per capita of up to 1.8 metric tons. This led to the issuance of a presidential decree in 2020 to minimize emissions by 26% due to the critical effect of CO2 released on climate change (Saleh et al., 2016).

Indonesia is currently required to harness its renewable energy potential (Hasan et al., 2012). Several authorities already noted the existence of enormous hydropower potential in the Southeast Asian region of the country (Tang et al., 2019) which was estimated to be 75,000 MW but only 34,000 MW can be exploited (Hasan et al., 2012).

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Some of these programs were designed to meet daily needs. Moroever, an increase in population can lead to a higher demand for water to meet food and humand needs. This means food and human activities are closely related to water (Akhirul et al., 2020; Setiacahyandari et al., 2022; Sitompul & Efrida, 2018). However, the current problem is that most energy are generated from the depleting non-renewable fossil fuels, thereby requiring humans to find renewable energy sources (Shiva Kumar & Sudhakar, 2015; Tang et al., 2017).

Hydropotential is generally usually used to satisfy only household and irrigation needs despite its ability to function as a renewable energy source, specifically to generate electrical energy (Syahputra & Soesanti, 2021). Therefore, this study focused on identifying the potential of hydropower as a renewable energy in Indonesia using geospatial and empirical approaches. The process involved highlighting several track records in the country, specifically in the Cipunegara watershed, such as the study conducted to determine the estuary changes in Cipunagara and Cimanuk Rivers using landsat imagery spatial analysis (Nur et al., 2020), and characterization of hydrocarbon reservoirs in Ozara Field, North West Java Basin using acoustic impedance inversion analysis (Zacky, 2020).

NRE was observed to have been developed in several countries using different models. An example of this is the study conducted in Turkey which used hydroelectric power plants on the carbon emission resulting the 408,533.57 tCO_2 fossil sources per year produced from the dam reduced carbon footprint (Bayazıt, 2021). Another study reported that hydropower was the leading renewable energy provider while solar and wind power were at the infant stage. This was confirmed by the findings of the survey conducted in 2019–2020 that the hydropower contributed 66,216 MW to the 1,53,888 MW renewable energy capacity of South Asia (Mitra, et al. 2023).

The development of NRE is considered urgent due to the prevalence of climate change problem in the global community. Most relevant studies did not focus on identifying the potential for hydropower renewable energy, specifically in the upstream area of the Cipunegara Watershed, West Java. Moreover, attention has been placed on renewable energy potential using literature and empirical studies but only a few applied geospatial and empirical elaboration modeling. Therefore, this study was conducted to identify and analyze hydropower-based renewable energy potential by reviewing several aspects such as hydrology, morphology, topography, meteorology, erosion, geology, and land use using the combination of geospatial and empirical modeling.

METHODS

Study Area

This study was conducting by incorporating a spatial approach in survey and this means the analysis focused on the inclusion of spatial variables in the study area (Yunus, 2016). This study was conducted in the upstream area of the Cipunegara watershed located in the administrative area of Subang and Sumedang regencies, West Java, Indonesia. The specific information on each location point is indicated in the following Figure 1. Moreover, the samples used were determined based on areal-based sampling technique while regional engineering was applied to examine the physical and cultural components (Yunus, 2016). Several observation points were selected based on practitioner studies as described in the following Table 1.

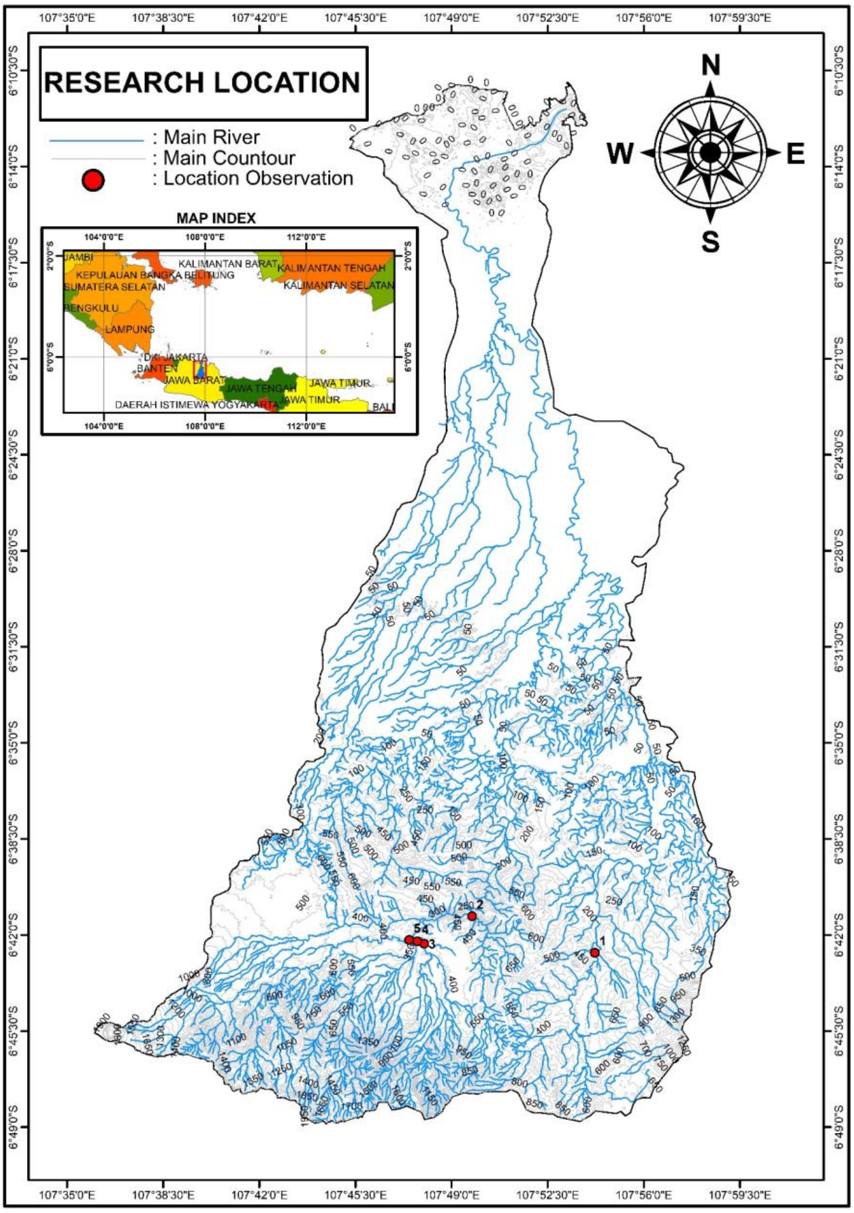

Figure 1. Study Area

Table 1. Observation Points to determine Hydropower-Based Renewable Energy Potential

Observation	Coordinates		Watershed Sub
	Coordinates (X)	Coordinates (Y)	
1	107.9036111	6.710833333	Cigadung
2	107.8291667	6.688611111	Cipunegara
3	107.8	6.705277778	Cipunegara
4	107.7958333	6.703888889	Cipunegara
5	107.790948	6.70302577	Cipunegara

Five locations selected for this study were in line with the target of the government in line with the recommendations made during the specific working visit of Commission V of the House of Representatives of Indonesia to Subang Regency, West Java Province at the second session of the 2021-2022. The Commission proposed the construction of Cipunegara Dam to overcome floods in Subang and Indramayu Regencies in addition to some other functions. The upstream area was observed to be physically suitable for dams based on hydrological, morphological, topographic and other assessments conducted.

