Ministry of National
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Republic of Indonesia

PHASE 4

SOLAR PV MAPPING AND DEVELOPMENT PLAN (INDONESIA)

THE POTENTIAL FLOATING SOLAR PV SITES IN JAMALI REGION

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ENERGY TRANSITION PARTNERSHIP

UNOPS

SOLAR PV MAPPING AND DEVELOPMENT PLAN (INDONESIA)

Phase 4 Report: The Potential Floating Solar PV Sites in JAMALI

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Glossary

Acronym	Explanation
AZE	Alliance for Zero Extinction sites
BAPPENAS	Ministry of National Development Planning
BNPB	National Disaster Management Agency
CH	Critical Habitat
E&S	Environmental and Social
ESIA	Environmental and Social Impact Assessment
ESMS	Environmental and Social Management Systems
ESMP	Environmental and Social Management Plan
ETP	Southeast Asia Energy Transition Partnership
FNC	Floating Net Cages
FPIC	Free, Prior, and Informed Consent
FPV	Floating solar PV site
GHG	Greenhouse Gas
GHI	Global Horizontal Irradiance
GIS	Geographical Information System
GSW	Global Surface Water
GW	Gigawatt
HCV	High Conservation Value
IBA	Important Bird and Biodiversity Areas
ICP	Informed Consultation and Participation
IFC	International Financial Corporation
IPSDA	Izin Pemanfaatan Sumber Daya - Water resources utilization permit
IUCN	International Union for Conservation of Nature
JRC	Joint Research Centre
KBA	Key Biodiversity Area
kWh	Kilowatt-hour
kWp	Kilowatt-peak (installed power)

JAMALI	Java, Madura, Bali
MCDM	Multi-Criteria Decision Matrix
MEMR	Ministry of Energy and Mineral Resource
MoEF	Ministry of Environment and Forestry
MW	Megawatt
MWL	Mean Water Level
NTFP	Non-Timber Forest Products
ODCB	Objek Diduga Cagar Budaya - Object of Alleged Cultural Heritage
PA	Protected Area
PBFs	Priority Biodiversity Features
PBPH	Perizinan Berusaha Pemanfaatan Hutan - Business Licensing for Forest Utilization
PLN	National Electricity Company
PSs	Performance Standards
PV	Photovoltaic
PVOUT	PV power production (Output)
RE	Renewable Energy
RUKN	National Electricity General Plan
RUPTL	The National Electricity Supply Business Plan
SDGs	Sustainable Development Goals
SERIS	Research Institute of Singapore
TWG	Technical Working Group
UNEP-WCMC	The UN Environment Programme World Conservation Monitoring Centre
VEI	Volcanic Eruption Index
VRE	Variable Renewable Energy
WHS	World Heritage Site
WDPA	World Database of Protected Areas
WRI	World Resources Institute
WSE	Water Surface Elevation

Executive Summary

The Southeast Asia Energy Transition Partnership (ETP) works with the Ministry of National Development Planning (BAPPENAS) to promote solar photovoltaic (PV) technology, aiming to accelerate solar PV project implementation and help Indonesia achieve net-zero emissions in the power sector by 2060.

Despite Indonesia's potential to reach 3,315 GW of solar PV installed capacity, based on the 2025-2060 National Electricity General Plan/ Rencana Umum Ketenagalistrikan Nasional (RUKN), only around 1 GW of solar power plants had been installed by 2024. Recognising land availability challenges for ground-mounted solar PV, particularly in the densely populated JAMALI region, this study expands the 1 GW Solar Mapping and Development project to evaluate the potential for Floating PV (FPV) as a complementary solution to scale up solar capacity without large-scale land acquisition.

This report presents the findings from a comprehensive technical, environmental, social, grid, and financial feasibility assessment covering 21 reservoirs in the JAMALI grid. From the exhaustive list of 51 water bodies in the JAMALI region exceeding 100 ha, 21 reservoirs were pre-selected based on size (favouring larger ones), type (artificial reservoirs, except Lake Beratan), absence of major protected areas, and operational relevance as identified in the RUPTL. Using a robust multi-criteria decision-making (MCDM) framework, each site was assessed based on key geospatial factors, including solar resource availability, shading, wind exposure, seasonal water level variation, reservoir shape complexity, and proximity to existing hydropower plants and substations. The assessment includes an environmental and social (E&S) risk assessment, a preliminary grid capacity check, and an indicative financial analysis. The findings indicate that FPV is technically feasible at many sites and offers strategic advantages, mainly because it avoids the large-scale land acquisition required for ground-mounted PV. However, it generally involves larger data collection and significant feasibility assessment than ground-mounted sites to address the design complexity and operational requirements.

The geospatial analysis provides a normalised score on a scale from 0 to 1 (0 being the lowest score and 1 the highest) for each reservoir, enabling comparison. As a result, the lowest score achieved among the reservoirs is 0.2, and the average is equal to 0.54, so a score below 0.5 is below average. The analysis shows that 12 out of 21 reservoirs analysed obtained a value scores above 0.5. A score above 0.5 can be interpreted as a reservoir facing fewer location-specific engineering challenges, meaning that more than half of the reservoirs analysed face fewer challenges. Indeed, the reservoirs with higher scores are usually closer to a substation and/or a hydropower station, have low water extent fluctuations and present advantages based on their shapes. Lower-scoring sites may require more advanced technical designs and operational measures to address issues like wind exposure, significant water extent level fluctuation, or high aquaculture activity. Although ground-mounted PV is generally simpler to engineer and build, FPV offers a practical alternative where land is scarce or intensively used for agriculture or settlement.

From an E&S perspective, no sites were excluded at this stage; however, some may require further actions aligned with their respective risk profiles. These actions include project studies and planning, as well as the development of environmental and social management plans, with the level of detail in supporting documentation determined by the specific risk criteria of each site, especially those with dense aquaculture operations, important cultural heritage features, or close community interaction. Aligning project planning with international E&S standards and preparing risk mitigation plans will be critical to ensuring social license to operate and long-term sustainability.

The grid assessment indicates that while some sites have extensive water surfaces with strong technical potential for large-scale FPV, their actual deployable capacity is often constrained by the existing grid's hosting capacity projected for 2030. Fully unlocking this potential will require grid upgrades and expansions to enable higher levels of solar PV integration.

The potential capacity of each site was determined by considering three key constraints: the 20% reservoir area limit under national regulations, the effective water surface consistently available for FPV, and the grid's maximum hosting capacity. The lowest of these three values defines each site's effective FPV potential. Based on this approach, the total site capacities range from 51 MWp to 1,146 MWp, with Cipancuh excluded due to having no effective water area, resulting in 20 reservoirs being analysed for financial assessment.

From a financial perspective, the 20 reservoirs' financial viability was assessed according to the various scenarios. The financial analysis is using tariff assumptions based on the ceiling price as stipulated in the Presidential Regulation no. 112/2022 for JAMALI, which is 6.95 cents USD/kWh from years 1 to 10, 4.17 cents USD/kWh from years 11 to 30. Detailed financial assumptions used in the analysis is as explained in Chapter 3.6. Most sites show moderate returns under conservative assumptions and the base case scenario. Most sites show moderate returns under conservative assumptions and the base case scenario. While comparisons between ground-mounted solar and FPV are not entirely like-for-like, FPV offers a strategic advantage: even if returns are moderate, its ability to utilize underused reservoir surfaces without costly and lengthy land acquisition processes makes it a strong complementary option in Indonesia's solar energy strategy.

Importantly, this high-level study is an initial screening tool and does not replace the need for site-specific detailed feasibility studies especially to provide confirmation on the average water depth and the water surface elevation. The development of any FPV project at these reservoirs must be preceded by a full feasibility analysis tailored to each site's technical, environmental, social, legal, and financial conditions. This should include site-specific measurements, detailed grid studies, stakeholder consultations, and an in-depth commercial viability and bankability evaluation in line with investors and lenders' requirements. Any changes to the assumptions used in this study, including the planned implementation timeline, might require updates to the analysis and might give different results.

Based on this integrated assessment, Waduk Kedung Ombo, Waduk Gajah Mungkur, Waduk Karangkates, and Waduk Jatigede emerge as the top priority sites, offering a balanced combination of strong technical potential, grid readiness, and relatively higher financial promise. These sites are recommended for more detailed feasibility work, early engagement with local stakeholders, and further investment planning to help Indonesia advance its solar targets while minimising land-use conflicts.

Below are the top 10 sites based on the site prioritization of this study:

Rank	Reservoir name	Geospatial score	E&S score	Risk rating	Potential capacity (MWp)	Capex	Project IRR (Base Case)[1]	Total score
1	**Waduk Kedung Ombo**	1.00	17	High	411	554,400	8.97%	**8.628**
2	**Waduk Gajah Mungkur**	0.89	14	Medium	340	580,815	8.19%	**8.206**
3	**Waduk Karangkates**	0.78	14	Medium	257	554,741	8.69%	**8.088**

1 Tariff is from PP 112 ceiling price (6.95)

Rank	Reservoir name	Geospatial score	E&S score	Risk rating	Potential capacity (MWp)	Capex	Project IRR (Base Case)[1]	Total score
4	**Waduk Jatigede**	0.79	16	High	662	545,444	7.86%	**7.708**
5	**Waduk Cirata**	0.63	15	Medium	1146	542,713	7.85%	**7.512**
6	**Waduk Jatiluhur**	0.63	16	High	651	542,217	7.72%	**7.153**
7	**Waduk Wadaslintang**	0.64	14	Medium	261	555,693	6.34%	**6.596**
8	**Waduk Mrica**	0.76	14	Medium	97	623,81	5.10%	**6.329**
9	**Waduk Cengklik**	0.60	15	Medium	58	619,201	6.08%	**6.152**
10	**Waduk Saguling**	0.29	**16**	High	310	566,787	7.43%	**5.844**

1. Introduction

1.1. Project Background

The Southeast Asia Energy Transition Partnership (ETP) is a technical assistance programme, hosted by the United Nations Office for Project Services (UNOPS). ETP partners with governments, philanthropies, the private sector, and civil society to harness the vast untapped potential of renewable energy in the energy mix in the Southeast Asian region.

The program mobilises and coordinates the necessary technical and financial resources to create an enabling environment for renewable energy, energy efficiency, and sustainable infrastructures to support the transition from using fossil fuels to renewable energy sources to advance climate action in Southeast Asia. In Indonesia, ETP collaborates with the Ministry of National Development Planning, (BAPPENAS), to advance solar PV technology, aiming to accelerate the implementation of solar PV projects and help the country achieve net-zero emissions in the power sector by 2060. The recently issued RUKN 2025-2060 targets a 49.5% of renewable energy (RE) in the energy mix by 2060 and is expected to start dominating the energy mix with 51.6% starting from 2044. The RUKN further mentions an investment need of almost USD 1 trillion to add 443 GW of electricity generation.

Despite Indonesia's potential to generate solar power, according to the 2025 RUKN, only approximately 1 GW of solar power plants had been installed by 2024. The development of solar PV in Indonesia faces significant challenges, necessitating the implementation of risk-reduction measures to overcome these obstacles and advance renewable energy.

The 1 GW Solar Mapping and Development project provides insights to key stakeholders, including BAPPENAS, the Ministry of Energy and Mineral Resources (MEMR), and PT PLN (Persero) (PLN) as the state-owned electricity company, which supports decision-making processes regarding investments in large-scale solar PV development within the JAMALI grid, while also offering insights applicable to other grid systems in Indonesia. The project builds upon ETP's previous initiative, the Upgrading PLN JAMALI Load Dispatch Centre, leveraging the newly designed system capabilities to better integrate Variable Renewable Energy (VRE) into the grid.

Initially provided in the previous deliverables, the overall study included a comprehensive map of potential ground-mounted solar PV sites, a grid integration assessment, and a pre-feasibility analysis of the top 20 selected sites. This study offers a holistic view of each site's feasibility and potential challenges by considering diverse factors such as land prices and grid integration. As per BAPPENAS' request to ETP, a complementary study to the ongoing project activities has been added to incorporate the potential of Floating Solar PV (FPV) in the JAMALI region and integrate FPV sites in the solar mapping and development project.

1.2. About the Report

Indonesia's development encounters specific challenges in the land acquisition process due to high population density, competition for land use, and lengthy regulatory procedures. Land availability often becomes a significant challenge in developing solar PV projects, especially in high-density population areas such as the JAMALI regions. Competing land uses for agriculture, housing, and industry significantly limit the areas available for large-scale solar installations in this region. Using land classified as productive agricultural land for solar PV triggers complex debates. Indeed, one of the most common challenges associated with solar power generation is the critical trade-off between food security and energy needs.

With the government's and PLN's current target to integrate Solar PV in the region, identifying potential sites for solar PV development is essential to support its acceleration. Limited and tedious access to land encouraged the key stakeholders to explore other options for expanding solar PV development in Indonesia, such as floating solar PV, which can become an alternative to overcome land-related issues.

This report aims to analyse the potential reservoir for FPV development in the JAMALI region by conducting a Geographic Information System (GIS) analysis of the technical aspects of solar PV development, an Environmental and Social Impact Assessment (ESIA), and a grid analysis. The objective is to reduce risks and support stakeholders' decision-making processes for solar PV investment.

This deliverable constitutes Phase 4 of the project, and the objective is to be completed through collaborative work between the consultants to enhance their expertise. By harnessing a holistic dataset, the consultants aim to improve the accuracy of existing mathematical models provided by Solargis. Additional factors such as zoning maps, reservoir water extent, proximity to hydropower stations and others are used to assign a score and sometimes eliminate the locations that are physically, legally, or otherwise not viable for implementing floating solar PV projects. Once the data is integrated into a GIS tool, the goal is to evaluate and prioritise the existing reservoirs/dams through the GIS and non-GIS Multi-Criteria Decision Matrix (MCDM) developed in this deliverable.

The solar installation potential is reviewed to align with PLN's strategic plans. In addition to the GIS analysis, a high-level environmental and social screening is conducted to evaluate the feasibility of floating solar PV development within the selected reservoir. Part of the analysis identifies the JAMALI grid's hosting capacity for the distributed floating solar PV installations. Additionally, this report assess the financial viability of the selected sites.

Overall, this deliverable is the last step of the project before the Final Report, which will provide complementary information to the selected ground-mounted PV sites and technical knowledge to key stakeholders, including BAPPENAS, MEMR, and PLN, to support decision-making on investments in large-scale solar PV development in the JAMALI grid and lessons learned for other grids in Indonesia.

1.3. Objectives of Report

Deliverable 5 comprehensively assesses FPV sites suitability within the JAMALI regions. The objective of this deliverable are as follows:

- Analyse the potential utility-scale Floating PV development in JAMALI, Indonesia
- Conduct a high level environmental and social assessment, grid analysis, and financial analysis for selected FPV in JAMALI region.
- Develop an MCDM, including GIS and non-GIS data layers, to prioritise sites according to environmental and social criteria and regulations.

1.4. Outputs of the Report

The outputs of this report are as follows:

1. Analyse the top 21 reservoirs for FPV development in JAMALI region
2. Regulatory, social, and environmental suitability analysis
3. Multi-Criteria Decision Matrix (MCDM) for the selection of the most suitable FPV installation

The report includes the selection methodology, the data types utilised for the output, and the final visual map of the potential sites for FPV installations across the JAMALI region. This report does not replace the feasibility study necessary to finalise the implementation of the FPV sites. The development of FPV projects in the analysed locations should be preceded by a complete feasibility analysis based

2. Preliminary Desk Study and Data Collection

2.1. Literature Review

on an expanded set of parameters, optimally augmented with local measurements.

FPV systems offer a compelling alternative to traditional ground-mounted solar PV installations, bringing both advantages and technical challenges. FPV systems are often deployed on bodies of water, including reservoirs, lakes, and dams. This approach not only conserves valuable land resources but can also reduce water evaporation and improve panel efficiency thanks to the cooling effect of the water surface[2].

However, the design and operation of FPV systems demand careful attention to several critical aspects. Industry best practices emphasise the need for robust and resilient anchoring and mooring systems to secure the floating platforms against wind, waves, and fluctuating water levels[3]. The floating structures must be made of durable, UV-resistant, and corrosion-proof materials to ensure long-term performance under constant exposure to sunlight and moisture. Additionally, maintaining electrical safety is essential, as the humid environment and proximity to water increase the risk of corrosion, insulation failure, and short circuits if not properly mitigated[4]. Site-specific engineering assessments are therefore vital, since factors such as water depth, currents, climate conditions, and reservoir management significantly influence design and operational requirements.

While the initial capital investment for FPV systems is generally about 20% higher than comparable ground-mounted photovoltaic systems, the benefits often justify this added cost[5]. FPV installations can achieve higher energy yields due to the passive cooling effect provided by the water, which helps solar panels operate more efficiently, particularly in warm climates[6]. Furthermore, FPV systems deliver additional environmental value, such as reducing algae growth by limiting sunlight penetration and conserving land that can instead be used for agriculture, recreation, or conservation.

Looking ahead, ongoing technological advancements, larger-scale deployments, and increasing industry experience are anticipated to lower costs and enhance the viability of floating solar power[7]. As the technology matures, floating photovoltaic (FPV) systems hold considerable potential for expanding renewable energy capacity in areas with limited available land but ample inland water resources.

One of the earliest comprehensive lessons learned and best practice literature on floating solar is the World Bank's Where Sun Meets Water: FLOATING SOLAR HANDBOOK FOR PRACTITIONERS, published in 2019. The handbook is particularly relevant as its studies were conducted in Singapore, a country

[2] Sahu, A., Yadav, N., & Sudhakar, K. (2016). Floating photovoltaic power plant: A review. Renewable and Sustainable Energy Reviews, 66, 815–824. https://doi.org/10.1016/j.rser.2016.08.051

[3] Cazzaniga, R., Cicu, M., Rosa-Clot, M., Rosa-Clot, P., Tina, G. M., & Ventura, C. (2018). Floating photovoltaic plants: Performance analysis and design solutions. Renewable and Sustainable Energy Reviews, 81, 1730–1741. https://doi.org/10.1016/j.rser.2017.05.269

[4] Trapani, K., & Millar, D. L. (2013). The thin film flexible floating photovoltaic (T3F-PV) array: The concept and development of the prototype. Renewable Energy, 52, 295–305. https://doi.org/10.1016/j.renene.2012.10.037

[5] Ramasamy, V., & Margolis, R. (2021). Floating Photovoltaic System Cost Benchmark: Q1 2021 installations on artificial water bodies (NREL/TP-7A40-80695). Golden, CO: National Renewable Energy Laboratory. https://doi.org/10.2172/1828287.