Data Collection Techniques

Data were collected through the techniques adapted from Yunus (2016) and explained as follows: Observation was applied to (1) non-human or non-living objects such as rivers, soil, geological layers, and geomorphological structures as well as (2) artificial non-human objects such as settlement complexes, rice fields, and others. Consultation with Experts was implemented to identify the locations used as samples as well as to identify areas with hydropower-based renewable energy potential. Map Interpretation was utilized to determine specific potential locations using several geospatial models to study certain aspects.

Data Analysis

The data obtained were analyzed using quantitative descriptive analysis techniques. The process involved applying a spatial approach with geospatial technology in the form of *ArcGIS* to identify the feasibility of potential locations for hydropower-based renewable energy. The scheme for the analysis is presented in the following Figure 2 with the due consideration of professional studies conducted by water resources management consultants. The parameters used are also specifically described in Table 2.

Table 2. Geospatial Modeling Parameters of Hydropower-Based NRE Potential Measurement

Observation Aspect	Measurement Indicators	Reference
Hydrology	Catchment Area	Nurhamidin et al. (2015)
Morphology	Identification of Landforms with gently sloping wavy morphology	Van Zuidam (1983)
	Identification of Landforms with undulating hilly morphology	
	Identification of Landforms with steep hilly morphology	
	Identification of Landforms with very steep mountain morphology	
Topography	Identification of flat topographic areas	Puslittanak (2004)
	Identification of the extent of sloping topography	
	Identification of topographic areas is rather steep	
	Identification of areas with steep topography	
	Identification of very steep topographic areas	
Meteorology	Rainfall Average	Rohmat & Setiawan (2019), Hidayah et al. (2022), and Rasyid et al., (2023)
	Rain Volume	
	SPOOL Volume	
Erosion	Identify very light erosion levels	Julien (2010)
	Identify the extent of light erosion	
	Identify moderate erosion levels	
	Identify the degree of heavy erosion	

	Identify the extent of very heavy erosion	
Geology	Fold	Sugianti et al. (2014); Yassar et al. (2020).
	Faults/Faults	
	Geologic Formations	
Land Use	Identify Forest land area	Zarkasih et al. (2018)
	Identify the land area of settlements	
	Identification of Plantation / Garden land area	
	Identify the area of rice fields	
	Identification of Shrub land area	
	Identify the extent of Dryland Agricultural land	
	Identification of Mixed Dryland Agricultural Land Land Area	
	Identification of Open Land land area	

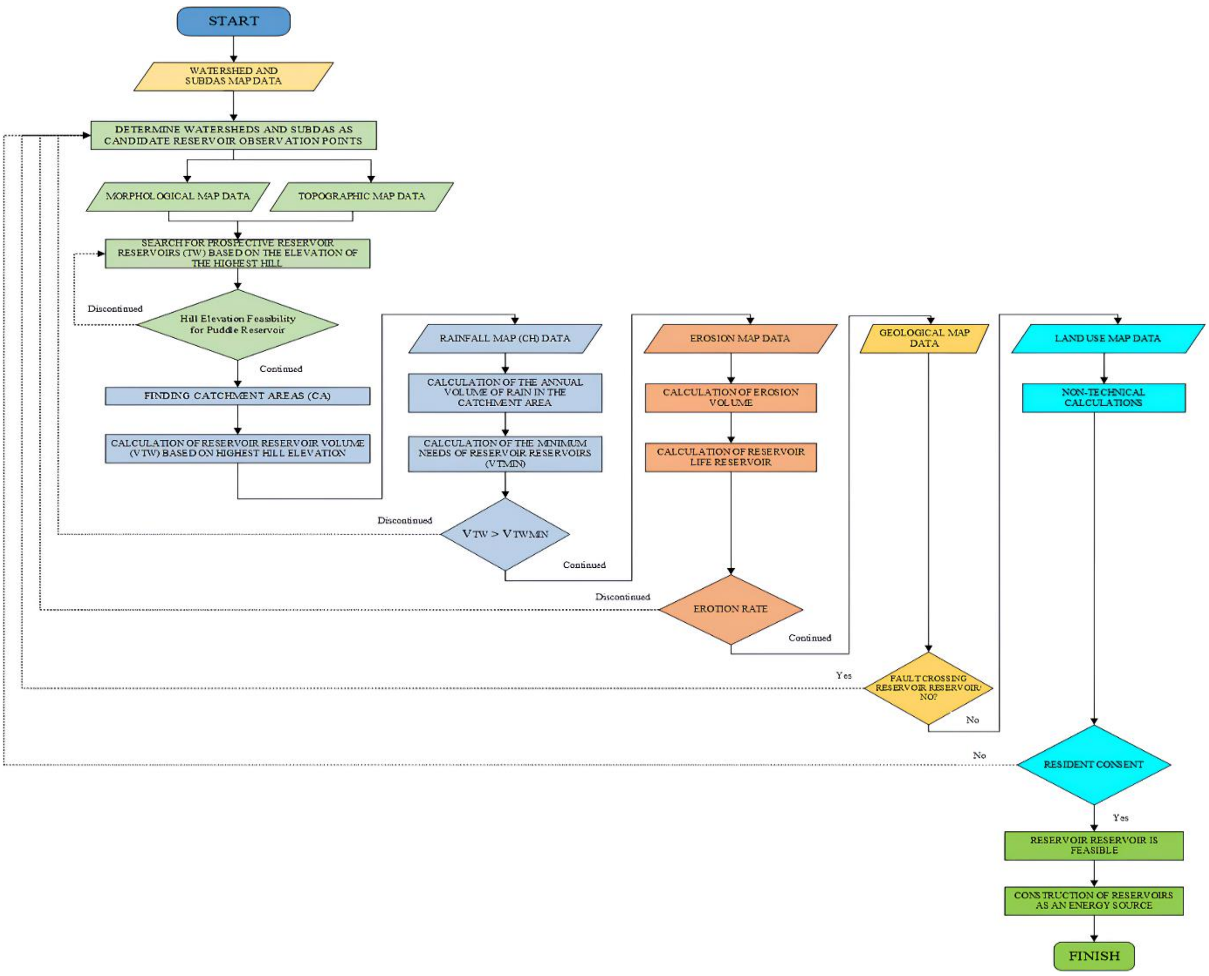

Figure 2. Scheme of Data Analysis of NRE Potential (DAM)

RESULTS AND DISCUSSION

Geospatial modeling scheme supported by empirical data obtained from surveys was used in this study and described as follows:

Renewable Energy Potential based on Hydrological Aspects

Cipunagara watershed is geographically located between 83° 12' - 82° 41' S and 127° 23' - 130° 57' E with a tropical climate and administratively placed in three regencies including Subang, Indramayu, and Sumedang. The main river in the watershed is Cipunagara with a total length of ± 104 km and an average width of 40 m. Its springs are located in Bandung Regency, precisely at the foothills of Mount Tangkuban Perahu (2,706 m a.s.l.), while the downstream is mainly in the Subang Regency area (Sunarko, 2021).

The watershed is elongated with a catchment area of 1,203 km^2 in the form of mountainous areas in the upstream and relatively gentle heights in the downstream used for rice fields (agriculture), gardens, settlements, and trades. Administratively, it is mostly bounded by Subang Regency with the Java Sea in the north, Subang in the west, Indramayu in the east, and Sumedang and West Bandung in the south (Sunarko, 2021). The geometric parameters of the watershed were measured and the results are presented in the following Table 3.

Table 3. Geometry of Cipunagara Watershed

Watershed Geometry Study	**Value**	**Unit**
Catchment Area	342.60	km^2
Main River Length	48.29	km
Total River Length	1000.32	km
Highest Elevation	2174.0	mdpl
Lowest Elevation	44.0	mdpl
Height Difference	2130.0	m
Catchment area length	36.7	km
Catchment area average width	7.1	km
Catchment area perimeter	106.0	km
River Density	2.9	km/km^2
Meandering	1.3	

The specific hydrological parameters observed at several locations are also indicated in Figure 3. Moreover, this aspect covered the width of the catchment area as indicated in the geospatial data presented in the following Table 4.

Table 4. Width of Catchment Area

Observation	Coordinate		Catchment Area	Sub watershed
	Coordinate X	Coordinate Y		
1	107.9036111	6.710833333	9597,46	Cigadung
2	107.8291667	6.688611111	3434,75	Cipunegara
3	107.8	6.705277778	6004,00	Cipunegara
4	107.7958333	6.703888889	6033,24	Cipunegara
5	107.790948	6.70302577	38593,00	Cipunegara

The eligibility criterion was that a wider catchment area would produce more discharge (Nurhamidin et al., 2015). Some observer practitioners also argued that a larger catchment area could accommodate a large water scale. This was further supported by dendritic patterns observed in the five points studied which were considered suitable to serve as inundation for the dam body. It was also discovered that some of these aspects were only a tiny part of the NRE potential assessment scheme. Therefore, an in-depth investigation was suggested to have a better overview.

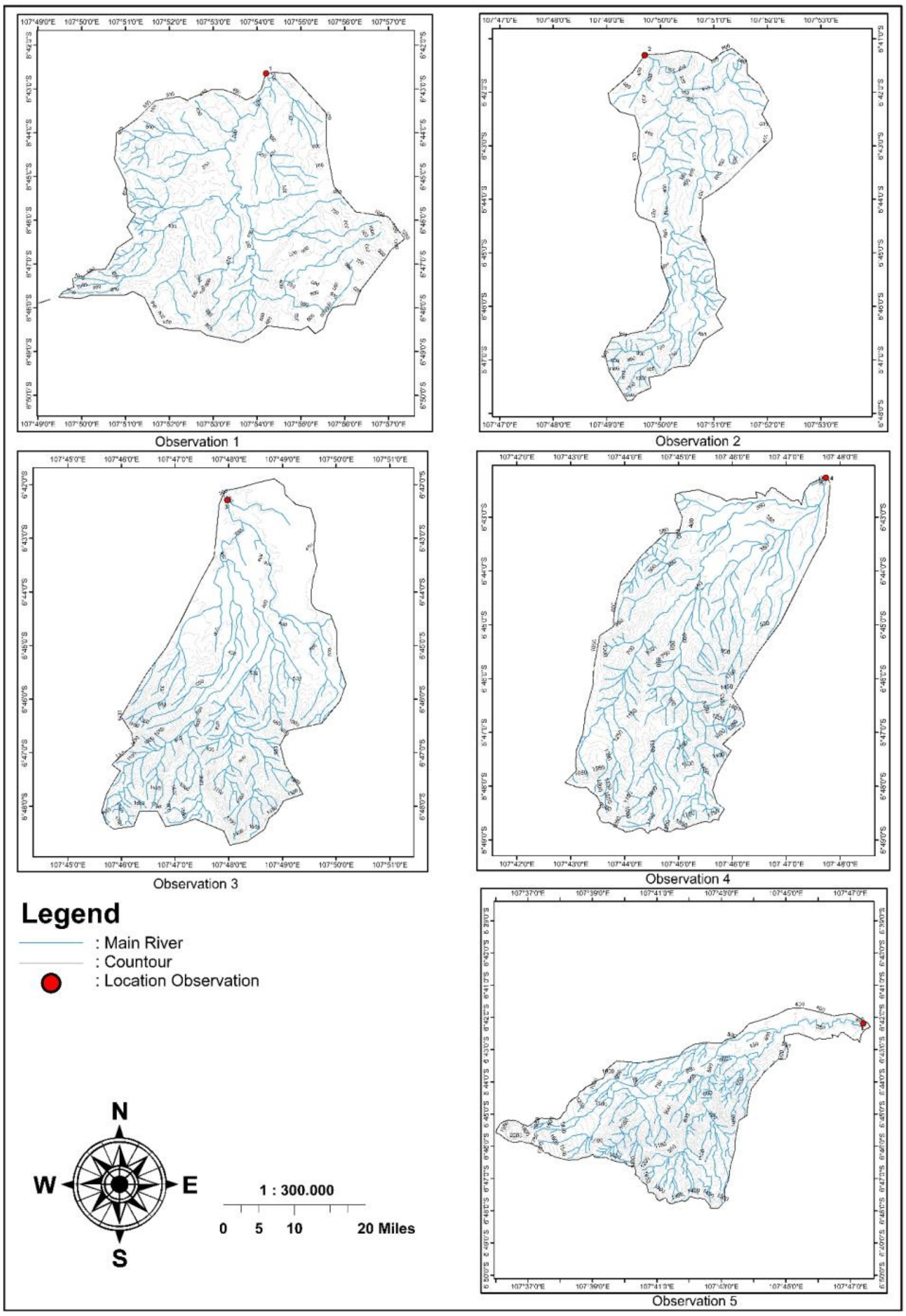

Figure 3. Observations based on Hydrological Aspects

Renewable Energy Potential based on Morphological Aspects

The morphological aspect was reviewed using a geospatial approach based on Van Zuidam (1983) criteria. An empirical method was also applied to identify prospective reservoir dikes. Moreover, some practitioners proposed that the standardization of feasibility for the morphological aspect of constructing a dam is in the undulating and steep hilly areas such as natural dikes. The data recorded from the observation points are presented in the following Table 5.

Table 5. Land Area by Morphology

Observation	Hilly Undulating	Steep Hills	Very Steep Mountains
1	40012,15547	81231106,41	40012,15547
2	0	29219573,96	5133992,465
3	0	27375875,1	32739247,5
4	0	18747474,43	41581727,96
5	0	24371304,9	63934683,66

The locations identified and analyzed in the preliminary feasibility study are presented in the Figure 9. This initial morphological feasibility was considered important in the process of planning a dam construction. The phenomenon was attached to the relationship between water availability and the physical conditions of an area such as the morphology, bulk, as well as the natural processes in the water cycle of the watershed (Zarkasih, 2018). Furthermore, several locations reviewed through an empirical approach indicated the potential for the implementation of levee construction. The observation data retrieved during the process are presented as follows:

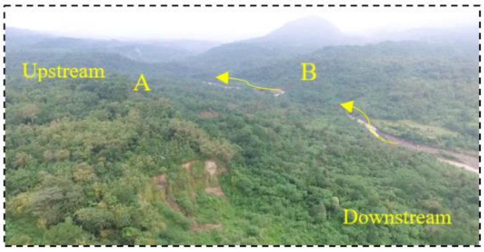

Figure 4. Observation 1

"Observation point 1 showed that the two hills, A and B, did not meet the feasibility standards to be used as embankments. This was because they were in low category and could increase the cost of building the embankment dam." (Results of Practitioner Study, 2023)

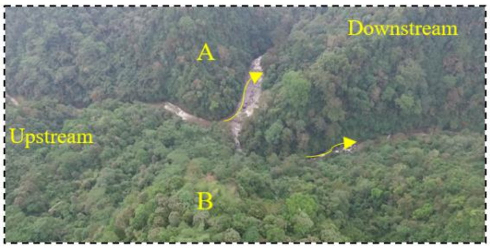

Figure 5. Observation 2

"Observation point 2 indicated that the two hills, A and B, appeared to have met the met the feasibility standard to be used as wmbankments. This was associated with their elevation which could reduce the cost of constructing the embankment dam." (Results of Practitioner Study, 2023)