[6] Liu, H., Wu, W., Yan, Q., & Li, M. (2017). Feasibility and economic analysis of a floating photovoltaic power plant. Renewable and Sustainable Energy Reviews, 78, 782–789. https://doi.org/10.1016/j.rser.2017.04.112

[7] International Renewable Energy Agency (IRENA). (2020). Floating solar photovoltaic in Indonesia: Assessing the potential of floating solar PV. Abu Dhabi: IRENA. Retrieved from https://www.irena.org/

with geographical and meteorological conditions comparable to Indonesia. Its focus on design considerations, technical challenges, and implementation best practices in a Southeast Asian context makes it a valuable reference for assessing FPV development potential in Indonesia.

Solar Power Europe followed suit with its recent publication of FPV Best Practice Guidelines in December of 2023. Another recent publication is the FPV Planning Guideline, published in 2024 by Indonesia's Ministry of Energy and Mineral Resources (MEMR).

This literature provided the fundamental relevant references and best practices for applying FPV technologies, site selection, and, in the case of the MEMR, published guidelines, regulatory and policy compliance.

A literature review examined industry experience in selecting, planning, and implementing floating solar PV projects from site selection, technology applications, environmental and social impacts, and other factors.

Table 1 below summarizes some of the relevant information for floating solar PV projects in Indonesia.

Table 1 Literature review

Source	Notes
Where Sun Meets Water[8]	▸ Factors in selecting locations for floating PV plant include location, weather, water body type and characteristics, ownership, soil bed conditions and bathymetry, water conditions, access to infrastructure, and others ▸ FPV projects may affect water quality and aquatic-supported biodiversity of flora and fauna ▸ Occupational health and safety hazards specific to FPV projects primarily include the risks associated with live power lines, electric and magnetic fields, and working over and under water. ▸ Primary community health and safety hazards specific to FPV facilities include water navigation and safety, aviation, and public access ▸ A comparison of floating PV and ground-mounted PV projects concluded that there are significant advantages to both technologies, and neither are superior to the other
Floating PV Best Practice Guidelines[9]	▸ Aligned with the content from the World Bank published Where Sun Meets Water handbook ▸ A feasibility report template is included containing a list of documents and specific topics to be included within each document ▸ Feasibility documents to be included: ▹ Technical feasibility ▹ Commercial feasibility ▹ Licensing, environmental, and social feasibility ▸ A table of criteria for the ideal floating solar PV is included

[8] World Bank, Energy Sector Management Assistance Program. (2019). Where Sun Meets Water: Floating Solar Handbook for Practitioners. World Bank Group. https://documents1.worldbank.org/curated/en/418961572293438109/pdf/Where-Sun-Meets-Water-Floating-Solar-Handbook-for-Practitioners.pdf

[9] SolarPower Europe. (2023, December 7). Floating PV Best Practice Guidelines (Version 1.2). SolarPower Europe. https://www.solarpowereurope.org/insights/thematic-reports/floating-pv-best-practice-guidelines-version-1-2

Guideline for Planning of Floating Solar PV Power Plants[10]	▸ Technical content is applicable for general use ▸ Includes visual impact factor of floating solar PV with a recommendation to assess the integration of FPV into the landscape on both an aesthetic and practical level ▸ Includes a floating PV project in Thailand that use an existing water body already being used for cooling processes within the premise of a bio-ethanol production facility ▸ Includes a chapter that addresses off-shore and near-shore floating solar PV installations challenges such as a highly corrosive environment, and increased mechanical stresses from high winds, wave movements, and currents

2.2. Data Collection Process

A multidimensional data collection approach was adopted to ensure a comprehensive MCDM analysis. Stakeholder interviews provided valuable qualitative insights into project issues, priorities, and practical experiences. Quantitative data, such as solar radiation from Solargis, offered reliable inputs essential for renewable energy projects. Open-source datasets, accessible online, added environmental and socioeconomic context, while targeted data purchases filled specific gaps, ensuring a robust and well-informed assessment. This combined approach integrates diverse perspectives and supports data-driven decision-making, as shown in Table 2.

Data collection relied on a mix of publicly available datasets, stakeholder-provided inputs, and internationally sourced data, all integrated into the GIS tool to capture environmental, social, regulatory, and other relevant factors for the MCDM. While assessing waterbody suitability for floating solar PV would have been valuable, detailed bathymetric data (e.g., soil bed depth) is generally unavailable. In some cases, only maximum depth data was accessible. However, this study obtained average water depth and water surface elevation (WSE) data for several reservoirs through the Surface Water and Ocean Topography (SWOT) mission.

This study also obtained relevant datasets from Indonesian stakeholders, particularly government agencies, including grid hosting capacity data from PLN and reservoir area definitions from the Ministry of Public Works. However, access to detailed public information from government agencies was limited. To address these gaps, internationally sourced public datasets were used where appropriate. Interviews with stakeholders complemented this by providing practical knowledge, best practices, and case study experiences.

Despite some limitations in stakeholder engagement, this study successfully involved key agencies. Nevertheless, the majority of quantitative data layers were obtained from Solargis, which served as a reliable foundation for the analysis.

[10] Kementerian Energi dan Sumber Daya Mineral Republik Indonesia, Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi. (2024). Panduan perencanaan pembangkit listrik tenaga surya terapung [Guideline for planning of floating solar PV power plants]. Kementerian ESDM. Retrieved from ebtke.esdm.go.id/elibrary/guideline-for-planning-of-floating-solar-pv-power-plants

Table 2. List of Data Collection

Data Category	Target Data	Source / Stakeholder	Type
Reservoir characteristics	Reservoir surface area	Ministry of Public Works & Housing (PUPR), and satellite data	Mixed sources
Solar resource data	Solar radiation (GHI, DNI, DHI, etc.)	Solargis	Purchased data / consultant data
Other spatial data layers	GIS layer data (see Table 3)	See Table 3	Mixed sources
Water depth / elevation	Average water depth and WSE	SWOT Mission (NASA/CNES)	Public international data
Grid integration	Maximum hosting capacity at substations	PLN (State Electricity Company)	Direct stakeholder data
Bathymetry (soil bed depth)	Soil bed depth across reservoir	Not publicly available (only partial data)	Limited stakeholder data
Environmental/social context	Land use, socio-economic, environmental constraints	Public GoI data and open-source datasets	Mixed sources
Regulatory framework	Regulation related to FPV development	See Table 4	Public regulatory data
Practical insights	Issues, priorities, best practices, case study experiences	Stakeholder interviews (PLN, government, and developers)	Direct stakeholder input

2.3. Spatial Data Layers

The consultants collected spatial data to consolidate the geospatial analysis. The following data layers were collected from available sources, as shown in Table 3.

Table 3 Spatial data layers

Data layer	Details	Source
Water bodies	Main source for the water bodies identification	OpenStreetMap Contributors (https://www.openstreetmap.org)

Sentinel-2 satellite imagery	Adaptation of the water bodies extent according to the recent satellite imagery; water extent changes, identification of the smallest water extent, identification of the invasive water plants (water hyacinth) extent and dynamics	Modified Copernicus Sentinel data 2016-2025 (ESA and Copernicus), processed by Sentinel hub and/or Solargis. (https://browser.dataspace.copernicus.eu)
Satellite map from Google Maps	Validation of water bodies extent, identification of the fish farms floating on the water level	Map data © 2025 Google, the map includes: Imagery © 2025 Maxar Technologies, Airbus Imagery from the dates: 17-Sep-2022 – 28-Apr-2025 (https://www.google.com/maps)
Water surface classification and variations	Analysis on water extent changes in the period 1984-2021, using the aggregated statistics for: Occurrence, seasonality, recurrence, transitions, maximum water extent	Global Surface Water (GSW), JRC, EU[11]
PV power potential production (PVOUT)	Calculated using Solargis in-house methods, from Solargis solar resource and meteorological data	Solargis
Spatial variability of solar resource	Calculated using Solargis in-house methods, based on Solargis 10-minute time-series of Global Horizontal Irradiance (GHI) data	Solargis
Built-up areas	Built-up surface grid, derived from Sentinel2 composite and Landsat satellite data	GHS-BUILT-S, year 2020, JRC, EU[12]
Protected areas	Based on IUCN categorization	World Database on Protected Areas (WDPA)[13]
Key biodiversity areas	Sites contributing significantly to the global persistence of biodiversity in terrestrial, freshwater and marine ecosystems.	World Database on Key Biodiversity Areas (WDKBA)[14]
Road network	Accessibility to water reservoirs	OpenStreetMap Contributors (https://www.openstreetmap.org)
Recent volcanic activity	Based on VEI (Volcanic Eruption Index) in the recent 100 years history	Global Volcanism Program, 2024[15]

[11] Pekel, Jean-François; Cottam, Andrew; Gorelick, Noel; Belward, Alan (2017): Global Surface Water Explorer dataset. European Commission, Joint Research Centre (JRC) [Dataset] PID: http://data.europa.eu/89h/jrc-gswe-global-surface-water-explorer-v1

[12] Pesaresi M., Politis P. (2023): GHS-BUILT-S R2023A - GHS built-up surface grid, derived from Sentinel2 composite and Landsat, multitemporal (1975-2030) European Commission, Joint Research Centre (JRC)

PID: http://data.europa.eu/89h/9f06f36f-4b11-47ec-abb0-4f8b7b1d72ea, doi:10.2905/9F06F36F-4B11-47EC-ABB0-4F8B7B1D72EA

[13] UNEP-WCMC and IUCN (2024), Protected Planet: [The World Database on Protected Areas (WDPA)] [Online], Cambridge, UK: UNEP-WCMC and IUCN. Available at: www.protectedplanet.net.

[14] BirdLife International (2024). The World Database of Key Biodiversity Areas. Developed by the KBA Partnership: BirdLife International, International Union for the Conservation of Nature, Amphibian Survival Alliance, Conservation International, Critical Ecosystem Partnership Fund, Global Environment Facility, Re:wild, NatureServe, Rainforest Trust, Royal Society for the Protection of Birds, Wildlife Conservation Society and World Wildlife Fund. Available at www.keybiodiversityareas.org. [Accessed 4/6/2024].

[15] Global Volcanism Program, 2024. [Database] Volcanoes of the World (v. 5.1.7; 26 Apr 2024). Distributed by Smithsonian Institution, compiled by Venzke, E. https://doi.org/10.5479/si.GVP.VOTW5-2023.5.1

Terrain horizon	Terrain horizon data, derived from digital elevation model data (SRTM, nominal resolution 90 m), is the main input for the algorithm estimating the GHI loss caused by terrain shading	CGIAR-CSI SRTM 90m Database, processed and calculated by Solargis
Basic wind speed	Basic wind speed data according to SNI 1727:2020 document as a basis for FPV design structure	SNI 1727:2020
Wind gust	Extreme wind gust events in the regions were derived from ERA5 Climate Reanalysis hourly time-series data from a period 1994-2024	ERA5 provided by ECMWF and Copernicus, post-processed by Solargis
Substations	Localization of 150/20 kV substations	MEMR Geoportal and RUPTL
Water surface elevation nd average water depth	Water surface elevation refers to the vertical height of the water surface above a defined reference point (usually sea level), measured at specific locations and times. Average Water Depth refers to the mean vertical distance between the water surface and the bottom of a water body, calculated by dividing the total volume of water by the surface area it covers	In the Surface Water and Ocean Topography (SWOT) context, the water surface elevation is derived from high-resolution satellite data to monitor global water level changes in lakes, rivers, and reservoirs. (https://podaac.jpl.nasa.gov/SWOT)
Hydro power plants	Existing hydro power plants on the selected reservoirs were identified and categorized from available public information	Global Energy Observatory, Google, KTH Royal Institute of Technology in Stockholm, Enipedia, World Resources Institute. 2019. Global Power Plant Database v1.2.0. Published on Resource Watch (http://resourcewatch.org/) and Google Earth Engine (https://earthengine.google.com/). Accessed through Resource Watch, (2025-04-04). www.resourcewatch.org.; OpenStreetMap Contributors

2.4. List of Relevant Regulations Affecting the Location Selection

This study considered several relevant regulations and provided suggestions on how the regulations affect the location selection in developing the MCDM. The regulations provided below were also key to E&S screening and the legal assessment. Table 4 summarizes regulations and recommendations on E&S screening and MCDM development. A key summary of each regulation can be found in ANNEX G – List of Relevant Regulations Affecting the Location Selection. A complete list of regulations relevant to the solar PV development in general is provided in ANNEX H - Detailed List of Relevant Regulations for FPV Implementation

Table 4 Summary of relevant regulations and recommendations on E&S screening and MCDM development

No	Policies / Regulations	Recommendations on E&S Screening
1	**Law No. 32 of 2009 on Environmental Protection and Management**	This regulation serves as one of the main references considered to determine the necessary actions based on a high-level assessment of the potential environmental and social risks of a potential site. It is not used directly to determine the risk assessment, as at this study stage there is no project-specific data available to enable a deeper review of the regulatory requirements.
2	**Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management**	
3	**Ministry of Environmental and Forestry Regulation No.04 of 2021 on the List of Business and/or Activities required to have Environmental Impact Analysis, Environmental Management Efforts, and Environmental Monitoring Efforts or Statement of Environmental Management and Monitoring Ability**	
4	**The Ministry of Public Works and Housing Regulation Number 27/PRT/M/2015 on Dams, as amended by Regulation Number 7 of 2023**	Maximizing the 20% limit for the FPV utilisation.
5	**Law No 1 Year 2014 Concerning Amendment to Law No 27 Year 2007 concerning Management of Coastal Zone and Small Islands**	This regulation is taken into consideration by the Consultant when conducting E&S Screening to exclude **sites located in mangrove areas**
6	**Government Regulation No. 7 of 1999** **Minister of Environmental and Forestry Regulation No. P.106/MENLHK/SETJEN/KUM.1/8 of 2018 on Second Amendment on Minister Regulation No. P.20/MENLHK/SETJEN/KUM.1/6 of 2018**	This regulation is a reference for the Consultant in carrying out E&S Screening to assess the risk of potential sites according to the presence of protected species in Indonesia.
7	**Government Regulation No. 23 of 2021 concerning Forestry Management**	This regulation is a reference for the Consultant in carrying out E&S Screening to assess the risk of potential sites according to the presence of invasive species in Indonesia.
8	**Government Regulation No. 23 of 2021 concerning Forestry Management**	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are located in.
9	**Government Regulation No. 23 of 2021 concerning Forestry Management**	
10	**Presidential Regulation No. 121 Year 2012 concerning Rehabilitation of Coastal Zone and Small Islands**	

No	Policies / Regulations	Recommendations on E&S Screening
11	**Presidential Regulation No. 120 Year 2020 concerning Peatland and Mangrove Restoration Body (Badan Restorasi Gambut dan Mangrove or BRGM)**	This regulation is taken into consideration when conducting E&S Screening to exclude sites located in mangrove areas
12	**Government Regulation No. 23 of 2021 concerning Forestry Management**	This regulation is taken into consideration when conducting E&S Screening to exclude sites located in mangrove areas
13	**Ministry of Environment and Forestry Regulation No. 7 of 2021 concerning Forestry Planning, Changes of Designation in Forest Area, and Changes of Function in Forest Area, and Forest Utilization**	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are situated in.
14	**Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) Regulation No. 1589 of 2021 concerning Map of the designation of protected rice fields**	This regulation is the Consultant´s recommendation to exclude potential sites in rice fields.
15	**Presidential Instruction No. 5 of 2019 concerning Termination Of Granting New License and Governance Improvement for Primary Forest and Peatlands**	This regulation is a reference in conducting E&S Screening to exclude potential sites located on moratorium land.
16	**Ministry of Environment and Forestry Decree No. SK. 3554/MENLHK-PKTL/IPSDH/ PLA.1 3/2023 of 2023 and Forestry Decree No. SK.12764/MENLHK-PKTL/IPSDH/ PLA. 1/ 11/2023 dated 22 November 2023 concerning Determination of an Indicative Map for Cessation of Granting Business Permits, Approvals for Use of Forest Areas, or New Forest Area Allocation Requirements for Primary Natural Forest and Peatland in 2023 Period I and Period II**	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are situated in.
17	**Keputusan Menteri Lingkungan Hidup dan Kehutanan SK. 8/Menlhk-PKTL/REN/ PLA.0/1/2023 tentang Peta Indikatif dan Areal Perhutanan Sosial (Revisi VIII)**	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the presence of social forest surrounding it.
18	**Key Biodiversity Area concerning Key Biodiversity Area**	This regulation is a reference to exclude potential sites located in high biodiversity areas.
19	**Ministry of Education, Culture, Research, and Technology concerning Cultural Heritage Database**	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
20	**Registration Body of Indigenous Area (Badan Registrasi Wilayah Adat) concerning Indigenous territory map**	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.

No	Policies / Regulations	Recommendations on E&S Screening
21	**Minister of Internal Affairs Regulation No. 52 Year 2014 on Customary Law Community Recognition**	This regulation is a reference to identify project areas potentially overlapping with customary territories. Screening should include verifying community recognition status and ensuring early engagement and consent-based approaches. The Consultant will use the Ministrial Data database to assess the presence of Customary Law Communities as recognized Indigenous People within and surrounding site selection area and include them in MCDM Analysis.
22	**Presidential Decree No. 186 Year 2014 concerning Empowerment of Remote Indigenous Communities**	This regulation is a reference to identify if a project site affects vulnerable or remote Indigenous communities, requiring tailored livelihood support, relocation safeguards, and inclusive consultation processes. The Consultant will use database from Ministrial Data to assess the presence of Remote Indigenous Communities within and surrounding sites selection area and include into MCDM Analysis.
23	**Law No. 11 of 2010 concerning Cultural Preservation**	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
24	**Law No. 5 of 2017 concerning Cultural Advancement**	This regulation is a reference to assess potential non-physical cultural impacts from project activities, including on traditional customs, oral traditions, and community rituals. Stakeholder engagement must include cultural bearers and local knowledge holders.
25	**Government Regulation No. 1 of 2022 concerning National Registry and Conservation of Cultural Heritage**	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
26	**Governor of West Java Decree No 96 of 2022 on Management of Floating Net Cage (FNC) in the Area of Cirata, Saguling and Jatiluhur dam**	This regulation is considered when conducting E&S screening to categorize the size of the FNC and assess the associated social risk implications.