Figure 6. Observation 3

"Observation point 3 confirmed that the appearance of two hills (A & B) as embankments was sufficient to meet the feasibility standards. This was because their elevation was high enough to build an embankment dam and reduce the cost of dike construction." (Results of Practitioner Study, 2023)

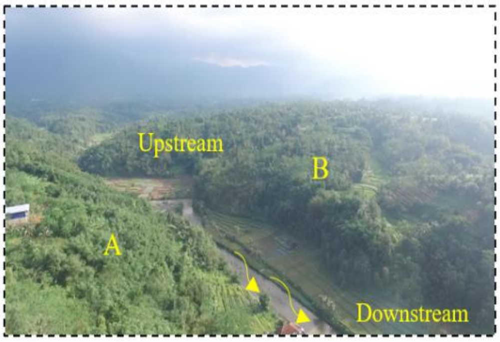

Figure 7. Observation 4

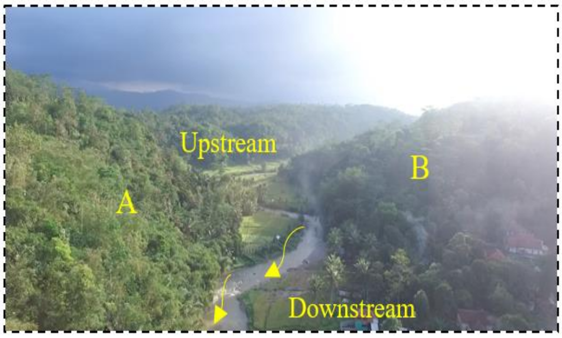

Figure 8. Observation 5

"Observation point 4 indicated that the appearance of two hills (A & B) as embankments was sufficient to meet the feasibility standards because the elevation was high enough to build an embankment dam." (Results of Practitioner Study, 2023)

"Observation point 5 showed that the appearance of two hills (A & B) as embankments was sufficient to meet the feasibility standards because the elevation was high enough to build a reservoir embankment." (Results of Practitioner Study, 2023)

The empirical results of the survey conducted in the five selected locations showed that locations 2, 3, 4, and 5 were considered suitable for natural dam embankments. Location 2 was found to be very feasible because of its steep elevations and the ability to reduce the cost of constructing the dam. Meanwhile, Location 1 was discovered to be unfeasible due to its slope morphology and absence of hilly terrain to be used as a natural embankment for the dam.

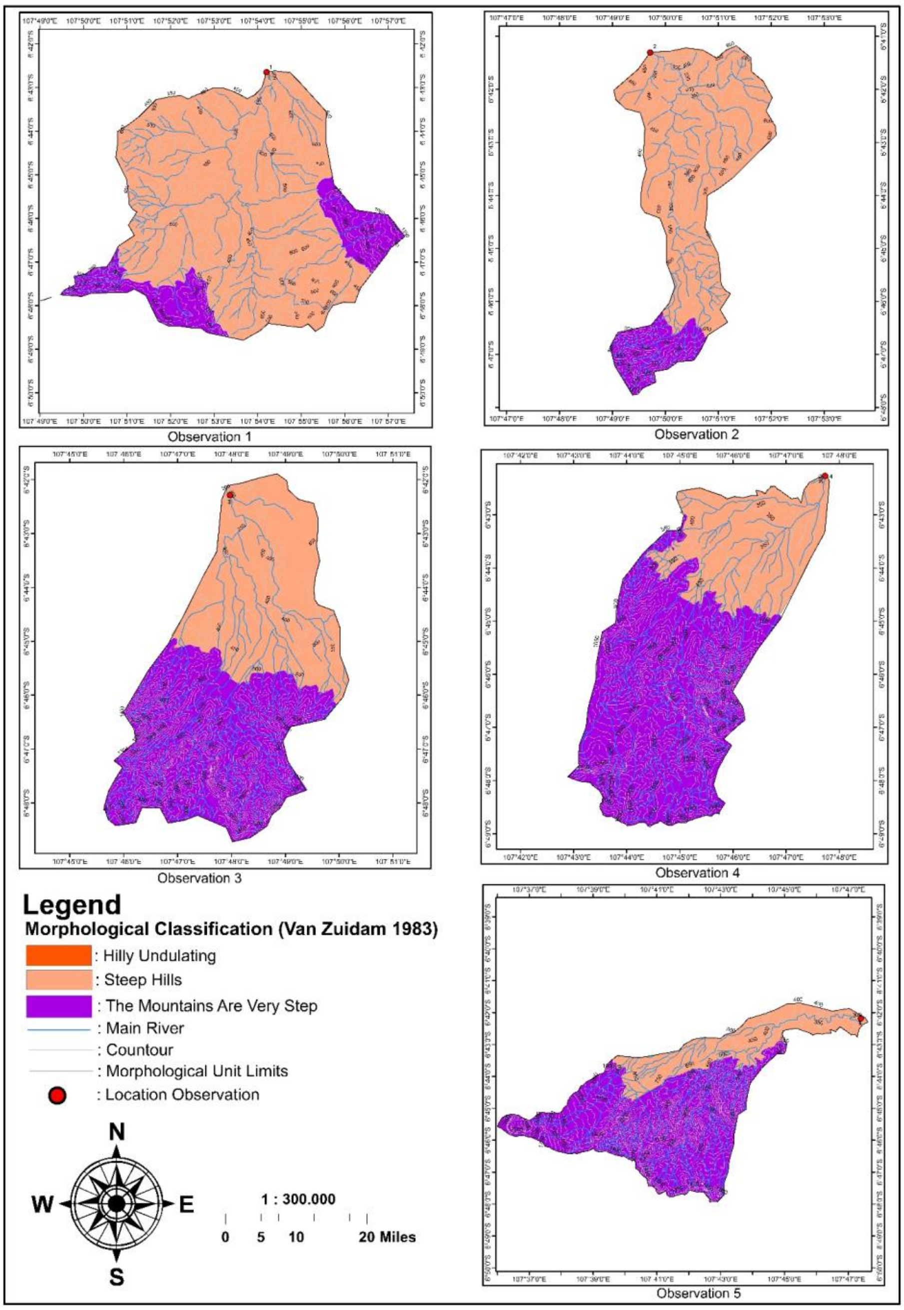

Figure 9. Observations based on Geomorphology Aspects

Renewable Energy Potential based on Topographic Aspects

The investigation of the topographic conditions is very important in the process of planning the construction of an embankment dam. This was associated with the their ability to predict and validate the potential breakdowns for the dam (Aureli et al., 2022) and serve as a model scheme to determine the influence of topographic form on dam behavior (Tian et al., 2021). The topographic conditions are also essential in determining the stability of landslide dams (Wu et al., 2020). They can further be incorporated with the morphology of the area to model the depositional projections and internal structure of a dam (Zhou et al., 2019). The topographic reviews conducted through the observation of the locations as part of the preliminary assessment to plan the embankment dam construction are presented in the following Figure 10.

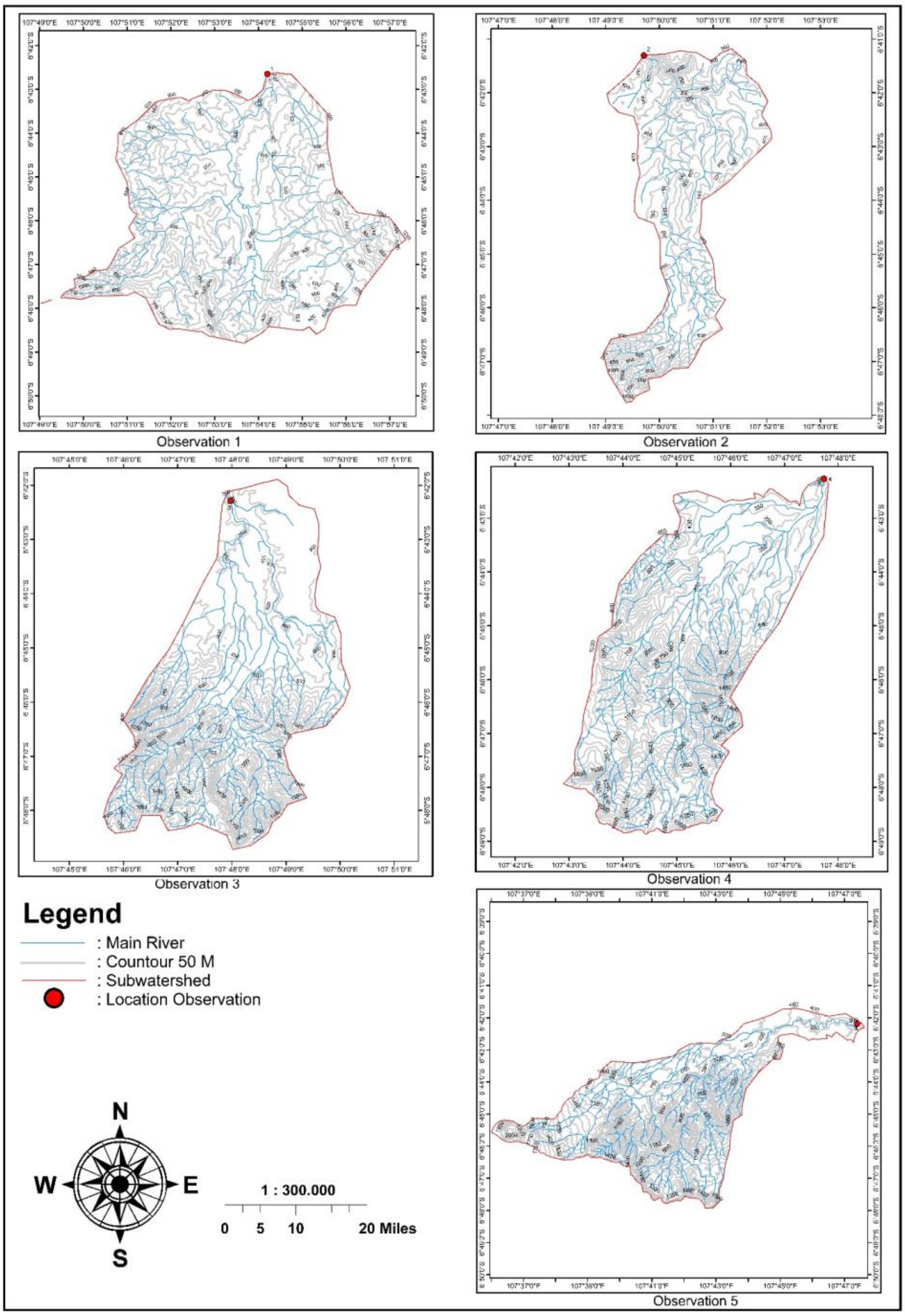

Figure 10. Observations based on Topographic Aspects

The geospatial scheme modeling investigation was used to show the priority of feasibility standards at Location 2. According to the information retrieved from practitioner studies, the location had two natural hills that met the feasibility standards and this could reduce the cost to be incurred by the central government in constructing the dam on a location with similar characteristics (Results of Practitioner Studies, 2023). This was reinforced by the extensive results obtained from the initial investigation in Table 6.

Table 6. Land Area by Slope

Observation	Splay	Classification	Wide
1	0 - 8 %	Flat	16446837.44
	8 - 15 %	Sloping	20307977.9
	15 - 25 %	Rather Steep	26929940.54
	25 - 45 %	Steep	27543730.47
	> 45 %	Very Steep	5409890.143
2	0 - 8 %	Flat	3960671.372
	8 - 15 %	Sloping	6705921.249
	15 - 25 %	Rather Steep	10371847.61
	25 - 45 %	Steep	8679795.601
	> 45 %	Very Steep	4629287.969
3	0 - 8 %	Flat	12871939.81
	8 - 15 %	Sloping	9464647.322
	15 - 25 %	Rather Steep	8206617.533
	25 - 45 %	Steep	11579909.89
	> 45 %	Very Steep	17916932.06
4	0 - 8 %	Flat	6734111.871
	8 - 15 %	Sloping	7426606.359
	15 - 25 %	Rather Steep	10269045.34
	25 - 45 %	Steep	17929331.61
	> 45 %	Very Steep	17974577.67
5	0 - 8 %	Flat	11731264.97
	8 - 15 %	Sloping	14538583.29
	15 - 25 %	Rather Steep	17649891.71
	25 - 45 %	Steep	23825022.32
	> 45 %	Very Steep	20468799.58

Renewable Energy Potential based on Meteorological Aspects

Rainfall data have been used by several stakeholders for different purposes such as agriculture, irrigation, transportation, industry, tourism, and others. This is in addition to its utilization in some other specific situations such as the management of dams (Rohmat & Setiawan, 2019). Moreover, accurate rainfall-runoff modeling was considered fundamental to the planning and management of water resources such as drinking water, agriculture, industry, hydropower, and others (Hidayah et al., 2022). This is the reason geospatial modeling was applied to each location and the results are presented in the following Figure 11.