3. Methodology

Figure 1 illustrates the overall methodology adopted for this study, which is structured into a series of interconnected stages. This study applied a comprehensive and systematic approach that integrates geospatial analysis, environmental, and social assessments, preliminary grid integration analysis, and financial modelling.

The study began with a desktop review and extensive data collection. This phase involved assessing all major reservoirs in the JAMALI region and pre-selecting potential sites based on surface area and their inclusion in the national electricity development plan (Rencana Usaha Penyediaan Tenaga Listrik or RUPTL). Reservoirs listed in the RUPTL 2025-2030 were given priority for detailed evaluation in the subsequent steps.

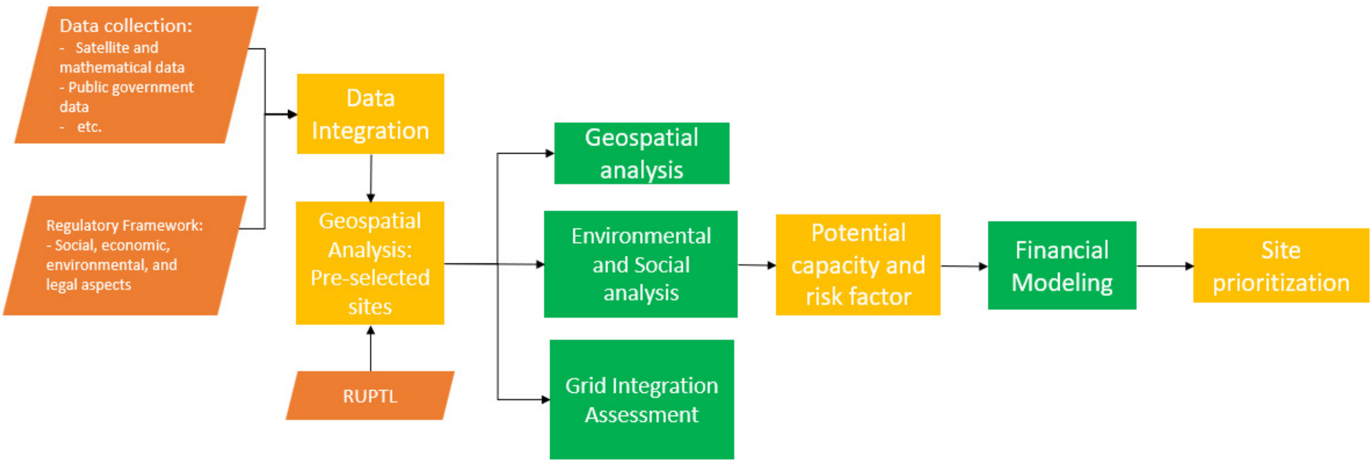


Figure 1 Overall methodology

A Multi-Criteria Decision Matrix (MCDM) framework was developed to determine the most suitable locations for floating PV development in the JAMALI region. This methodology consisted of four key activities:

1. Geospatial analysis: To identify technically feasible locations for floating PV deployment across the JAMALI region.
2. Environmental, social, and legal analysis: To validate the technical findings and assess potential risks related to environmental, social, and regulatory factors.
3. Preliminary grid integration assessment: To estimate the maximum hosting capacity of solar PV at the substation level for each shortlisted site.
4. Financial modelling: To analyse the financial viability and bankability of each floating PV site.

Each step of this methodology is described in detail in the subsequent sections: Geospatial Analysis, Environmental and Social Analysis, Grid Integration Assessment, and Financial Analysis.

3.1. Regulatory Analysis

Reviewing the relevant regulations establishes the context and landscape of the 1GW solar PV development. Relevant regulations were analysed to provide suggestions on how they affect location selection. The regulations are split into two categories:

- Regulations that are directly relevant to the MCDM and
- Other regulations that do not directly affect the MCDM but are relevant to the broader project analysis, such as available government support and permit requirements for floating solar PV development, have also been identified.

The regulatory review process involves three primary steps, as described in the following diagram in Figure 2.

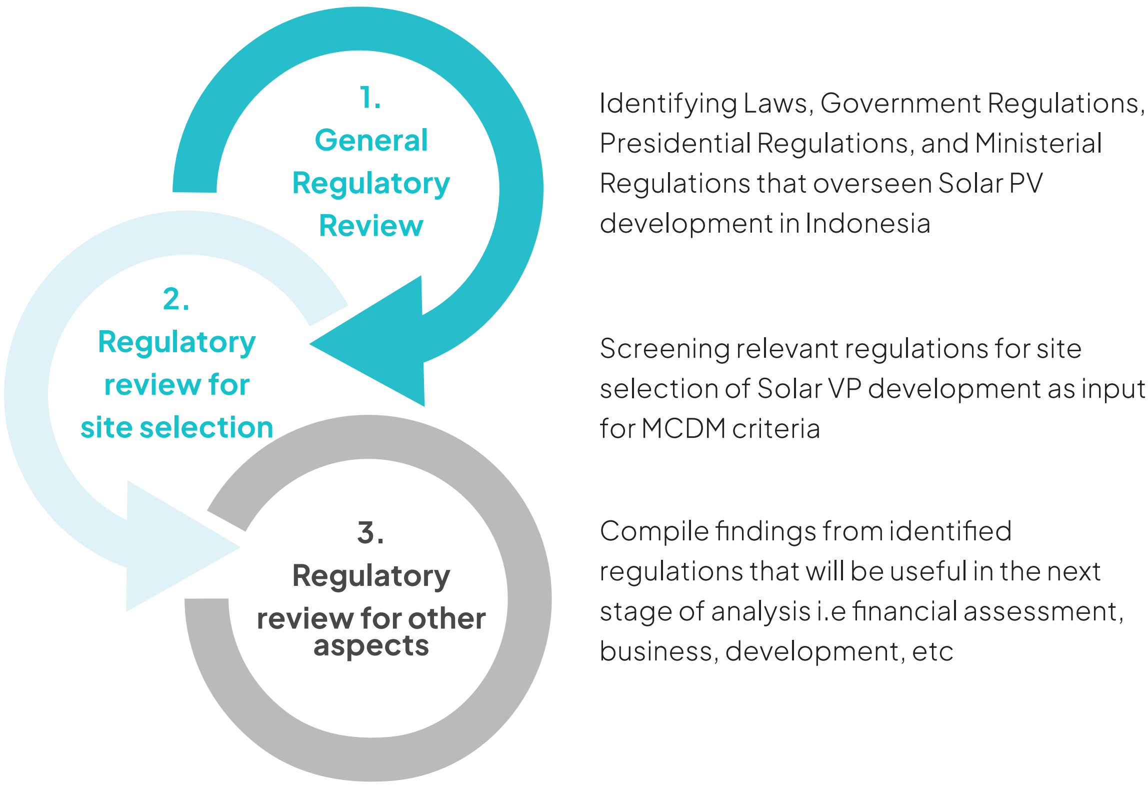


Figure 2 Regulatory review methodology

Firstly, all regulations related to Solar PV development focusing on FPV in Indonesia are identified, including laws, government, presidential, and ministerial regulations. The identified regulations are limited to nationwide regulations as the detailed implementation on the regional level usually differs based on applicable local procedures[16].

The list of relevant regulations summarises regulations and suggestions for MCDM criteria development and E&S screening. Regulations that will be considered for the next stage are provided in ANNEX H - Detailed List of Relevant Regulations for FPV Implementation. It is also important to note that a more detailed legal assessment will be required to complement the regulatory reviews before any decisions are made regarding solar PV development.

The regulatory data collection and screening include reviewing of the following:

- **Compliance with National Spatial Planning:** Analyse whether the proposed project activities align with National Spatial Planning regulations and land use designations. Sites categorized

[16] Local regulatory review will be done after the potential sites have been decided

as waterbodies are permitted for FPV facilities under The Ministry of Public Works and Public Housing (MOPWH) Ministerial Regulation No. 7 of 2023. FPV (with limits set on the allowable coverage area for the installation). Given that, the potential sites are initially confirmed to be in alignment with applicable requirements.

- **Regulations related to E&S Aspects**: In addition to the regulatory review of spatial compliance with existing permits, regulations related to E&S aspects were assessed. The review includes the regulation governing the management of fishing activity (floating net cages), presence of protected species and areas of high biodiversity, and considered factors such as forestry classification, moratorium land status, proximity to mangrove areas, and the presence of cultural heritage sites or indigenous peoples (IP) and vulnerable communities in the areas where the sites are located. This also includes regulations on restoration plans for specific reservoirs, which reflect heightened concern and consideration of potential environmental and social impacts such as in Presidential Regulation No. 15 of 2018 on the Acceleration of Pollution Control and Damage Recovery of the Citarum Watershed, and West Java Governor Decree No. 96 of 2022 on the Management of Floating Net Cages (FNC) in the Cirata, Saguling, and Jatiluhur dam areas.
- **Review of surrounding land cover type and compliance with forest land tenure:** Analyse whether the project site will be located under forestry area managed by Ministry of Forestry, or will be located outside forestry area (i.e., other land use or “Area Penggunaan Lain”/APL). It is necessary to determine whether the project area falls within forestry area or not, especially since one of the forestry area categories cannot be converted/utilized for any kinds of project (i.e., conservation forest), hence will prohibit the Project from being conducted on that site. If a potential site is located within a forest area, it is necessary to determine the specific forest classification, production forest, protection forest, or conservation forest. Development is not permitted within conservation forest areas. For sites classified as production or protection forest, the project developer must apply for a Forest Utilization Approval (Persetujuan Penggunaan Kawasan Hutan or PPKH) from the Ministry of Forestry. Power generation projects, such as floating solar PV, are eligible to obtain a PPKH, subject to meeting the relevant requirements. The data used for the analysis is derived from the latest GIS database from former Ministry of Environment and Forestry: https://sigap.menlhk.go.id/sigap/peta-interaktif
- **High level regulatory review of Indonesia’s requirements and review on international safeguards,** such as those of environmental permit required by the business (e.g. AMDAL, UKL/UPL) and international safeguards such as IFC performance standards.
- **Identification of available government incentives or support for PV development** as stipulated in Presidential Regulation No. 112 of 2022 concerning Accelerating the Development of Renewable Energy for Providing Electric Power and Minister of Public Works and Housing Regulation Number 27/PRT/M/2015 concerning DAM as amended through Minister of Public Works and Housing Regulation Number 7 of 2023.
- **Compliance with PLN grid connection procedures and the grid codes** mentioned in Minister of Energy and Mineral Resources Regulation No. 20 of 2020 about Codes of Electricity Power System Network (Grid Code) to analyze connection procedures, technical requirements, and the permitting process for connecting solar PV plants to the JAMALI region.

3.2. Geospatial Analysis

The geospatial analysis describes the technical feasibility of developing a FPV power plant in the selected reservoirs and lakes in the JAMALI region. The objective is a pre-feasibility analysis limited in scope to the available data layers. The outcome of the geospatial analysis is a ranked list of the selected reservoirs based on their suitability for FPV development and a high-level description of the suitability based on the analysed factors.

The geospatial analysis is based on the available data layers described in 2.3. The selection of factors is inspired by the previously published guidelines[17] and handbooks 5, 6[18]. Data layers, such as water level movement, bathymetry, or substrate mapping, which it was not possible to obtain within the scope of the study, were not publicly available, and engagement with local authorities was too lengthy to provide this data in good time. However, some indicative data were calculated for the water surface variation. The average water depth and the variation in water surface elevation will remain indicative and not influence the scoring and ranking at this stage of the studies.

These parameters are essential for the localisation of an FPV within a reservoir, as well as the design and, subsequently, the cost of the power plant. Nevertheless, this prefeasibility study can achieve its objective of comparing and ranking the water bodies without considering these parameters. The development of FPV projects in the analysed locations should be preceded by a complete feasibility analysis based on an expanded set of parameters, optimally augmented with local measurements.

The geospatial analysis is limited in scope to the factors affecting the technical feasibility of developing FPV in the selected reservoirs. The following chapters analyse all other relevant factors to further augment the geospatial study's outcomes.

3.2.1. Preselection of Sites for Analysis

The geospatial and further analyses were conducted on a shortlist of reservoirs and lakes in the JAMALI region. Based on the compiled dataset of water reservoirs in the JAMALI region, 51 distinct water bodies with a surface area exceeding 100 hectares were identified (see ANNEX A – Basic Information of Considered Water Bodies for details). From this group, 21 reservoirs were selected for further analysis. These selected water bodies range in size from 288 ha to 7,091 ha, measured at their Mean Water Level (the calculation of the Mean Water Level is explained in section 3.2.2). Figure 3 below illustrates the preselection of sites process.

[17] Kementerian Energi dan Sumber Daya Mineral Republik Indonesia, Direktorat Jenderal Energi Baru, Terbarukan, dan Konservasi Energi. (2024). Panduan perencanaan pembangkit listrik tenaga surya terapung [Guideline for planning of floating solar PV power plants]. Kementerian ESDM. Retrieved from ebtke.esdm.go.id/elibrary/guideline-for-planning-of-floating-solar-pv-power-plants

[18] World Bank, Energy Sector Management Assistance Program. (2019). Where Sun Meets Water: Floating Solar Handbook for Practitioners. World Bank Group. https://documents1.worldbank.org/curated/en/418961572293438109/pdf/Where-Sun-Meets-Water-Floating-Solar-Handbook-for-Practitioners.pdf

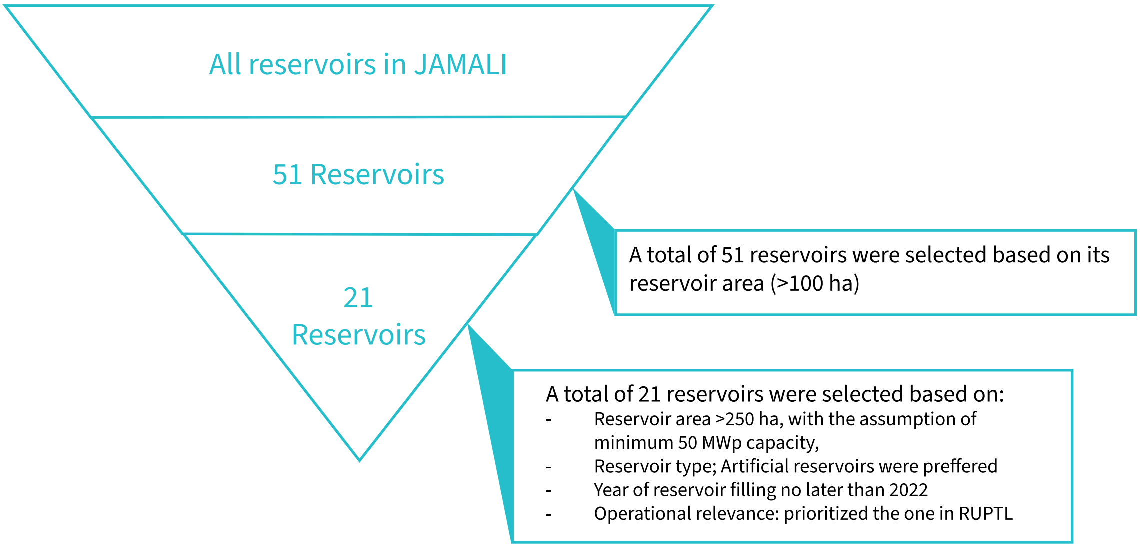


Figure 3. Pre-selection of sites process

The following criteria, derived based on expert assessment, guided the selection:

- Reservoir size: Preference was given to larger water bodies, as these provide enough space to develop the FPV considering the 20% of the surface area availability limit imposed by local legislation.
- Reservoir type: Artificial (built-up) reservoirs were preferred; natural lakes were excluded, except for Lake Beratan. This is due to the potential impact on the sensitive ecosystems present in natural lakes, which generally do not exist on artificial water bodies.
- Environmental constraints: Water bodies with significant onshore or offshore protected areas were excluded.
- Operational relevance: Preference was given to water bodies identified in the RUPTL
- Year of reservoir filling: preference was given to the reservoirs commissioned after 2015, as this means at least 10 years of satellite data were available for analysis, and parameters such as mean water level area and effective area could be established confidently.

Figure 4 below shows the water bodies selected for further analysis, and Table 5 details their main features. Details of all 51 considered water bodies can be found in ANNEX A – Basic Information of Considered Water Bodies.

Additionally, the data integration and preliminary analysis in this study reveal discrepancies between the reservoir areas reported by the Ministry of PUPR and those observed in satellite data. To address this, a conservative approach was adopted for a potential capacity estimation by using the smaller total area from either source. The analysis shows that, in most cases, the satellite-derived areas are smaller.

Figure 4 Localisation of 21 selected water bodies in the context of the river network and other water bodies in JAMALI region

Table 5 Details of the 21 water bodies selected for analysis

No	Reservoir name	Latitude	Longitude	Geometry			
				Area by PUPR /other sources (ha)	Area MWL [ha]	Perimeter [km]	Estimated Capacity based on total Areas 20% [MWp]
1	Waduk Jatiluhur	-6.52361	107.388328	7780	7091.4	220.1	1418
2	Waduk Cirata	-6.72934	107.284372	6200	5729.6	190.7	1146
3	Waduk Gajah Mungkur	-7.8995	110.897754	8800	4849.3	208.8	970
4	Waduk Kedung Ombo	-7.27278	110.82	4600	3838.6	210.3	768
5	Waduk Saguling	-6.91714	107.392735	5600	3515.6	399.4	703
6	Waduk Jatigede	-6.87674	108.091554	4946	3392.0	127.2	678
7	Waduk Karangkates	-8.1831	112.481261	1500	1283.0	71.5	257
8	Waduk Wadaslintang	-7.00871	109.197771	1320	1141.8	55.4	228
9	Waduk Cacaban	-7.0356	108.808428	790	642.6	49.1	129
10	Waduk Malahayu	-7.21078	112.270628	540	538.4	35.2	108
11	Waduk Mrica	-7.53766	111.795419	1250	487.0	34.1	97
12	Waduk Gondang	-8.27204	115.174092	544	484.6	33.2	97
13	Waduk Widas	-7.01272	108.406833	560	437.7	52.2	88
14	Danau Beratan	-8.01948	111.795002	375	383.4	8.1	75

No	Reservoir name	Latitude	Longitude	Geometry			
				Area by PUPR /other sources (ha)	Area MWL [ha]	Perimeter [km]	Estimated Capacity based on total Areas 20% [MWp]
15	Waduk Darma	-7.40705	111.563892	397	382.1	16.3	76
16	Waduk Wonorejo	-6.49503	107.9457	380	362.1	21.0	72
17	Waduk Pondok	-7.36707	111.86911	380	332.1	49.5	66
18	Waduk Cipancuh	-8.14677	112.45625	387	329.0	23.0	66
19	Waduk Pacal	-7.50963	110.726335	520	317.3	33.2	63
20	Waduk Lahor	-6.52361	107.388328	263	315.1	34.4	53
21	Waduk Cengklik	-6.72934	107.284372	253	288.7	11.0	51

3.2.2. Mean Water Level Area (MWL)

The surface area of water bodies is an essential parameter for identifying reservoirs suitable for utility-scale FPV development. Due to the lack of accurate data on reservoir extents from official sources, a custom dataset of water bodies using publicly available data was compiled.

The Mean Water Level (MWL) area is used as a representative value for the typical reservoir area and serves as the basis for some of the subsequent calculations. Reservoir water levels naturally fluctuate across seasons and years, influenced by inflow and outflow dynamics. The MWL area reflects the typical reservoir extent observed in time-series satellite imagery (Figure 5). The MWL area was used during the site preselection, when it was decided to narrow the list of analysed water bodies to those with an MWL area of over 100 ha. Water areas are shown in dark colour (infrared spectrum). MWL area is indicated by cyan colour, which is common for most of the time in the recent years.

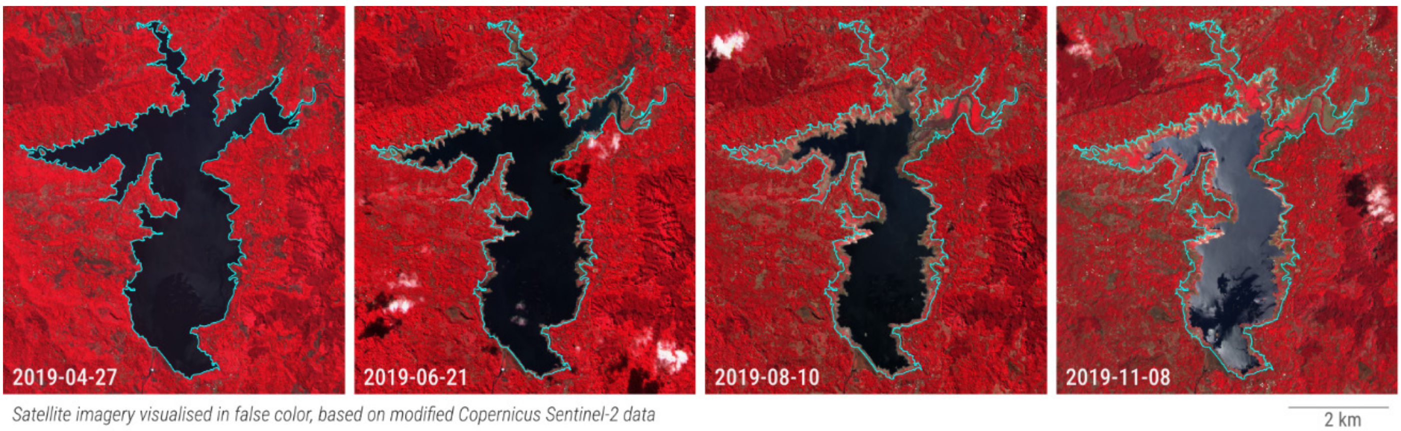


Figure 5 Water extent changes in time, example of Wadaslintang reservoir on Sentinel-2 satellite imagery (Copernicus) for four days in the year 2019

3.2.3. Estimated FPV Capacity (based on area)

The potential installed capacity of an FPV for each reservoir was estimated from the MWL area using two approaches:

5. Following the legal limitations of FPV development in Indonesia, 20% of the MWL area was assumed to be available[19].
6. As a maximum estimate (upper bound), the effective area (see definition in the section 3.2.4) was assumed to be available.

Both approaches assume a conservative installation density of 1 MWp of FPV capacity per hectare of water surface. This allows ample space to accommodate service infrastructure and maintenance corridors between FPV arrays. While real-world installations can achieve densities of up to 2 MWp/ha (thanks to ongoing advancements in FPV design and anchoring systems), this lower estimate reflects a more cautious and practical planning assumption. Notably, the utility-scale FPV project on the Cirata reservoir in Java demonstrates a similar space utilisation, with approximately 192 MWp installed over 198 hectares, equivalent to roughly 1 MWp/ha. This reinforces the realism and reliability of the assumption.

3.2.4. Effective Area

The effective area, expressed as a percentage of the MWL area, refers to the portion of the reservoir that consistently holds water. This is illustrated in the Figure 6 below. The top image shows the MWL area, with colour coding to indicate sections of the reservoir that have historically dried up (areas shaded in brown represent zones that frequently dry out). The bottom part of the figure presents satellite images, shown in false-colour spectrum, highlighting examples of reduced reservoir areas during drier periods.

The effective was estimated based on analysis of satellite images over the last 10 years. The effective area indicates the risk of water extent changes due to seasonal and yearly cycles. The smallest effective area in most of the analysed reservoirs was observed from September to November 2019, likely due to prevailing meteorological conditions. Many reservoirs appear to be used heavily for agricultural irrigation and hence undergo severe changes in their area.

[19] Based on the Regulation Number 27/PRT/M/2015 on Dams, as amended by Regulation Number 7 of 2023 indicated in the list of regulaitons in section 2.4 from the Ministry of Public Works and Housing

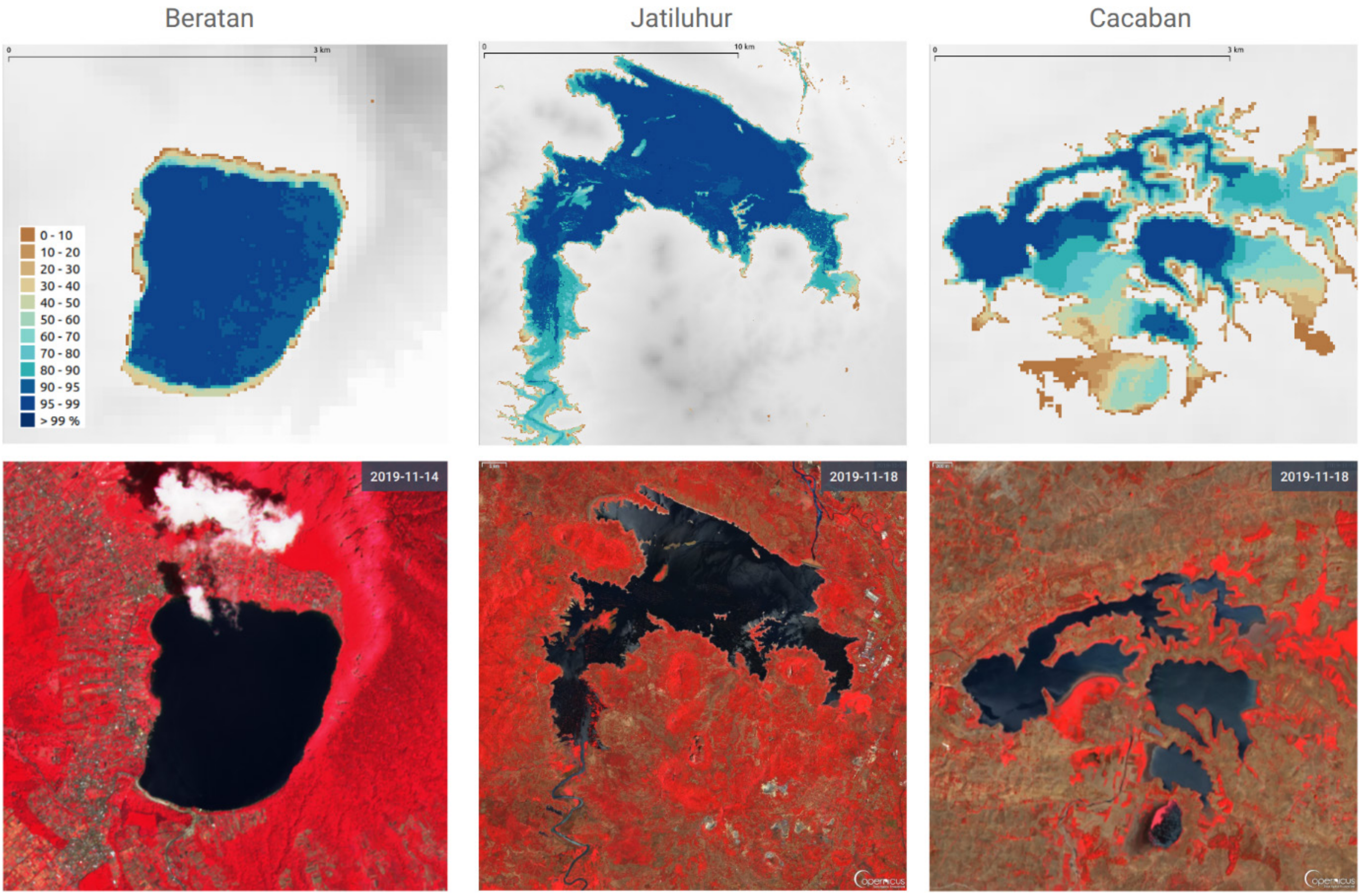


Figure 6 Examples of three reservoirs and their area changes observed on satellite images and interpreted time-series of satellite data. Top: Water occurrence in % of time, based on GSW (JRC) dataset. Dark blue color represents permanent or quasi permanent water occurrence. Bottom: False-color (infrared, water is dark color) Sentinel-2 satellite images from month with historically lowest water levels (November 2019).

3.2.5. Reservoir Shape Complexity

The reservoir shape complexity, expressed as kilometres of shoreline per hectare of area, measures the fragmentation of the reservoir area. This is illustrated in Figure 7 below, showing the Cirata and Saguling reservoirs. Cirata's shape complexity is 0.03 km/ha, while Saguling's is 0.11 km/ha. The Saguling reservoir is characterised by long and narrow corridors of water, small bays, and no large open water area.

A utility-scale FPV built on a reservoir with a complex shape would have to be fragmented, requiring a complex arrangement of floats, cables, and all supporting infrastructure. Therefore, the high reservoir complexity shape is disadvantageous to the development of FPV.

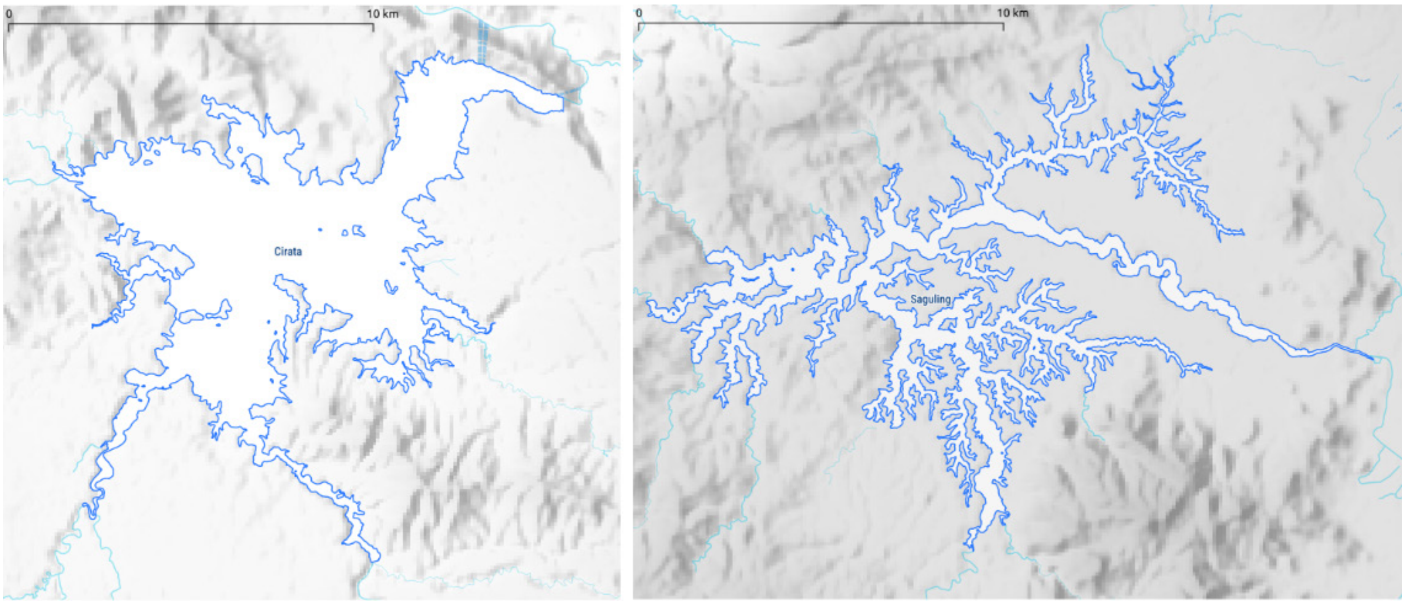


Figure 7 Example of shape complexity of Cirata (left) and Saguling (right) reservoirs

3.2.6. Water Surface Elevation and Average Water Depth

Average Water Depth refers to the mean vertical distance between the water surface and the bottom of a water body, calculated by dividing the total volume of water by the surface area it covers. This metric simplifies a water body´s depth and is helpful for the FPV feasibility assessments.

Water Surface Elevation (WSE) refers to the vertical height of the water surface above a defined reference point (usually sea level), measured at specific locations and times.

Both are critical factors for the FPV feasibility study because they directly influence the project's technical and economic viability. For the technical considerations, these two factors help determine the anchoring and mooring design and structural stability so that the system remains stable during water fluctuations. Then, based on the decisions made, the design directly influences the installation costs and the estimations of future operations and maintenance costs.

The Surface Water and Ocean Topography (SWOT) mission, launched in December 2022, is the first satellite designed for a global survey of surface water, including oceans, lakes, rivers, reservoirs, and wetlands. It provides high-resolution measurements of rivers over 100 m wide and water bodies larger than 250 × 250 m, with global coverage and a maximum revisit time of 21 days. Since no local data were available, SWOT served as the primary data source for this analysis.

In the SWOT satellite mission context, average water depth and WSE is derived from high-resolution satellite observations to monitor water level changes in lakes, rivers, and reservoirs globally.

3.2.7. Mean PVOUT

PV power output (PVOUT) is the main performance characteristic of any PV power plant, regardless of whether it is mounted on water or land. The mean PVOUT parameter describes the expected power production of the FPV on the reservoir. It is calculated based on Solargis data and the PV simulation algorithm as the yearly average of PV power generation potential in the last 18 years (period 2007-2024). The calculation is performed with a spatial resolution of 30 arcsec resolution (approx. 1 km). Since each reservoir spans multiple pixels with calculated PVOUT, the final representative value was derived as the spatial mean over the MWL area of each reservoir (Figure 8). The parameter is normalized to kWh/kWp (i.e. yearly power production per installed kWp) to enable comparison between the locations.

For the calculation of the expected PVOUT, Solargis solar and meteorological data are used as input to the Solargis PV simulator. The system configuration is set as free-standing ground-mounted structure, with the PV modules at the optimum fixed tilt (i.e. tilt maximising the yearly irradiance in plane of array) for the location. The real configuration of the FPV will be different from this setup, as the FPV installations are typically installed at a lower tilt angle, and with smaller row spacing, compared to the ground-mounted PV power plants. However, as the objective of the geospatial analysis is a relative ranking of the locations, it is only important that the method for calculating the expected PVOUT is consistent. The ground-mounted variant allows for a fast PVOUT calculation, and it is extensively validated against real-world measurements, hence can be relied upon to provide accurate PVOUT estimates. As mentioned previously, any development of an FPV should be preceded by a full feasibility analysis, a part of which should be a PVOUT simulation considering the real proposed configuration of the PV power plant.