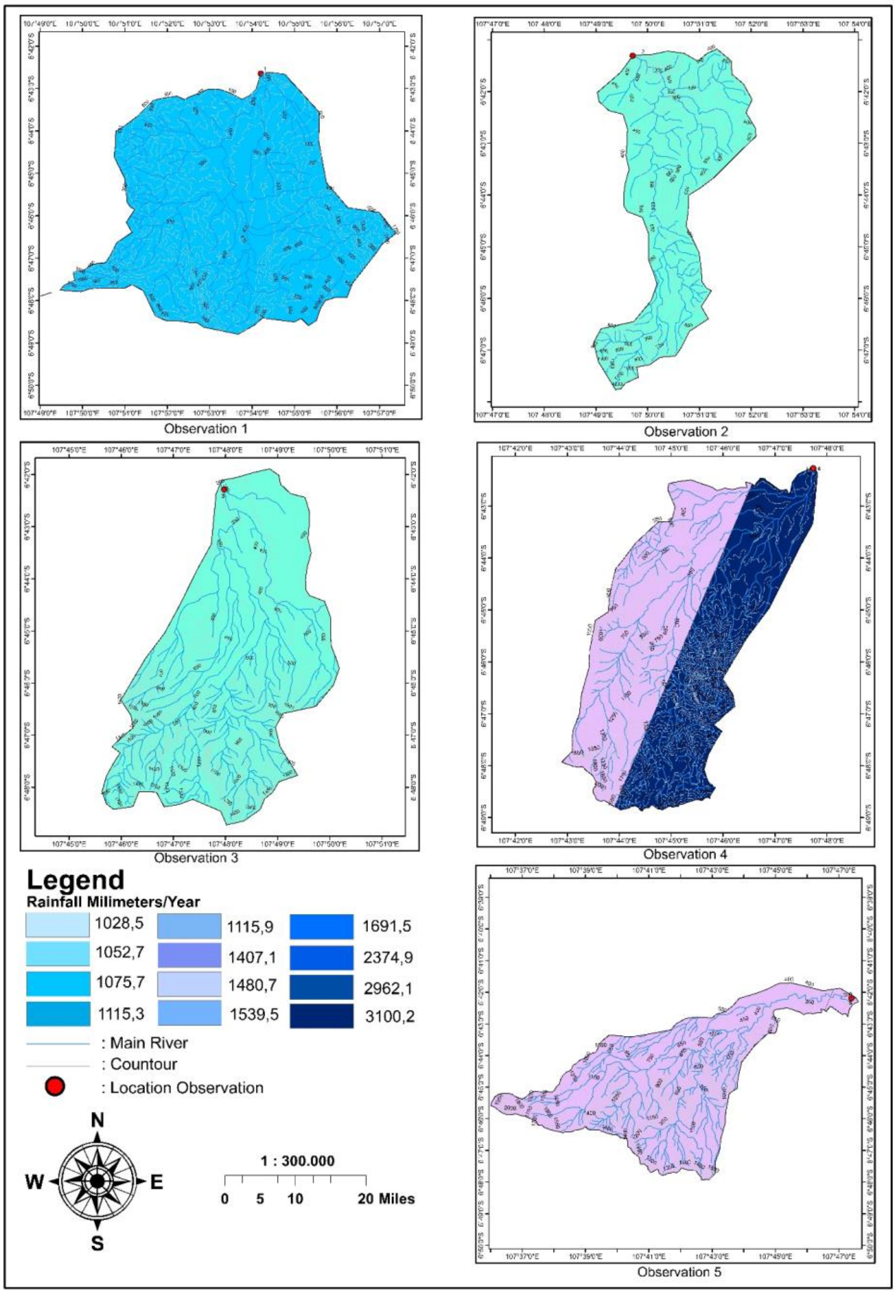

Figure 11. Observations based on Meteorological Aspects

Meteorological reviews in the form of average annual rainfall are one of the primary considerations in designing water reservoirs. This was further confirmed by some studies that rain needs to be modelled into flow discharge to determine the potential of water resources in a catchment area (Sitanggang et al., 2014). Numerical rain analysis was observed to have been conducted to determine the rain intensity in a catchment area (Rasyid et al., 2023). However, the percentage of NRE potential was determined in this study through geospatial modeling analysis using *ArcGIS* and *AutoCAD* software as presented in the following Table 7.

Table 7. Percentage of Renewable Energy Potential

Observation	Catchment area	Rainfall		Average Rain Volume	SPOOL Volume	Percentage
1	9597.46	3,1002	0	340,556,970	2,186,709,108	642.10
2	3434.75	3,1002	0	106,739,886	173,135,767	162.20
3	6004.00	3,1002	0	187,469,094	44,215,310	23.59
4	6033.24	2,9621	3,1002	177,518,653	134,484,174	75.76
5	38593.00	2,9621	3,1002	262,116,229	79,406,270	30.29

The information obtained from the practitioner studies indicated that the five locations observed had the rough potential and feasibility to be used for dam construction. This was further reflected in some numerical calculations concerning several aspects. Moreover, the standardization of rain numeracy feasibility was required to be determined on a minimum time scale of 10 years (Results of Practitioner Studies, 2023).

Renewable Energy Potential based on Erosion Aspects

The erosion aspects were reviewed to project future sedimentation. This was considered necessary because sediments have the ability to cause hydropower dam failure (Salau & Ifabiyi, 2019). The treatment of sedimented areas usually require high budgets in addition to the impacts on sustainability in the form of eutrophication in dam areas. This led to the implementation of numeracy scheme modeling to identify erosion rates in catchment Areas using the formular designed Julien (2010) which involved predictions through the Universal Soil Loss Equation (USLE) approach. The number of erosion rates per year needed to be determined due to its influence on the quality of dam infrastructure (Results of Practitioner Studies, 2023). The erosion rates calculated at each observation point are presented in the following Table 8.

Table 8. Erosion Rates Calculation

Observation	Catchment Area (Ha)	Erosion Volume		Spool Volume (m^3/year)	Dam Age (year)
		(ton/year)	(m^3/year)		
1	9597.46	2224048	2,668,857,60	186190521	69.76
2	3434.75	1,034,869,00	1,241,842,80	173135767	139.42
3	6004.00	806,420,70	967,704,84	44215310	45.69
4	6033.24	1,230,788,67	1,476,946,40	134484174	91.06
5	38593.00	10,512,388,40	12,614,866,08	79406270	6.29

The specific information on the erosion rates is indicated in the following Figure 12.

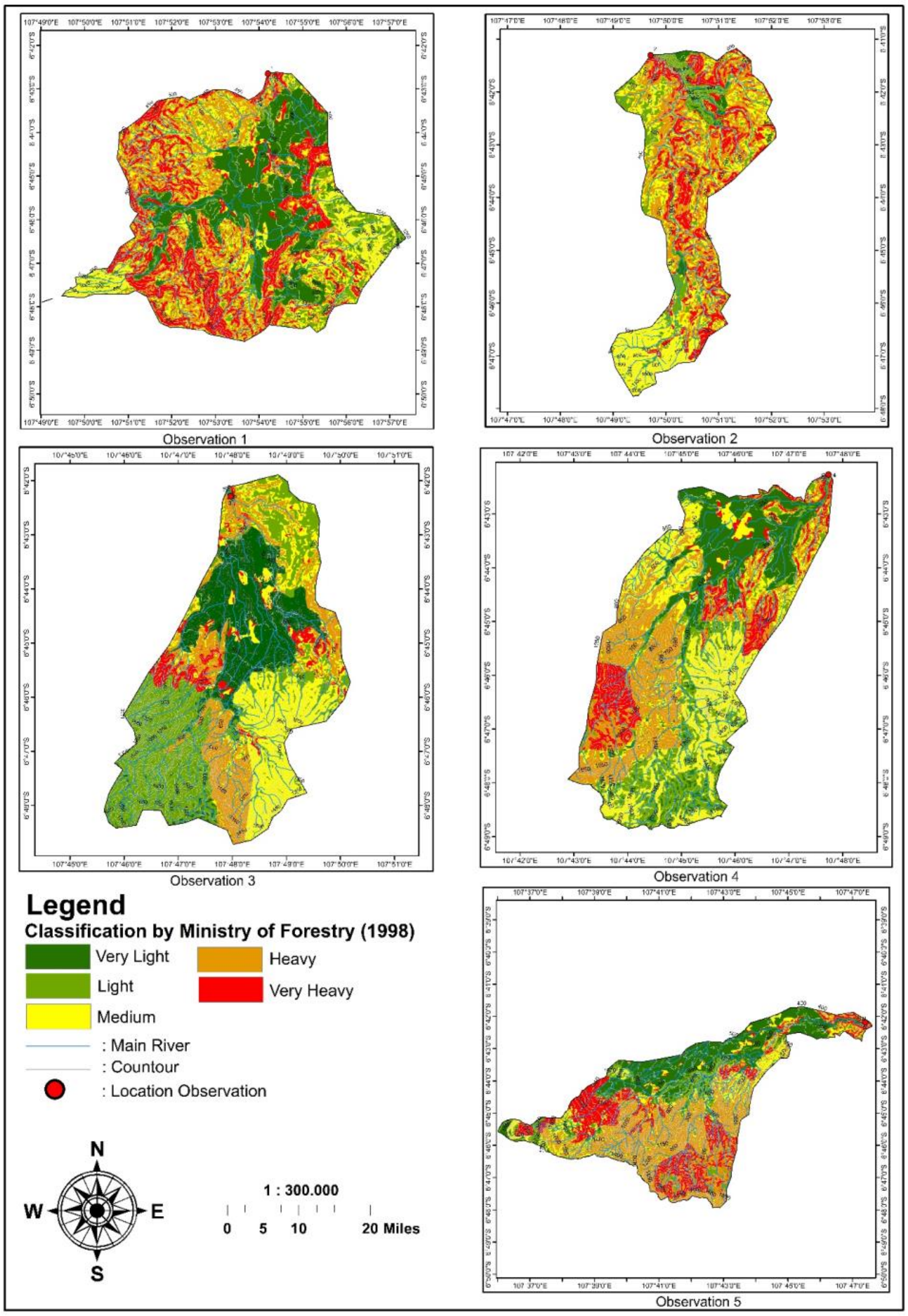

Figure 12. Observations based on Erosion Aspects

The erosion rate projections and geospatial modeling schemes showed that the third and fifth locations had the most significant erosion rate volume compared to the other others. Meanwhile, feasibility assessment rarely recommends a site with a high erosion rate for dam construction.