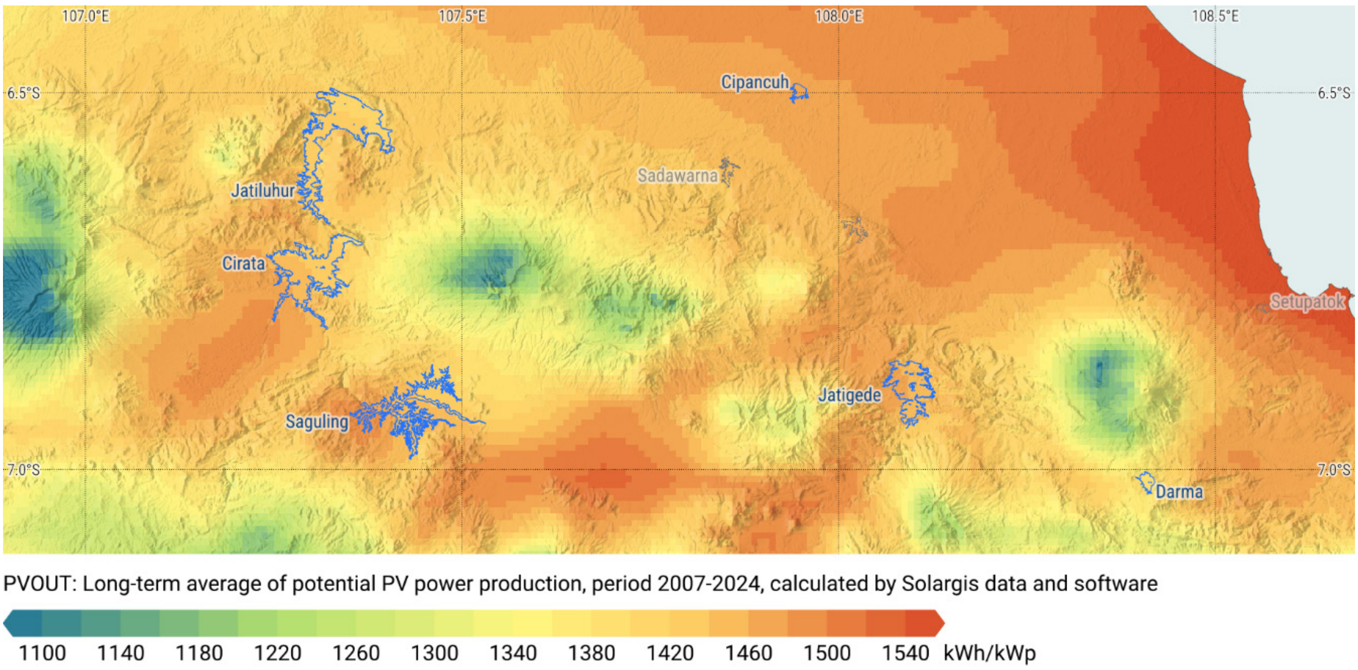


Figure 8 Reservoirs overlaid on the PVOUT map. Spatial mean for each reservoir is computed from all pixel values covering the water body

3.2.8. Terrain Shading

Shading from terrain, either nearby or far horizon, is an important factor to consider when localising the PV power plant, as it leads to losses in the PV power production. The mean shading is calculated as the mean reduction in Global Horizontal Irradiation (GHI) over the MWL area of the reservoir due to the surrounding terrain and far horizon. The terrain effects are considered at a spatial resolution of 9 arcsec (nominally 250 m). The Figure 9 below illustrates the calculation of the terrain shading.

The mean shading parameter can be considered a risk—the higher the value, the larger the shading effects on the reservoir, and the more care must be taken when localising the power plant within the water body. At the feasibility analysis stage, a specific shading map can be created for each reservoir.

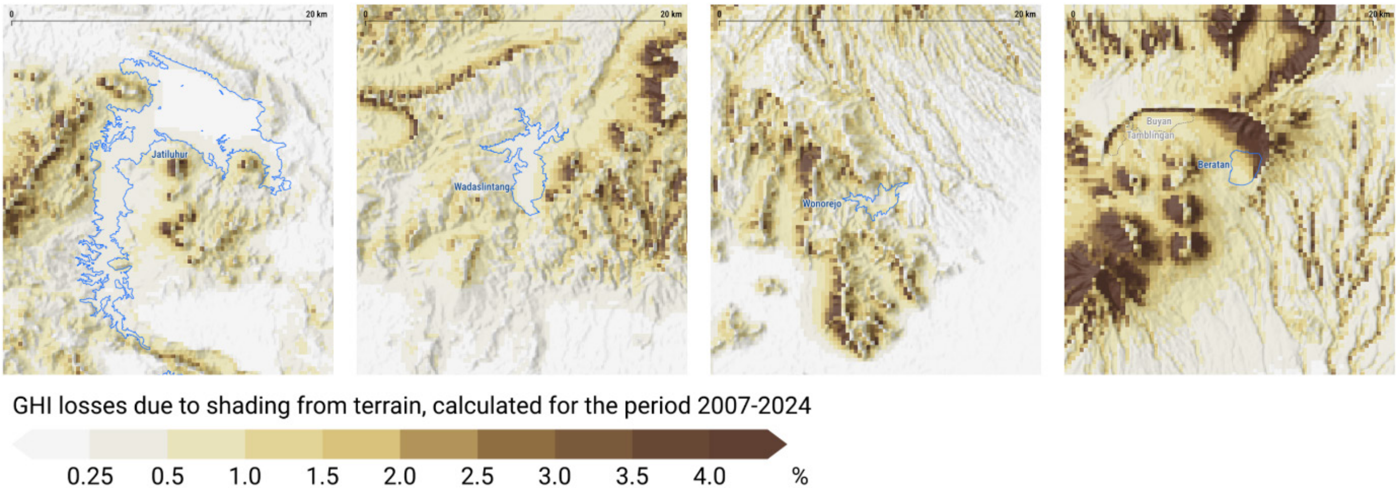


Figure 9 Long-term average of GHI losses due to shading from terrain [%], example of four water bodies: Jatiluhur, Wadaslintang, Wonorejo, Beratan. The indicator for the reservoir is calculated as a spatial mean

3.2.9. Wind Speed

Wind speed is an essential factor to consider for any PV power plant. For FPVs it is especially important, as wind causes waves to arise on the water body, which the FPV must be designed to withstand. In practice, structures, including FPVs are designed to basic wind speeds. Basic wind speed (also known as fundamental wind speed) is generally defined as the peak gust wind speed (usually over a 3-second or 10-minute average period) measured at 10 meters above ground level in open terrain, with a specified return period (often e.g. 50 years), and adjusted for mean recurrence interval, topography, and exposure conditions. The basic wind speeds are also typically aggregated over a wider area, and a safety factor may be applied. This may lead to an overestimation of the typical wind speeds at a particular location.

For the analysed water bodies in JAMALI, the basic wind speeds are defined by range from SNI 1727:2020 — Minimum Loads for the Design of Buildings and Other Structures as shown in Table 6 below.

Table 6 Basic wind speed for all analysed water bodies

Reservoir name	Basic Wind Speed (V) [m/s]
Waduk Pacal	27–30
Waduk Gondang	27–30
Waduk Cirata	30–33
Waduk Jatiluhur	30–33
Waduk Saguling	30–33
Waduk Widas	27–30
Waduk Lahor	28–31
Waduk Karangkates (Sutami)	28–31
Waduk Wadaslintang	28–31
Waduk Wonorejo	28–31
Waduk Mrica	28–31

Reservoir name	Basic Wind Speed (V) [m/s]
Waduk Cengklik	28–31
Waduk Malahayu	28–32
Waduk Cipancuh	28–32
Waduk Darma	30–32
Waduk Pondok	28–31
Danau Beratan	30–33
Waduk Jatigede	30–32
Waduk Cacaban	28–32
Waduk Gajah Mungkur	27–30
Waduk Kedung Ombo	27–30

To confirm the basic wind speed figures, wind speeds and wind gusts were additionally evaluated for each analysed water body. The data is based on ERA5 climate reanalysis hourly data (by ECMWF and Copernicus), covering 1994-2024.

In general, it was found that the prevalent wind speeds and wind gusts are lower than the defined basic wind speeds for the analysed water bodies. This is illustrated in the Figure 10 below which shows the cumulative distribution function (CDF) of wind speed and wind gust for the reservoir with the highest observed wind speeds (Gajah Mungkur) and a reservoir with average to low wind speeds (Saguling). The P99 value (i.e. value higher than 99% of samples) for wind gust is 9.9 m/s and 11.2 m/s for Saguling and Gajah Mungkur respectively, demonstrating low wind speeds and wind gusts.

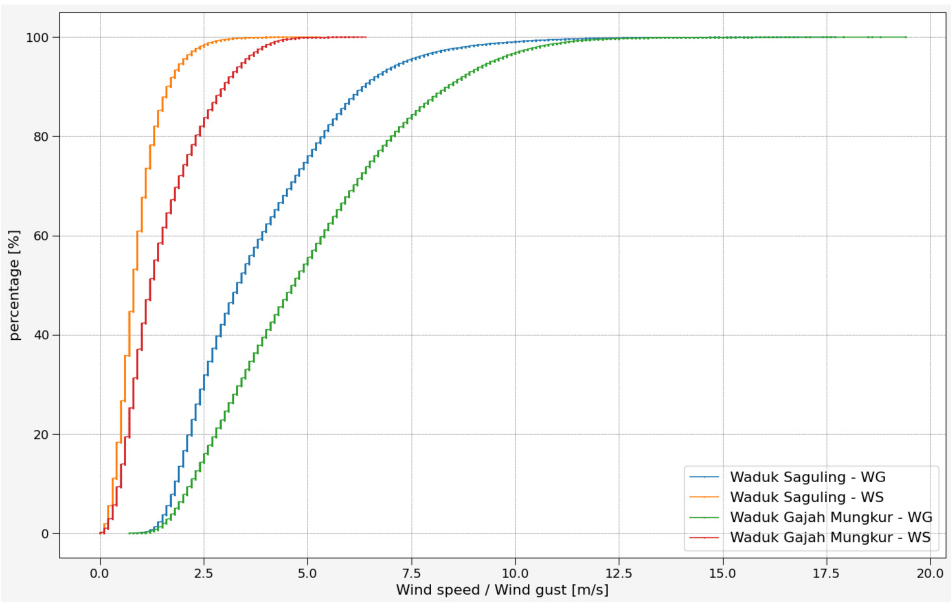


Figure 10 Cumulative distribution function of wind speed (WS) and wind gust (WG) at Saguling and Gajah Mungkur

To look at prevalent wind speeds, the long-term average values of wind speed for the 4 water bodies with the highest observed wind speeds are shown in Figure 11 As shown, the typical wind speeds at these locations are significantly below the basic wind speeds.

As this is a pre-feasibility analysis, it works with ERA5 wind data in hourly granularity and approx. 25 km spatial resolution. Therefore, the wind speed at the exact location of the potential FPV at each reservoir will potentially be different from the one available in this dataset. High-quality local measurements are advised at the feasibility stage to obtain design wind speeds.

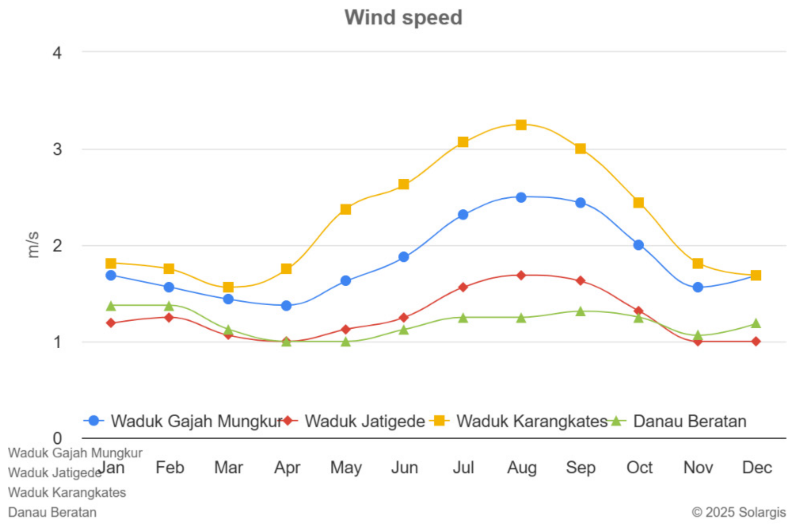


Figure 11 Average monthly wind speed at 4 reservoirs with the highest occurrence of wind gusts over 20.8 m/s

3.2.10. Closest Volcano

Volcanic activity poses a risk to any PV power plant. The closer the volcano, the higher the risk of an eruption damaging the power plant. In this analysis, the direct air distance to the nearest active volcano was considered (Figure 12). An active volcano is defined as one with at least one documented eruption or volcanic event within the past 100 years, regardless of magnitude. The data for evaluation of this parameter is taken from the USGS.

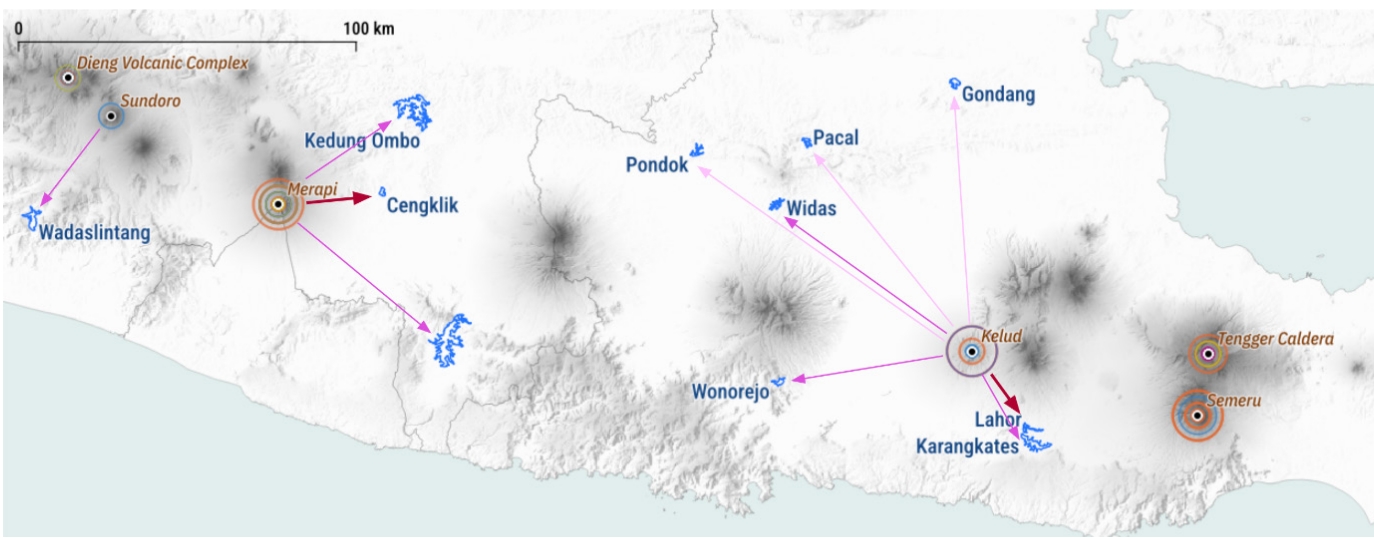


Figure 12 Measuring the shortest distance from the active volcano to water body coastline. The size of the circles around the volcano indicates the magnitude of the eruption (VEI)

3.2.11. Road Access

Road access to the reservoir is crucial during the construction of the FPV and maintenance activities. While not a blocking parameter, poor road access will increase the development cost. This analysis does not aim to identify the optimal access road to the reservoir but instead provides a broader assessment of the surrounding road network within the vicinity of the shoreline.

Input data from OpenStreetMap were analysed and cross-verified with satellite imagery from multiple sources – see Figure 13. Generally, roads classified as class 2 or higher are paved, two-lane roads that provide good truck access. Class 3 roads may be either paved or unpaved and often have limited width, typically accommodating only a single lane. Roads of lower classes are generally unpaved and less suitable for heavy or large vehicles.

The approach is based on evaluating road proximity to the reservoir shoreline. Specifically, we assess the presence of roads within a 1 km buffer from the reservoir shoreline and classify the sites accordingly. If multiple class 2 or higher roads are located within this distance, the site is categorised as "accessible" (assigned a value of 0). If no such roads are present, the site receives a score of 1 for the road access parameter. A detailed on-site assessment is recommended for the sites scored 1 for this parameter to determine the actual accessibility. Although this analysis did not identify a suitable road, alternative means of accessing the reservoir may be available.

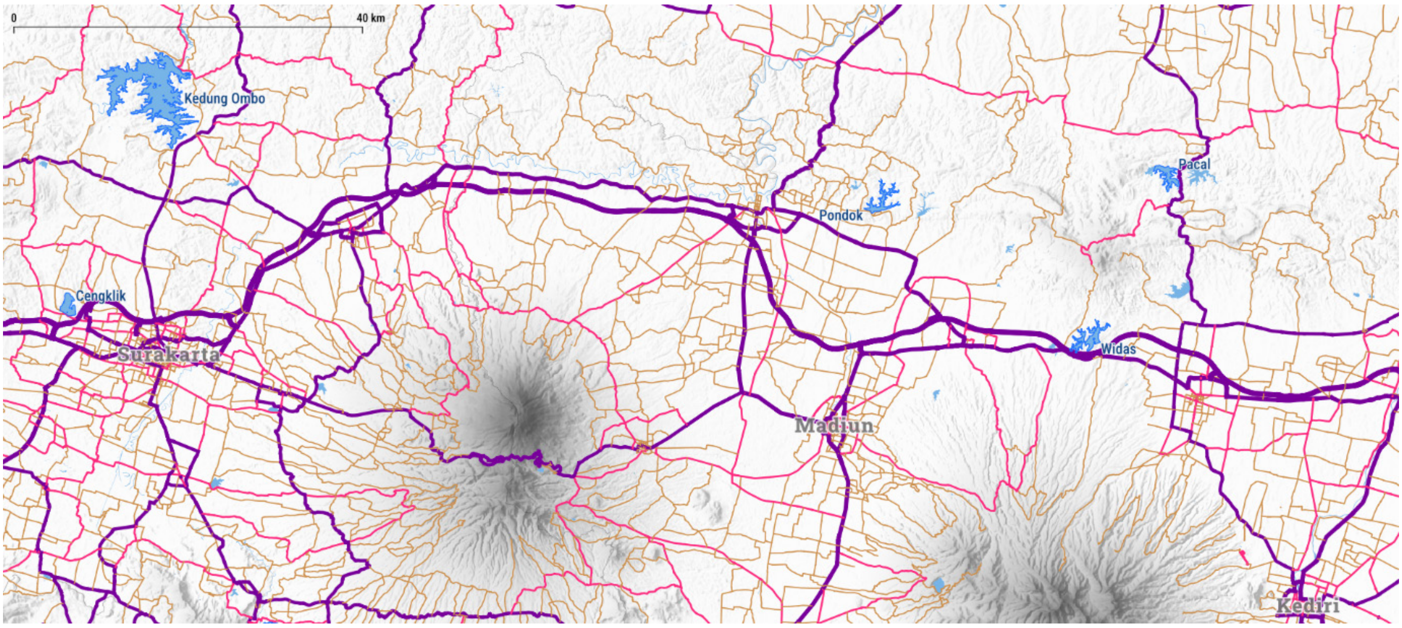


Figure 13 Road network analysis in the vicinity of the reservoirs, example of the region near the cities Surakarta, Madiun and Kediri. Violet colour represents highways, trunks and 1st class roads, red colour represents 2nd class, and brown represents 3rd class roads

Among 21 analysed reservoirs, only Pondok reservoir does not have direct access by higher-class roads.

3.2.12. Hydropower on the Same Reservoir

Presence of a hydro power plant on the same reservoir as a potential FPV offers synergic effects. An existing hydro power plant will have an established power export infrastructure (such as a substation and power lines), which may be shared with the FPV, or expanded if needed; both are easier and less expensive than building new power infrastructure. Furthermore, as the rainfall in JAMALI is cyclical, with a dry period between May and October, the power output of the hydro power plants may fluctuate seasonally due to a lack of water. The FPV can help fill this production gap, utilising the power infrastructure's spare capacity and ensuring a steady power supply.

In this approach, the reservoirs are categorised based on the size of the hydro power plant at the reservoir. The values for the parameter were assigned within the following categories:

- Value 0 for no installed hydropower capacity
- Value 1 for installed hydropower capacity ≤100 MWp (small)
- Value 2 for installed hydropower capacity 100 – 200 MWp (medium)
- Value 3 for installed hydropower capacity >200 MWp (large)

3.2.13. Electrical Substation Proximity

Available electrical infrastructure for power export means the total costs of FPV development are lower. Therefore, the proximity of the reservoirs (taken from the reservoir dam or outflow) to the nearest 150 kV electrical substation was mapped. The mapping is shown in Figure 14 below. The available spare capacity in the individual substations, also an important decision factor, is mapped within the preliminary grid analysis presented in chapter 3.4.

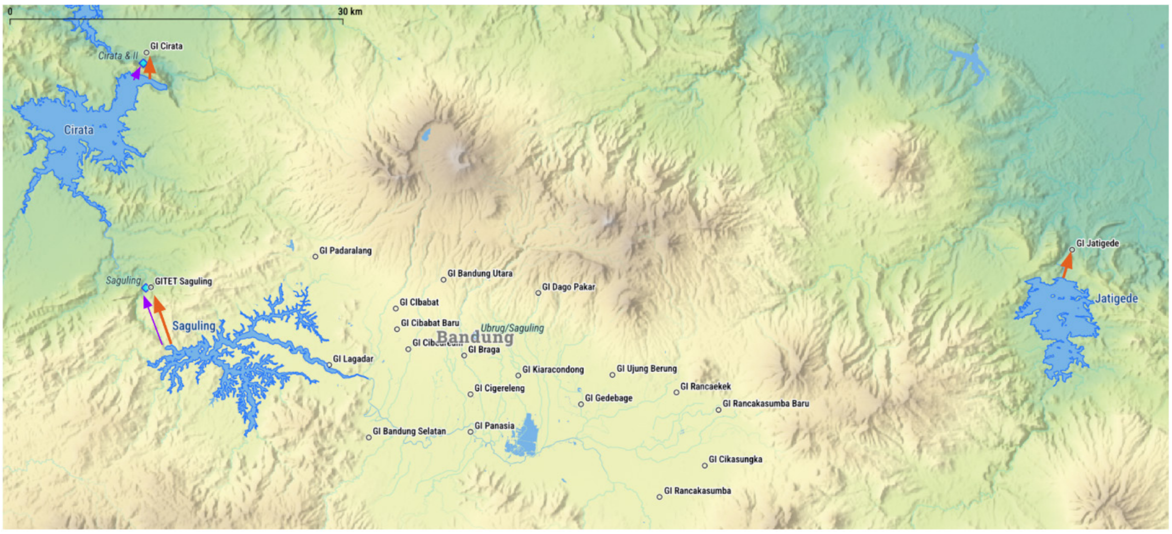


Figure 14 Measuring direct distance from the water body coastline to the closest 150/20 kV substation (orange arrows) and localization of the hydropower plants relevant to reservoirs (violet arrows). Example of the reservoirs Cirata, Saguling and Jatigede

3.2.14. Floating Net Cages

Many reservoirs in the JAMALI region are being actively used for aquatic farming. Even though the floating net cages could be displaced to make space for the FPV, this will present additional requirements and hence should be considered as a risk for the FPV development.

The coverage of floating net cages within the reservoirs was estimated based on visual inspection and interpretation of satellite imagery – see Figure 15. Images from 2022 to 2024 were used for this analysis. The scale of aquatic farming does not change rapidly; hence, the identified extent of floating net cages can be considered relevant in the short to medium term.

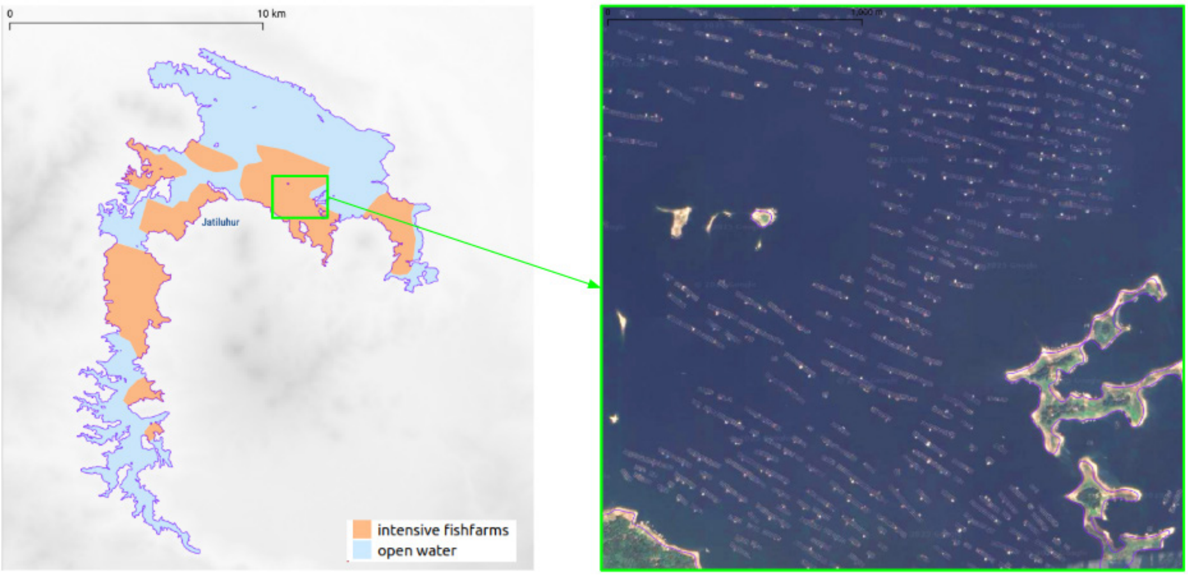


Figure 15 Example of interpretation of the floating net cages and their mapping

3.2.15. Built-up Area on the Shore

Some reservoirs are highly utilised, either as urban spaces, agricultural facilities, or leisure areas, so their shorelines are heavily developed. FPV requires onshore infrastructure such as inverters, transformer stations, maintenance stores, and lay-down areas. Even more land on the shore is required during the construction, when the equipment must be laid down as close as possible to the water to simplify the installation.

For this reason, the proportion of the built-up area on the shore was mapped and evaluated. The area of 325 meters from the MWL shore was considered. The built-up area was derived from the GHS-BUILT-C (R2023) data in 10-meter resolution – see Figure 16. The final parameter is a percentage of the area occupied by buildings or other human structures.

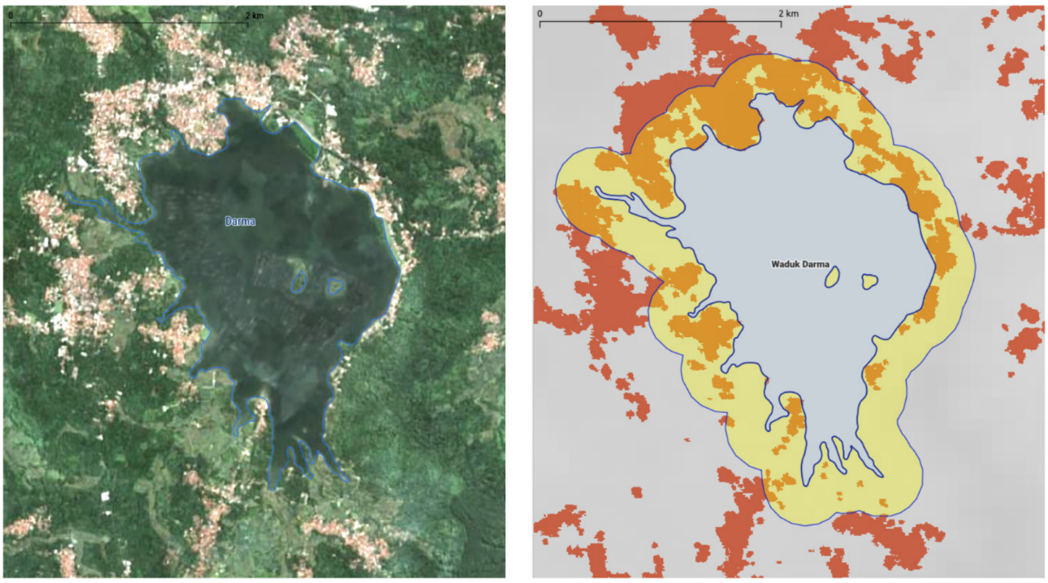


Figure 16 Mapping of the built-up areas, example of the area near Darma reservoir.Right: Red color indicates interpreted built-up areas (GHS-BUILT-S, year 2020, JRC, EU), yellow area represents 0.003° (approx. 325 m) buffer zone from the shoreline

3.2.16. Water Hyacinth Coverage

Water hyacinths or Eichhornia crassipes is an invasive species in Indonesia, growing abundantly on the surface of water reservoirs. They pose a risk to any structure on the surface of the water, especially FPV, where they can damage cables and electrical connections and accelerate the degradation of PV modules, floats, and support structures. Although they can be removed and effectively controlled, this requires additional O&M costs.

The water hyacinth extent on the surface of the analysed reservoirs was estimated based on visual interpretation of satellite imagery – see Figure 17. The maximum observed extent in the period 2022 – 2024 was considered. The extent was then converted to the following empirically derived categories:

- Value 0 for no water hyacinth on the surface of the reservoir
- Value 1 for ≤10 % coverage of the surface of the reservoir (low)
- Value 2 for 10-40 % coverage of the surface of the reservoir (medium)
- Value 3 for >40 % coverage of the surface of the reservoir (high)

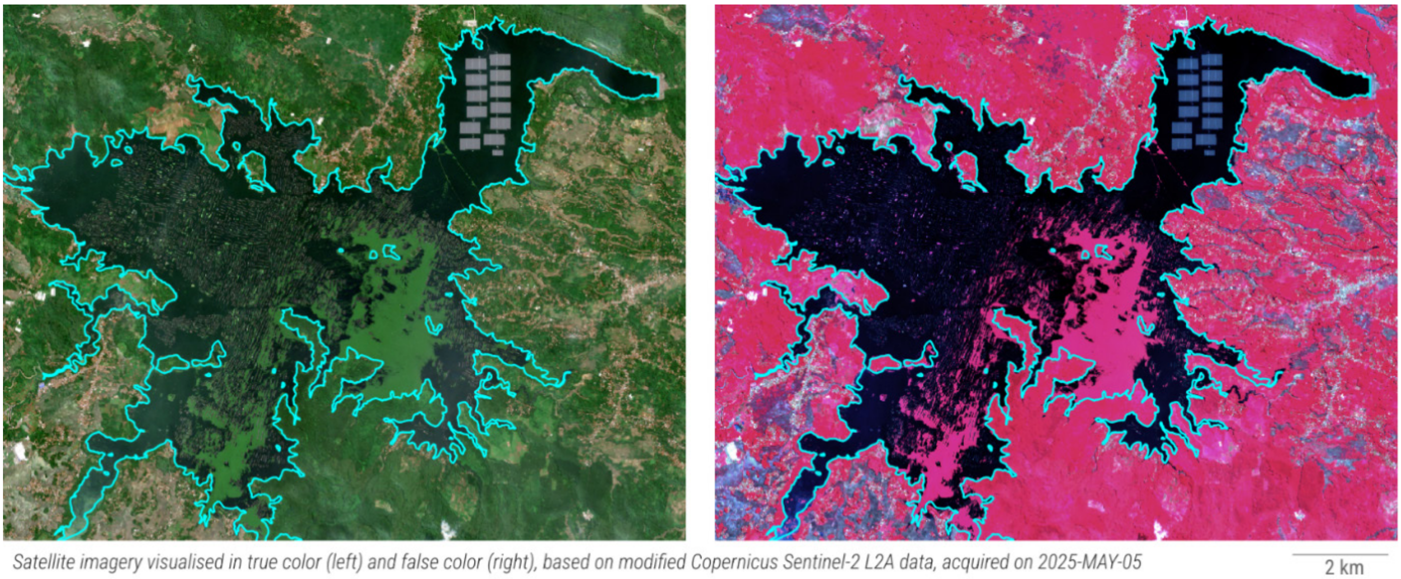


Figure 17 Indicative mapping of the largest extent of water hyacinth, example of Cirata reservoir, status on 5 May 2025. Left: Sentinel-2 imagery in visible spectrum. Right: Sentinel-2 imagery in false colour (infrared) spectrum. Bright-red colour indicates the extent of the water hyacinth on the water level

3.2.17. Geospatial Factor Weigthing

The parameters used in the geospatial analysis, described above, were combined into a weighted ranking system to produce a list of the reservoirs ordered according to their technical suitability for FPV development. The weighting reflects expert assessment of the criticality of individual parameters and is described in Table 7 below.

Table 7 Weighting system in the geospatial analysis

Parameter	Weight	Justification
Effective area	0.7	If the water level drops and the floaters land at the bottom, the FPV risks major damage. This parameter, therefore, provides a practical limit for FPV size and is a major determinant of FPV feasibility. High criticality
Reservoir shape complexity	0.2	The complex shape requires more engineering work in the design to accommodate the FPV within the available area, but it does not ultimately pose any risk or significant cost to the development. Low criticality
Average water depth	N/A	Average water depth refers to the mean vertical distance between the water surface and the bottom of a body of water, calculated by dividing the total volume of water by the surface area it covers. The average water depth allows the planners to select areas of the reservoir that are deep enough to support FPV, minimizing relocation and decommissioning risks. It should be carefully considered for further FPV feasibility assessments. High criticality
Water surface elevation variation	N/A	The WSE measurements and variation is determinant for the decision-making of the design and technology to be chosen for the anchoring and morring. The WSE will be indicated per reservoir but won´t be included in the scoring at this stage. The final FPV location within the reservoir will significantly influence the relevant WSE data and should be carefully considered in further analysis. High criticality
Mean PVOUT	0.8	PV power production potential is the main performance characteristic of the FPV and determines the project's financial performance. High criticality
Mean shading	0.5	Shading has a major effect on the potential PV power production of the FPV plant. However, the correct localisation of the FPV can avoid the strongest shading in the design phase. Medium criticality
Basic wind speed	0.5	Wind is one of the major risk factors for FPV. It can damage the plant directly or cause waves that can damage the plant and contribute to losses due to misalignment of the PV modules. While design to the basic wind speed should reduce this risk, a higher basic wind speed significantly increases the CAPEX of the FPV structure. Medium criticality

Parameter	Weight	Justification
Closest volcano	0.2	Volcanic activity is assessed based on a very long history. Any eruption will likely lead to performance loss due to volcanic ash, but not major damage. Low criticality
Road access	0.2	High-quality roads are only strictly required in the construction phase, and typically can be created if needed. Low criticality
Hydropower colocation	0.4	Colocation with hydropower has synergistic effects, potentially decreasing FPV development costs. However, it is not a determinant of feasibility Medium criticality
Electrical substation proximity	0.5	Existing power infrastructure decreases the development costs, but can be constructed if necessary, and hence does not determine feasibility Medium criticality
Floating net cages coverage	0.2	Aquatic farming and FPV can typically coexist on a single reservoir (viz Cirata), and the floating net cages can also be displaced, should this be necessary. Low criticality
Built-up area on shore	0.1	Lay down areas can be constructed further from the shore, leading to minimal cost/efficiency ramifications, and some access to the shore is always available. Low criticality
Water hyacinth coverage	0.1	Water hyacinths can be effectively controlled in the area of the FPV, and hence their risks mitigated with only minimum cost implications. Low criticality

3.3. Environmental and Social Analysis

The Environmental and Social (E&S) Analysis is a complementary assessment that supports the geospatial analysis conducted on potential reservoirs for FPV development. This analysis further evaluates each potential site's environmental, social, and biodiversity suitability and its surroundings. The primary objective of this assessment is to rank the sites based on the suitability of these three aspects, considering the varying levels of risk, potential impacts, and relevant consequences if a site is selected for development as a floating solar PV project, Additionally, the assessment excludes sites that are not viable due to regulatory restrictions, such as those subject to land moratoriums, or such as those located within areas of national importance like mangroves area.

Overall, the E&S analysis aims to achieve the following objectives:

- Outline the E&S Framework: Describe the E&S framework, including the International Finance Corporation (IFC) Performance Standards (PSs) requirements.
- Review Local Regulation: Summarise the Indonesian environmental and social requirements relevant to FPV projects, highlighting key regulations and relevant E&S considerations.
- Conduct E&S Analysis: Using land-use maps, provide a desktop assessment of the socio-environmental conditions at the proposed project sites, including a high-level risk evaluation and recommendation of mitigation measures. Considering that the FPV type of project covers offshore and onshore components, the assessment conducted in this document focused on the offshore. Offshore refers to the waterbody area, focuses on the FPV placement in the waterbody and does not refer to the marine/ocean offshore context.