Renewable Energy Potential based on Geological Aspects

The review of the geological aspects was considered important in the process of planning dam construction for micro-hydro-based renewable energy due to the detrimental impact of constructing in an improper area such as the existence of leaks in the dam body (Results of Practitioner Studies, 2023). Therefore, the results of the geospatial modeling in each location are presented in the following Figure 13.

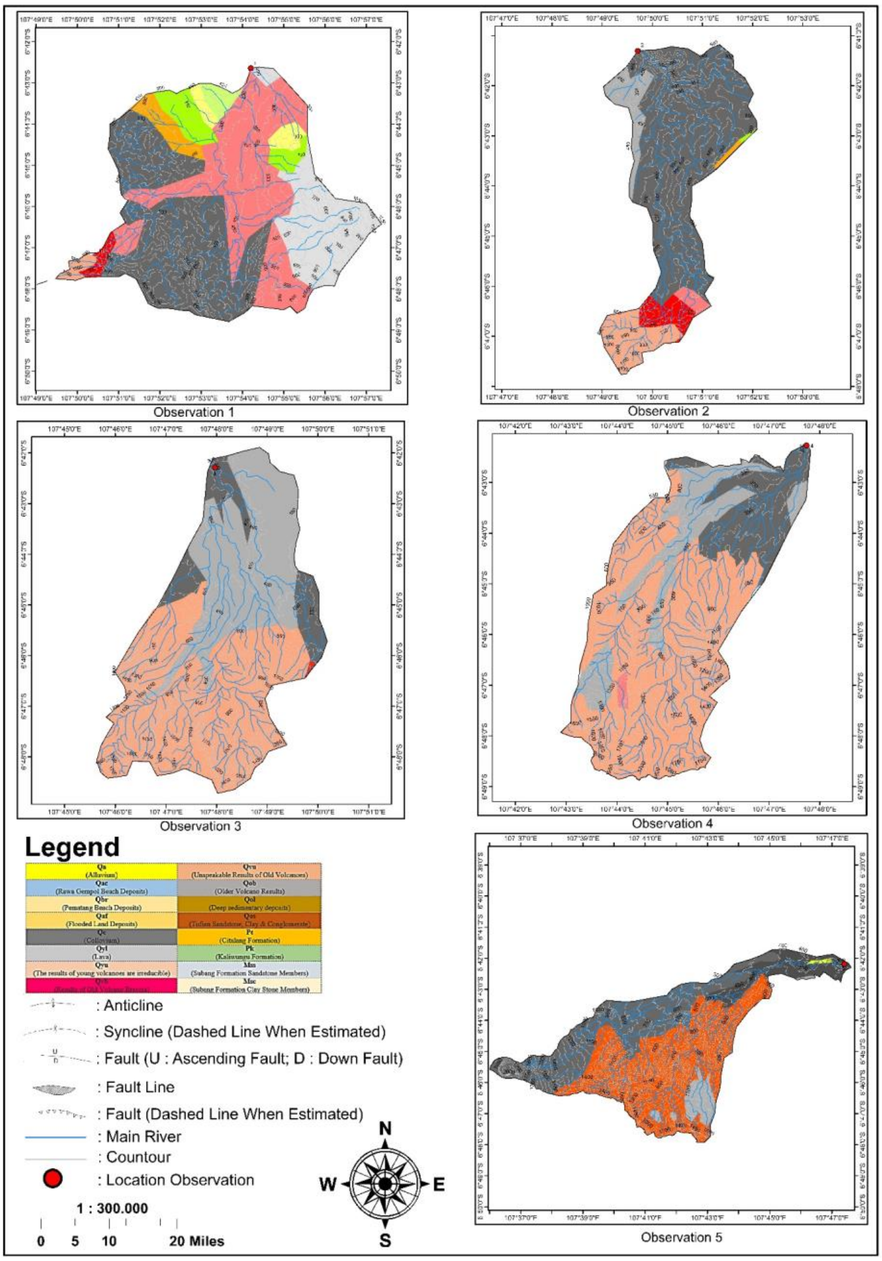

Figure 13. Observations based on Geological Aspects

The results categorized location 1 as dangerous and unfit while the faults in the catchment areas of other locations did not show any significant influence on the prospective dam (Results of Practitioner Studies, 2023).

Renewable Energy Potential based on Land Use Aspects

The land use aspect is usually considered as the final stage of determining the appropriate location for dams. This was linked to the fact that the socio-cultural condition of the community was considered one of the variables to ensure smooth dam construction by practitioners in physical studies (Results of Practitioner Studies, 2023). The construction of dam in Indonesia was required to focus on this aspect because the country has different beliefs based on tribe and culture. Furthermore, compensation to be given to the users of the land needs to be evaluated due to the limited budget provided by the stakeholders for land acquisition. The results obtained for each location are presented in Figure 14.

The dam cannot be constructed in forest areas because they are not considered part of SDGs or carbon stocks cultivated by the central or national government. Meanwhile, the dam can be sited in residential areas with permission and land compensation agreed upon by the affected residents (Results of Practitioner Studies, 2023). The potential of each location based on land use is presented in Table 9.

Table 9. Land Use in Each Location Selected for Embankment Dam

Observation	Land Use Review									
	Wb	T	Fo	S	P	M	A	R	Fi	Ol
1	-	-	-	-	-	-	√	-	-	-
2	-	-	√	-	-	-	√	√	-	-
3	-	-	-	-	-	-	√	√	-	-
4	-	-	-	-	-	-	√	√	-	-
5	-	-	-	√	-	-	√	√	-	-

Note: Wb (Water body); T (Thicket); Fo (Forest); S (Settlement); P (Plantation); M (Mining); A (Agriculture); R (Ricefield); Fi (Fishpond); Ol (Open land)

The land use area for each location specifically identified through geospatial modeling is presented in the following Table 10.

Table 10. Land Use Area of Observation Location

Observation	Land Use	Land Area (Ha)
1	Secondary Dryland Forest	317135.7566
	Plantation Forest	8477223.761
	Settlement	4327984.278
	Plantation	3010680.806
	Dryland Agriculture	9918443.737
	Mixed Dryland Farming	43794208.97
	Paddy	25848973.24
	Open Ground	207686.1957
2	Secondary Dryland Forest	2008325.341
	Plantation Forest	4495123.004
	Settlement	946892.5989
	Dryland Agriculture	16707508.37
	Mixed Dryland Farming	9631013.123
	Paddy	352243.4945
	Open Ground	207440.0754
3	Secondary Dryland Forest	13211882.15
	Plantation Forest	16124942.73
	Settlement	2286161.747
	Dryland Agriculture	1886988.678
	Mixed Dryland Farming	12696853.25
	Paddy	13822814.3

	Open Ground	47452.82592
4	Secondary Dryland Forest	17587210.58
	Plantation Forest	17515588.9
	Settlement	1382212.234
	Dryland Agriculture	246338.5214
	Mixed Dryland Farming	12318921.33
	Paddy	11280709.89
	Open Ground	41279.61641
5	Secondary Dryland Forest	1822570.212
	Plantation Forest	33789300.69
	Settlement	1941528.068
	Plantation	5532260.922
	Dryland Agriculture	3666670.447
	Mixed Dryland Farming	16292681.01
	Paddy	24468703.15
	Open Ground	782062.7218

Land-use review is normally the final aspect of the rough planning for the construction of dams. It is considered important due to the need to obtain land turnover and residents' approval to construct water infrastructure like dams. In this study, several locations were categorized as suitable for dam construction but it is necessary to consider the approval needed and the compensation fee to be paid to the surrounding communities. An area with more residential land required a higher budget but the area owned by the central or regional government was confirmed to need lesser budget (Results of Practitioner Studies, 2023).