The method of E&S analysis applied in this study consists of the following steps:

3.3.1. Environmental and Social Regulatory Screening

The regulatory screening aims to identify the E&S regulations applicable to FPV development in Indonesia and to capture key social, economic, environmental, and regulatory factors not fully reflected in the geospatial data and analysis. This high-level screening overviews relevant E&S considerations, including spatial boundaries or registries such as land classifications, key biodiversity or protected areas, indigenous territories, and cultural heritage sites. These regulatory maps are overlaid with potential site locations to inform the E&S assessment. The legal framework was further explained in chapter 3.1.

3.3.2. Environmental Screening

The environmental screening provides a high-level understanding of the environmental conditions of the project areas (selected sites), and mitigation measures are identified based on that. These measures can be considered as an input for further project design stages. The environmental data collection and screening process includes the following components:

- Biophysical. A comprehensive description of the area's biophysical and socio-economic characteristics, including preliminary identification of ecosystem services and vulnerability to climate change.
- Water stress and watershed condition. An analysis of water stress and watershed condition compares the total water demand from domestic, industrial, irrigation, and livestock uses to the available renewable surface and groundwater supplies, indicating water stress and overall watershed condition.
- Natural hazard parameters. Identifying and assessing risks associated with natural hazards such as floods, earthquakes, and landslides. GIS tools will be used to overlay potential solar PV sites

with hazard maps from the National Disaster Management Agency (BNPB) portal and analyse historical data on flood events, earthquakes, and landslides in recent years.

- Patterns of land use & forestry Status. Analysis of land use patterns in the potential project location. This includes providing a land use and cover map, demarcating various land uses and identifying natural and modified onshore habitat types and forestry status within 5 km radius from the potential sites in the offshore (reservoir/lakes).
- Biodiversity. Publicly available databases from the former Ministry of Environment and Forestry (MoEF) and the Nature Conservation Agency are utilised to assess potential protected areas designated as conservation forests, national parks, nature and wildlife reserves. A global database is utilized to identify high biodiversity value areas, i.e., key biodiversity areas and species that may inhabit these regions. An initial assessment determines whether these factors may trigger Critical Habitats or Priority Biodiversity Features (PBFs). The assessment may prevent the project's impact, which is considered Critical Habitat or PBFs. Further assessment of the general condition of the existing habitat and species is conducted to assess the potential impact on local flora and fauna, particularly endangered species or protected habitats, to minimise habitat loss and disruption.

3.3.3. Social Screening

The social screening provides a high-level understanding of the social conditions of the potential sites. It assesses how the development of FPV projects may generate a range of social impacts on communities within and surrounding the proposed sites. A systematic social screening process has been undertaken to identify potential social risks. Key elements of the screening include:

Livelihood Sources: Local economic activities are assessed and identified. This includes:

- Floating Net Cages (FNC). The floating net cage analysis is conducted through individual visual assessment using satellite imagery and quantified data from geospatial analysis.
  - Floating Structures: Similar classification is applied to floating businesses (e.g., tourism pontoons, food stalls), with high-density zones (>40%) indicating substantial livelihood disruption risk.
  - Residential Proximity: As typically the FPV Components will include offshore (e.g. floating PV modules, monitoring station) and onshore (e.g., switchyard, platform, office) components, residential areas within a 5 km radius may face direct or indirect impacts—such as access restrictions or construction disruption. While not necessarily indicating displacement, this proximity requires further assessment to determine risks and the need for resettlement planning or community engagement in line with IFC Performance Standards.
- Tourism and Recreation: The importance of the site for tourism or recreation is evaluated. High-value tourist areas are more sensitive to visual intrusion and access limitations, potentially leading to economic and reputational risks.
- Water Transportation: Where water transport is heavily relied upon for daily mobility or livelihoods, project activities may disrupt navigation and safety, requiring mitigation plans.
- Indigenous Peoples: Indigenous presence is screened using official data from the Ministry of Environment, the Ministry of Social, and the BRWA (Badan Registrasi Wilayah Adat) Web-GIS data. Where Indigenous Peoples have strong socio-cultural and livelihood ties to the area, the project will require Free, Prior, and Informed Consent (FPIC) and tailored engagement and will be considered a higher risk. Areas with no or limited Indigenous representation have lower potential for impacts on both the projects and on Indigenous communities.
- Cultural Heritage: The assessment identifies the proximity of cultural heritage assets, such as archaeological sites, historic buildings, and locations of spiritual significance. Sites within a 5 km radius are flagged for potential visual, geographic, or spiritual sensitivity. Where major heritage

sites exist within or adjacent to the project footprint, the risk of community opposition and the need for mitigation measures is significantly elevated.

3.3.4. Definition of the E&S Parameters

3.3.4.1. IFC performance standards

The alignment and compliance with applicable E&S regulations and international safeguards, such as IFC performance standards, are assessed at a high level.

The IFC Performance Standard is globally recognised as a benchmark for best practices in project financing. These standards ensure that projects maintain high levels of sustainability and social responsibility. Adhering to IFC PSs enables projects to attract investment from reputable financial institutions, mitigate environmental and social risks, and build positive relationships with local communities and stakeholders. Furthermore, promoting private sector participation necessitates using IFC standards as a reference, given their global acceptance and credibility.

While several international E&S standards exist, such as the ADB Safeguard Policy Statement (2009), the World Bank Environmental and Social Framework (2017), and ISO-based management systems, the IFC Performance Standards were selected as the reference framework in this study due to their strong alignment with private sector investment requirements. These standards are widely adopted by development finance institutions and Equator Principle Financial Institutions for infrastructure projects, including solar PV developments. Their structured, risk-based approach is particularly suitable for early-stage screening. It offers practical guidance on managing land, biodiversity, cultural heritage, and Indigenous Peoples' issues, key areas for PV solar projects.

IFC requires projects to adopt and implement eight environmental and social performance standards. The table of IFC Performance Standards, providing key requirements for each standard can be found in ANNEX D - IFC Standard Performances Table.

The selected E&S parameters are applicable for early-stage project assessments and are based on the relevant International IFC Performance Standards (PSs), specifically PS 5 to PS 8. These standards help determine each site's E&S risk category. IFC PS 1 to PS 4, which generally apply to active or ongoing project operations, are not considered at this preliminary stage.

The Table 8 below outlines the key requirements of the IFC Performance Standards included in this study, which will be among the scoring parameters of the E&S analysis.

Table 8 IFC Performance standards applicable for E&S analysis

Performance Standards (PS)	Key Requirements
PS 5: Land Acquisition and Involuntary Resettlement	The IFC PS 5 requirements include compensation and benefits for displaced persons, community engagement, resettlement and livelihood restoration planning and implementation, and a grievance mechanism for physical and economic displacement.
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	The IFC PS 6 ensures that biodiversity is protected and conserved, sustainable management and use of natural resources is used wherever feasible throughout the project lifecycle. The key concerns required by the IFC PS6 include protecting and conserving biodiversity by assessing and managing modified and natural habitats, critical habitats, legally protected and internationally recognised areas, and invasive alien species; managing ecosystem services; managing living natural resources; and managing supply chains.
PS 7: Indigenous People	The IFC PS 7 requires the Project to anticipate and avoid adverse impacts on the Indigenous People, including People screening and impact assessment, maintain relationships based on Informed Consultation and Participation (ICP), obtain FPIC if the project significantly affects the Indigenous People, and promote sustainable development benefits and opportunities.
PS 8: Cultural Heritage	The IFC PS8 requires sites to protect cultural heritage from any adverse impacts of Project activities and support its preservation. In this case, the implications of IPs are being assessed.

3.3.4.2. Limitations of the E&S assessment

It is important to note certain assumptions and limitations regarding applying the IFC standards. IFC PS 5 acknowledges that project-related land acquisition and land use restrictions can adversely impact communities and individuals who rely on such land. Involuntary resettlement refers to both physical displacement (e.g., relocation or loss of housing) and economic displacement (e.g., loss of assets or access to income-generating resources). Resettlement is deemed involuntary when affected persons or communities do not have the legal right to refuse land acquisition or land use restrictions, which may occur in cases of (i) lawful expropriation or regulatory restrictions, and (ii) negotiated settlements where legal enforcement is available if negotiations fail.

Given the high-level nature of this E&S screening, this assessment does not delve into detailed analysis of individual land acquisition activities or resettlement action plans for each site. These aspects would require further investigation at a later stage of project development.

In the context of FPV projects, the PS 5-related assessment focuses on the presence of residential areas, tourism and recreational activities (as common secondary uses of water bodies), and livelihood activities on top of water bodies in reservoir areas, which may include FNCs and other floating structures that may be affected by or conflict with the development of FPV infrastructure.

A specific biodiversity assessment is required to comply with IFC Performance Standard 6 (PS6). Currently, limited information on biodiversity is available in the spatial database. The critical habitat screening layer, provided by UNEP-WCMC, serves as a tool to spatially determine whether an area meets the essential criteria of habitat outlined in IFC PS6. However, this information offers only a high-level overview with limited accuracy. Therefore, it is essential to complement this data with ground truthing and site confirmation, utilising appropriate methodologies for each taxon or species category.

The land cover map from the Indonesian database was utilised to gain insights into the surrounding natural and modified habitats within the potential sites' onshore areas. The onshore assessment reveals the presence of significant natural habitats, specifically identifying primary and secondary dryland forest areas within the potential area.

Regarding IFC PS 7 - Indigenous People and IFC PS 8 - Cultural Heritage, the Consultant team gathered data from available public sources based on Ministerial Data, NGO Data, and Aerial View observation of the surrounding areas of the reservoir sites. This assessment does not include field validation, which may be required later to confirm the findings and the initial screening conducted in this report.

3.3.4.3. E&S parameters

The sites selected through the geospatial analysis will be assessed further based on the defined parameters and scoring. The sites within mangrove areas and/or land moratorium areas will be excluded and will not qualify. The qualified potential sites are then analysed using the following E&S parameters, for a total of 9 criteria, including the IFC PS mentioned in the previous paragraph – see Table 9.

Table 9 E&S parameters & criteria

Parameters	Criteria
Environment Social (Aligned With Ps5)	1. Land Cover
	2. Water Stress Risk
	3. Presence Of Population, And Potential For Physical And Economic Displacement
Parameters: Biodiversity (Aligned With Ps6)	4. Areas Of High Biodiversity Value (World Heritage Sites (WHS), Alliance for Zero Extinction sites (AZE), Important Bird and Biodiversity Areas (IBA), Key Biodiversity Area (KBA), Protected Areas (PA), World Database of Protected Areas (WDPA))
	5. UNEP-WCMC Global Critical Habitat And Trigger Species
	6. Onshore Area
	7. Forestry Status
Parameters: Indigenous People (Aligned With Ps7)	8. Presence Of Indigenous Peoples
Parameters: Cultural Heritage (Aligned With Ps8	9. Cultural Heritage Sites

3.3.5. E&S Scoring Parameters

3.3.5.1. Identification of excluded and qualified areas

Based on the regulatory assessment conducted for FPV development, the following requirements are identified as grounds for potential site exclusion – see Table 10

Table 10 Binary criteria for E&S analysis

Binary criteria	Definition of the excluded areas
Forest moratorium	According to the ndicative Map of Business Permit Granting Termination (Peta Indikatif Penghentian Pemberian Izin Berusaha or PIPPIB): a site located in the PIPPIB area is prohibited for any development. The Ministry of Environment and Forestry issues regular updates on PIPPIB areas usually every six months. The reference for this screening is the latest version of PIPPIB which is 2023 period II PIPPIB based on the Minister of Environment and Forestry Decree No. SK.12764/MENLHK-PKTL/IPSDH/ PLA. 1/ 11/2023 dated 22 November 2023.
Parameters: Biodiversity (Aligned With Ps6)	The Government of Indonesia's Forestry and Other Land Use (FOLU) Net Sink 2030 focuses on mangrove areas and peatland to reduce GHG emissions from the forest and land sector and increase carbon absorption. Reducing the deforestation rate of mangrove areas and forests is one of 15 mitigation action plans in Indonesia's FOLU Net Sink 2030. Hence, preserving current mangrove areas will be a priority to increase the carbon sink.

3.3.5.2. Scoring parameters of the qualified areas

Each of the nine key criteria will be assigned a risk rating (low, medium, or high), corresponding to a score of 1 to 3. In contrast, the exclusion criteria correspond to a score of zero and are used as a base multiplier, resulting in a total score of zero for sites that must be excluded. Therefore, the theoretical cumulative scores for each qualified site range from 9 (indicating the lowest E&S risk) to 27 (indicating the highest E&S risk). However, a statistical adjustment will be applied to better reflect the actual distribution of risks across all potential sites and avoid skewed results, where scores are overly concentrated at either the high or low end. Further explained in Section 4.2, this adjustment ensures a more balanced and meaningful risk distribution.

Lower total scores indicate fewer environmental and social risks, and thus greater suitability for FPV power development.

Table 11 Risk categories from inception report

Risk Category	Description	Actions point
Excluded	**Excluded** Significant E&S Risk, ineligible for financing or investment due to their significant, irreversible, or unacceptable environmental and social risks and impacts Considerations for exclusion are as follows: ▸ Moratorium of permit issuance (PIPPIB) ▸ Mangroves Area	No Go site

Category A	**High Risk** The site has the potential to trigger IFC PS 6 and IFC PS 5, which might need further detailed study on biodiversity and a detailed study and social restoration management and plan, respectively. The site may pose potential significant adverse impacts (environmental, social, or financial) **that are often diverse, irreversible, or unprecedented.**	Requires comprehensive and detailed planning documentation, such as an Environmental and Social Impact Assessment (ESIA) and the development of Mitigation actions (ESMP). Projects must comply with the applicable local regulatory framework.
Category B	**Moderate Risk** Site with potential trigger to IFC PS5, which might need a prolonged, detailed study and a complex land acquisition process. **Site may pose potential limited adverse impacts that are fewer, generally site-specific, and mostly reversible or manageable through mitigation measures.**	Requires scaled & tailored to site-specific risks planning documentation, such as ESIA, and development of an ESMP. Projects must comply with the applicable local regulatory framework. Due diligence with potential site visits, is required for projects funded or supported by entities under the **Equator Principles Financial Institutions (EPFIs)**, as these projects are subject to international environmental and social standards.
Category C	**Low Risk** Projects have minimal or no adverse environmental or social risks and impacts.	Require compliance with the applicable local regulatory framework.

3.3.6. Site Qualification and Ranking

Once each parameter is assessed and scored as described below, the results will be combined to generate the final output. Range-based scoring calculates the overall E&S risk levels for the potential sites. The objective of this process is to prioritise sites with lower E&S risks.

The final output ranks the sites from lower to higher risk to support informed decision-making for PV development.

The Table 12 below details each parameter's scoring range, which consists of low, medium, and high risk. Each site will be analysed and assigned a score based on these definitions

The Table 11 below references risk categories, corresponding descriptions, and recommended action points.

Table 12 Risk rating for E&S criteria

No	Criteria	Low Risk	Medium Risk	High Risk
1	Land Cover	Plantation Forest	Mining Area; Shrubland; Open Land/Savanna; Open Land/Savanna; Shrubs/Mixed Garden; Plantation/Garden; Mixed Agriculture; Secondary Forest	Primary Dryland Forest; Settlements; Water Body; Dryland Agriculture; Mixed Agriculture; Rice Field; Airport/Harbor
2	Water Stress Risk	Low to Low-Medium water stress risk in WRI Water Atlas	Medium-high water stress risk in WRI Water Atlas	High to extremely high-water stress risk in WRI Water Atlas

No	Criteria	Low Risk	Medium Risk	High Risk
3	**Presence of population, and potential for physical and economic displacement**	• Sparse or distant residential areas. Low risk of physical or economic displacement. • >10 Km distance from the nearest residential area • Limited tourism or recreation activities. Low concern for visual or access impacts. • There are few or limited floating net cages. Small-scale fish farming is present but not dominant. The risk of livelihood disruption is low. • <20% Presence of FNC compared to available water Body • Very few or no floating structures. Minimal to no impact on floating businesses. • <20% Presence of Floating Structures compared to the available water body	• Moderate residential presence close to the reservoir. Some risk of land use conflicts or displacement. • 5-10 Km distance from the nearest residential area • Moderate tourism or recreational importance. Some concerns over visual aesthetics or access disruptions. • Moderate number of floating net cages present. Fish farming is a notable activity but not the dominant livelihood. Some livelihood disruption may occur. • 20 - 40% Presence of FNC compared to the available water body • Moderate number of floating structures, often serving tourism or local needs. Some business disruption is expected. • 20 - 40% Presence of floating structures compared to the available water body	• Dense residential communities around the reservoir. High risk of displacement, resettlement, or community resistance. • <5 Km distance from nearest residential area • Major tourist attraction or recreational hotspot. High sensitivity to visual changes, access restrictions, and potential community opposition. • There is a high density of floating net cages. Fish farming is a primary livelihood activity, and relocation or disruption would significantly impact the community's economy. • >40% Presence of FNC compared to available water body • High concentration of floating structures. Significant disruption to businesses and local economy would occur. • > 40% Presence of floating structures compared to available water body
4	**Areas of high biodiversity value (WHS, AZE, IBA, KBA, PA, WDPA)**	Located outside KBA/PA	High biodiversity values found within the potential site, but not identified as protected area/conservation forest, IBA, or AZE. The KBA factsheet shows "list of species unlikely to trigger KBA".	High biodiversity values found within the potential site, including conservation forest, KBA with likely species trigger in the KBA factsheet, AZE and IBA site
5	**UNEP-WCMC Global Critical Habitat and Trigger Species**	Unclassified	Potential	Likely

No	Criteria	Low Risk	Medium Risk	High Risk
6	Onshore areas	Natural habitat (primary and secondary dryland forest) is not present in all zones	Natural habitat (primary and secondary dryland forest) is present in zone 3 only	Natural habitat (primary and secondary dryland forest) is present in zone 1 and/or 2
7	Forestry status	Other use	Limited production Forest, Production Forest	Protection Forest
8	Presence of Indigenous Peoples (aligned with PS7)	No Indigenous Peoples presence within and/ or around the reservoir. No specific Indigenous group requiring special consultation.	Presence of Indigenous Peoples but with limited socio-cultural connection to reservoir	Significant Indigenous Peoples presence. Strong collective attachment cultural and livelihood connections to the reservoir. FPIC and special considerations will be required.
9	Cultural heritage sites (aligned with PS8)	No identified cultural heritage sites nearby (within 6-10 km radius). Low risk of cultural disruption.	Some cultural heritage sites (within 5 km radius). visual or geographic proximity.	Major cultural heritage sites nearby or within the project footprint. High risk of cultural, spiritual, and community opposition.