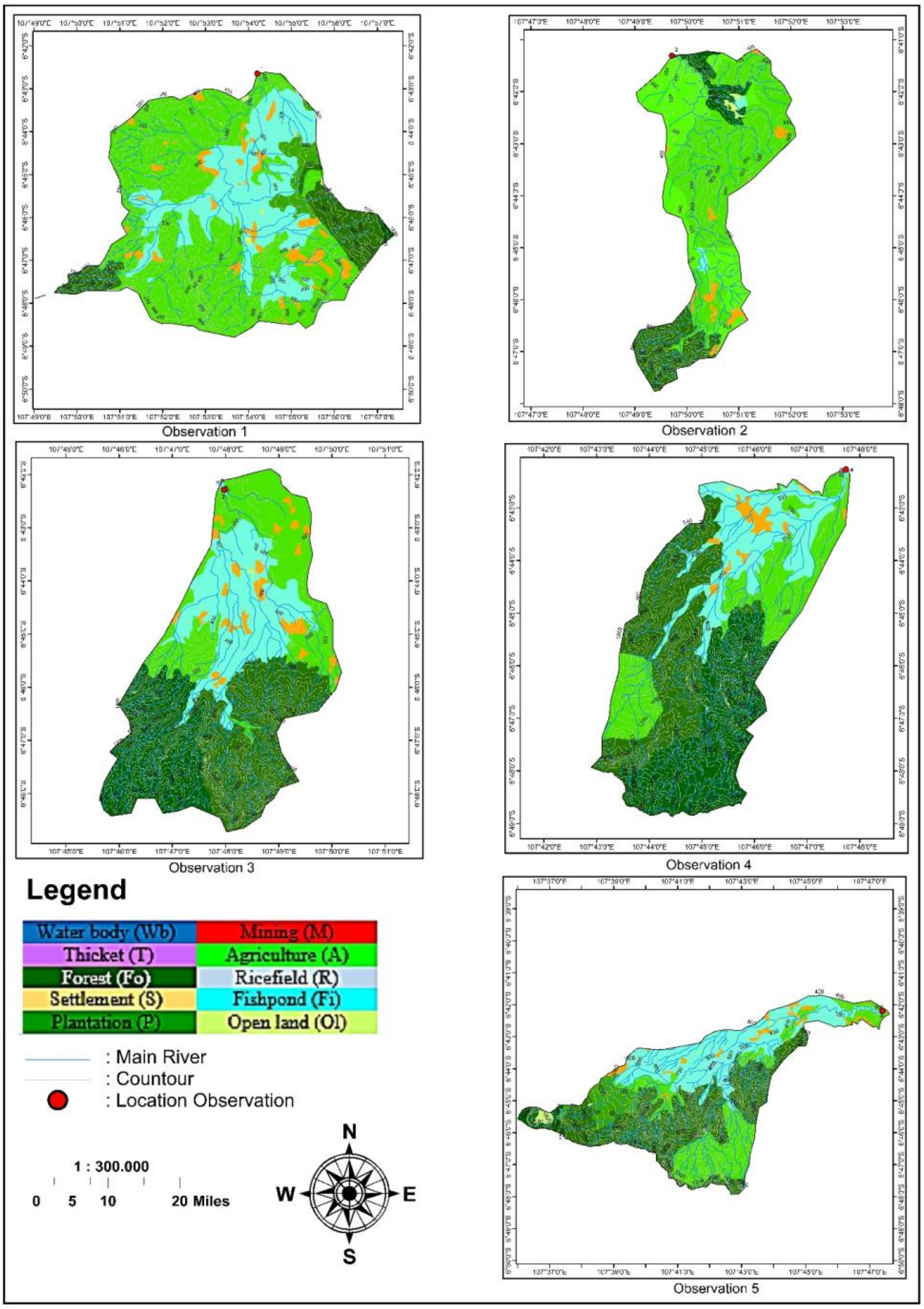

Figure 14. Observations based on Land Use Aspects

The elements existing on the site were also discovered to be influencing the construction feasibility. For example, sacred sites cannot be moved, thereby making the construction of dams to be difficult while some other elements can be shifted to the planning area. This aspect is considered important due to the need for the planners to understand the culture and beliefs of the affected communities during the planning and implementation phases. Moreover, it is impossible to implement the plans when there are discrepancies in the social-cultural aspect even though all the physical aspects met the feasibility standards for dam construction (Results of Practitioner Studies, 2023). The observational studies conducted based on the modeling results and practitioners' considerations led to the summary presented in the following Table 11.

Table 11. Feasibility of Dam Planning as Micro Hydro-Based NRE Potential

Observation	Recommendation Scale based on Practitioner Studies							%
	Hydrology	Morphology	Topography	Meteorology	Erosion Rate	Geology	Land use	
1	√	X	X	√	√	X	√	0%
2	√	√	√	√		√	√	80%
3	√	√	√	√	X	√	√	40%
4	√	√	√	√	√	√	√	60%
5	√	√	√	√	X	√	√	40%

Note: (√): Recommended (X): Not recommended

The results showed that Location 2 was most suitable to construct the dam needed to generate electricity as indicated by the 80% feasibility obtained through the geospatial modeling scheme. This was in line with the findings of some previous related studies conducted using the same method to identify the potential of NRE in the Cipunegara watershed towards encouraging the implementation of the national research master plan 2017-2045 regarding new and renewable energy. The energy sources recently developed were observed to prioritize eco-friendliness and sustainability. Moreover, the complexity of population growth has eventually led to the need to balance the electricity supply energy for daily needs. Another important factor considered significant in everyday life of the people is the availability of water (Zarkasih et al., 2018). This was the reason for the inclusion of renewable energy development as one of the targets and indicators of SDGs and it was required to be met in order to improve the achievement of other SDGs (Astari et al., 2021; Zhou, X., & Moinuddin, 2017).

CONCLUSION

In conclusion, this study incorporated both geospatial modeling schemes and fundamental empirical data to identify the NRE potential development, especially in micro hydropower in the Cipunegara watershed. The modeling schemes were based on several aspects including hydrology, morphology, topography, meteorology, erosion rate, geology, and land use. The results showed that Location 2 had the highest feasibility to construct dam with hydropower-based NRE potential. This was expected to be used as an essential reference for the government in the process of developing the NRE potentials in the Cipunegara watershed of West Java Province. However, the results were not expected to be used as the final decision to determine the feasibility of the area for dam construction but could serve as considerations for the government to expand micro-hydro NRE potential in the country as part of the efforts to realize government and global programs to supply eco-friendly electricity in the current era of global climate change.

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DECLARATIONS

Conflict of Interest

The authors declared that they had no known competing interests.

Ethical Approval

On behalf of all authors, the corresponding author states that the paper satisfies Ethical Standards conditions, no human participants, or animals are involved in the research.

Informed Consent

On behalf of all authors, the corresponding author states that no human participants are involved in the research and, therefore, informed consent is not required by them.

DATA AVAILABILITY

Data used to support the findings of this study are available from the corresponding author upon request.

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