The detailed scoring table and final rankings are presented in Section 4.2

3.4. Pre-Grid Integration Assessment

The grid impact assessment aims to analyse the feasibility of developing approximately 1 GW of solar PV in the JAMALI system and identify potential impacts and risks. Social, environmental, and regulatory reviews have been conducted to pre-select and rank the proposed sites. A total of 21 sites were then input into the system to carry out several studies and assess the potential impact on the existing grid.

Data collection and power system modelling focus on several critical components of the grid infrastructure, including power plants (location, type, and capacity), transmission systems (routes, lengths, and capacities), and loads (substations, demand profiles, and growth projections). These components are modelled to reflect both the current system and planned expansions. The primary reference for modelling the JAMALI system is DRUPTL 2024-2033, combined with previously acquired data.

It is important to note that the official power system development plan, RUPTL 2025-2034, was released after this study was completed. Upon comparison, the overall development plans for generation, transmission, and substations from 2025 to 2030 remain relatively consistent between the two documents.

- The planned addition of new renewable energy capacity (VRE) from 2024 to 2030 is 2,700 MW in the DRUPTL 2024-2033 and 2,560 MW from 2025-2030 in the RUPTL 2025-2034.
- The total planned transmission expansion over the same period is 10,074 km in the DRUPTL 2024-2033 and 10,289 km in the RUPTL 2025-2034.
- For substations, the planned transformer capacity addition is 47,910 MVA in the DRUPTL 2024-2033 and 52,410 MVA in the RUPTL 2025-2034.

These figures indicate that the planned system reinforcements and renewable energy integration targets for the JAMALI grid through 2030 are aligned in both planning documents, with only minor differences in total capacity and network expansion. Therefore, the analysis and simulation conducted using the DRUPTL

2024-2033 data remain relevant and valid with respect to the most recent RUPTL 2025-2034 projections. Once the system model is completed, further analyses are conducted to evaluate both economic and technical impacts. Economic analysis utilizes PLEXOS, while technical assessments employ DIgSILENT PowerFactory as presented in Grid Integration Assessment in Phase 2.

The previous study conducted in Phase 2, the Grid Integration Assessment, revealed that the current JAMALI system could accommodate an additional 2.2 GW by 2030 on top of the existing plan. Therefore, this study focuses on a maximum hosting capacity analysis for specific substations to evaluate the potential capacity at each site. The following analyses are included in this study:

1. **Distance to the nearest substation**

One important process before conducting both economic and technical analysis, given that potential site selections have been previously made, is site prioritization. A part of site analysis will be done based on the proximity of the sites to the nearest 150 kV substation, with the assumptions that around 200 kUSD/km will be applied as the cost to connect those PV sites.

2. **Maximum hosting capacity**

The methodology for the maximum hosting capacity analysis can be found Figure 17. The first step to determine the maximum PV that can be developed in an area is to conduct a maximum hosting capacity of a substation, which is the maximum amount of PV that can be injected into a substation, either from a single PV site or a cluster of PV sites. The hosting capacity of a substation is based on two limitations: voltage level and component's loading. Basically, the amount of PV connected to a substation gradually increases until one of those constraints is exceeded. Then, the numbers are compared with the potential of the site or cluster that is connected to that substation.

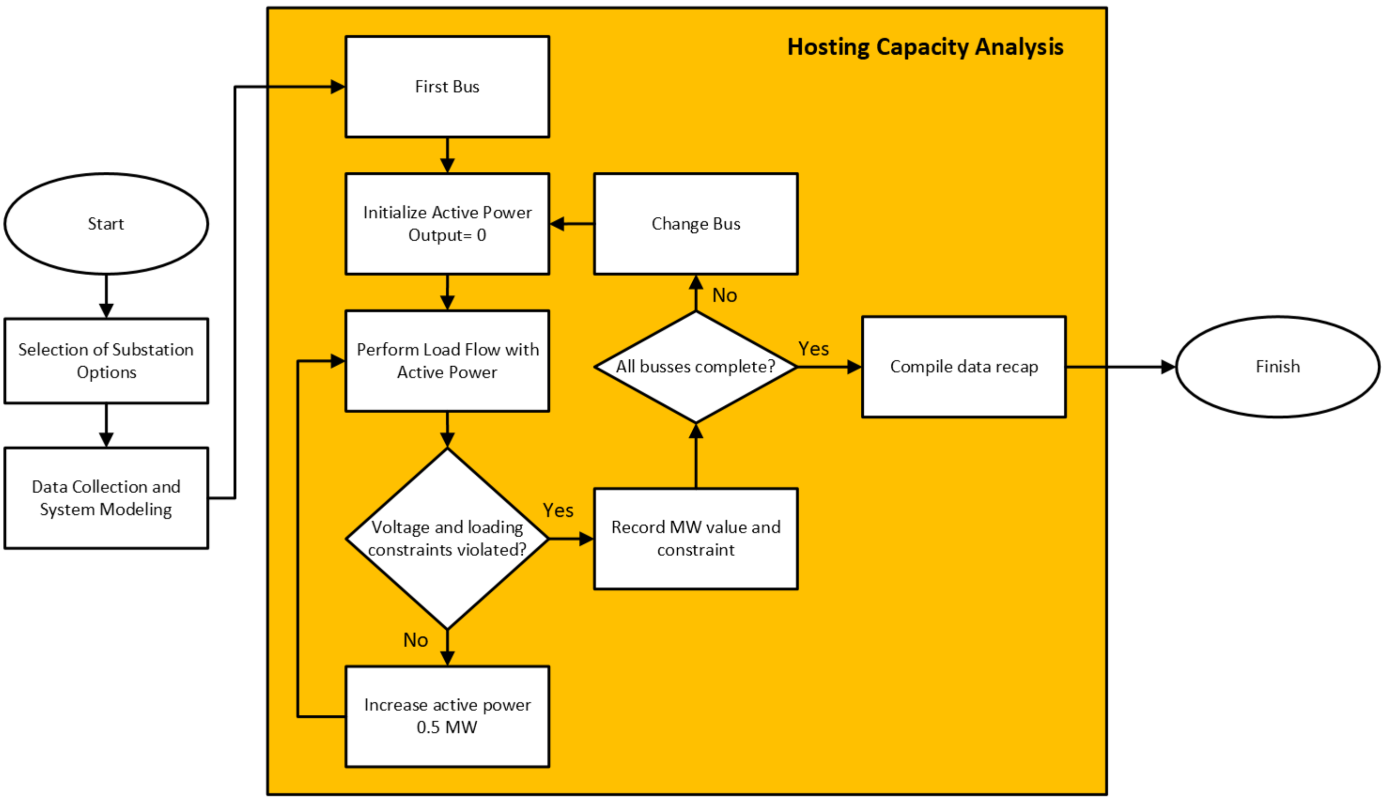


Figure 18 Hosting capacity analysis methodology

3.5. Potential Capacity

The potential capacity of each site is determined with the objective of maximising the usable water surface area for FPV development, while considering the following constraints:

- 20% of the total reservoir area: As described in the regulatory analysis, current practice for FPV development in Indonesia, based on the Ministry of Public Works and Housing Regulation Number 27/PRT/M/2015 on Dams, as amended by Regulation Number 7 of 2023, limits the maximum reservoir surface area that can be utilised for floating PV installations to 20%. As mentioned in section 3.2.1, this study used a conservative approach by using the smaller total area from either the PUPR or satellite datasets.
- Effective area: As detailed in Section 3.2.4, the effective area is a portion of the reservoir that consistently holds water, representing the effective water surface available for floating PV. It is assumed that FPV systems will be installed within this MWL area to ensure that the floaters do not come into contact with the reservoir bed.
- Maximum hosting capacity of the grid: Consistent with the previous grid integration study, the maximum capacity that can be injected into the grid is limited by the technical hosting capacity of the nearest substations.

Therefore, the lowest value among these three constraints determines the effective potential capacity for floating PV at each site. For example, if 20% of the reservoir area would allow for more capacity than the grid can accommodate, the site's potential capacity will be capped at the grid's maximum hosting limit.

3.6. Financial Analysis

3.6.1. Financial Analysis Methodology

Financial analysis was done by simulating various scenarios using macroeconomic and project-specific assumptions, including inflation, exchange rates, ceiling price, power generation, capital and operational costs. The financial feasibility analysis results are then presented, covering both the base case and additional scenarios such as excluding evacuation line costs. Additional sensitivity analysis was done to see the impact of changing variables such as CAPEX and OPEX assumptions to the financial feasibility of the sites. The report explores several proposed solutions to improve financial viability, including adjusting the ceiling price, excluding evacuation line costs from tariff calculations, and leveraging blended finance and guarantees. Finally, the conclusion synthesizes the findings, highlighting conditions under which certain sites may be feasible and recommending further analysis and policy actions to enhance project bankability.

3.6.2. Macroeconomic Assumptions

3.6.2.1. Inflation

The inflation assumptions used in this report's financial analysis refer to the Economic Intelligence Unit Five Year Forecast for 2025 (EIU, 2025). Table 13 below shows the inflation projections used for the OPEX in the analysis:

Table 13 Inflation rate used in the financial feasibility analysis

	2025	2026	2027	2028+
Indonesia's Inflation Rate	2.80%	3.10%	3.10%	3.00%

3.6.2.2. Currency exchange

The currency used in the financial projections in this report is the US Dollar (USD), as most of the revenues and costs incurred during the project's construction and operation are estimated to be denominated in USD. The exchange rate is used to calculate some of the capital expenditure CAPEX and OPEX components, such as the evacuation line price and land price for land rent cost, since the only available data is in Indonesian Rupiah (IDR). The assumed exchange rate of the Rupiah against the USD used for the project is IDR 16,209. This exchange rate is based on the middle rate data from the Bank of Indonesia as of July 4th, 2025 (Bank Indonesia, 2025).For this report, the exchange rate is kept constant throughout. Analysis of the how USD/IDR foreign exchange rate can vary within the next few years and/or its impact to the project is outside the scope of this study.

3.6.2.3. Loan interest rate

The loan interest rate used for this analysis is 8.0% for borrowing in USD currency, which is commonly used by developers in the renewable energy sector. Developers could try to access green and climate financing or sustainability-linked financing to have a lower interest rate than conventional market financing instruments. However, there might be additional requirements and obligations such as development of a detailed Environmental and Social Impact Assessment (ESIA) that might be requested by the lenders that must needs to be considered carefully when accessing these types of instruments. Examples of some available green financial instruments are listed below in the Table 14.

Table 14 Available green financing instruments

No.	Green Financial Instruments	Type of financing	Indicative Loan Interest Rate and Tenor
1	Bank Mandiri Sustainability Bond	Sustainability bond	2.00% semi-annual for 5-year bullet
2	ASEAN Catalytic Green Finance Facility (ACGF) Concessional Lending Terms by ADB	Concessional finance	Year 1–5: 1% Year 6–25: 1.5%
3	PT SMI Sustainable Green Bond I	Green bond	3 years: 7.55% 5 years: 7.80%
4	SDG Indonesia One	Blended finance	Different for each project

3.6.2.4. Ceiling Price

The ceiling price is based on the Presidential Regulation (Perpres) No. 112 of 2022. The ceiling prices are calculated by multiplying a standard price by a location factor (F factor), regardless of the planned capacity. The standard price varies depending on the year of operation, with different rates for years 1 to 10 and years 11 to 30 of operation.

The F factor and solar PV ceiling prices can be seen in Table 15 and Table 16 , respectively.

Table 15 Location factor (F) based on presidential regulation No.112 of 2022

No.	Location	F Factor
1	Jawa, Madura, Bali	1.00
	‣ Small Islands	1.10
2	Sumatera	1.10
	‣ Kepulauan Riau	1.20
	‣ Mentawai	1.20
	‣ Bangka Belitung	1.10
	‣ Small Islands	1.15
3	Kalimantan	1.10
	‣ Small Islands	1.15
4	Sulawesi	1.10
	‣ Small islands	1.15

No.	Location	F Factor
5	Nusa Tenggara	1.20
	‣ Small islands	1.25
6	Maluku Utara	1.25
	‣ Small islands	1.30
7	Maluku	1.25
	‣ Small islands	1.30
8	Papua Barat	1.50
9	Papua	1.50

Table 16 Ceiling price (Harga Patokan Tertinggi) based on presidential regulation No.112 of 2022

No	Capacity	HPT (Harga Patokan Tertinggi) / Ceiling Price for Solar Plant (cent USD/kWh)		HPT for Solar Plant with the government's land (cent USD/kWh)	
		Year 1 to 10	Year 11 to 30	Year 1 to 10	Year 11 to 30
1	1 MW	11.47	6.88	11.47	6.54
2	>1MW-3MW	9.94	5.97	9.94	5.67
3	>3 MW-5MW	8.77	5.26	8.77	5.00
4	>5MW-10MW	8.26	4.96	8.26	4.71
5	>10 MW-20MW	7.94	4.76	7.94	4.52
6	>20MW	6.95	4.17	6.95	3.96

The financial analysis will assess the feasibility of 20 sites in JAMALI selected from the previous analysis. JAMALI region has the lowest F factor, which can be a disadvantage as it leads to a low ceiling price. The tariff assumption used in this analysis will be from row 6 in Table 13, which is 6.95 cents USD/kWh from years 1 to 10, 4.17 cents USD/kWh, and 3.96 cents USD/kWh from years 11 to 30 for scenarios without government land and with government land, respectively.

However, based on a discussion with the solar developers, the lowest tariff that could be granted for a solar PV development so far is 5.5 cents USD/kWh. Therefore, a ceiling price of 5.5 cents USD/kWh was also used in the financial analysis in this report.

This tariff assumption has also been validated by discussions with two project developers in Indonesia, who indicated that the actual renewable energy tariff is becoming increasingly competitive and is always lower than the price ceiling set by the regulation.

By contrast, based on the meeting with a representative from PLN, it was noted that some developers have raised concerns regarding the tariffs under the current Perpres No. 112/2022, stating that the current ceiling is still relatively low and does not give the return rate generally expected by the market.

However, it is worth noting that even though the developers and PLN were informed that the purpose of the interviews was to understand challenges specific to solar PV development in JAMALI, their comments could have been about the renewable energy tariff in general, including solar PV development in areas outside JAMALI where nearby grids are not available.

3.6.3. Power Generation Assumptions

Power generation assumptions are essential for financial analysis as they will define the total revenue from the FPV. Accurate power generation estimates are essential for predicting the project's cash inflows. The assumptions for the power generation are taken from the PVout value from the geospatial analysis computed according to the methodology explained in section 3.2.7.

Additionally, the financial analysis will assess the impact of the substation distance and the land price on the project's financial feasibility.

3.6.4. Capital Expenditure and Operational Expenditure

3.6.4.1. Capital Expenditure

Power Plant

The capacity of each site heavily influences the CAPEX for the main power plant. Economies of scale apply the rule for the main power plant, meaning that the smaller the plant capacities, the higher the relative costs per kW. To reflect this behaviour, adjustments have been made to the unit prices. Additionally, the project lifetime is assumed to be 30 years for the purpose of this analysis.

The average CAPEX cost per kW from various developers for the power plant is as shown Table 17 as follows:

Table 17 CAPEX price for main power plant

No	Capacity (MWp)	CAPEX (USD/kWp)
1	Between 0 and 50	624
2	Between 50 and 75	612
3	Between 75 and 100	600
4	Between 100 and 250	582
5	Between 250 and 500	552
6	More than 500	540

Based on the previous Table 17 and the potential capacity in section 4.4, the CAPEX for the power plant at each of the selected sites has been calculated. Detailed information regarding the central power plant's CAPEX s as shown in the following Table 18.

Table 18 CAPEX for each reservoir

No	Reservoir name	CAPEX (USD/MkWpP)
1	Waduk Jatiluhur	542,217
2	Waduk Cirata	542,713
3	Waduk Gajah Mungkur	580,815
4	Waduk Kedung Ombo	554,400
5	Waduk Saguling	566,787
6	Waduk Jatigede	545,444
7	Waduk Karangkates	554,741
8	Waduk Wadaslintang	555,693
9	Waduk Cacaban	711,609
10	Waduk Malahayu	889,898
11	Waduk Mrica	623,816
12	Waduk Gondang	849,523
13	Waduk Widas	787,605
14	Danau Beratan	635,042
15	Waduk Darma	723,356
16	Waduk Wonorejo	837,241
17	Waduk Pondok	830,094
18	Waduk Pacal	1,085,963
19	Waduk Lahor	552,090
20	Waduk Cengklik	619,201

3.6.4.2. Operational Expenditure

The OPEX used for this financial analysis consists of land rent costs and O&M expenses for the main power plant. For this analysis, the OPEX will be separated into fixed and variable costs.

The land rent cost is calculated using a percentage of the land price. It is assumed that 10 hectares (ha) will be required for each site for land rent cost. The percentage is different for each site, depending on the local government's regulation. The land rent cost is calculated using percentage of land price. It is assumed that 10 hectares (ha) will be required for each site for land rent cost. The percentage is different for each site, depending on the local government's regulation.

The O&M fixed cost is calculated using an assumption of USD 12.36 per kW per year, based on the average annual O&M Cost in 2023[20] while the variable cost is calculated using an assumption of USD 0.0005 per kWh.

The fixed O&M cost includes the following:

1. Technical Operation
2. Insurance
3. Preventive Maintenance
4. Commercial Operation
5. Corrective Maintenance
6. Greenkeeping
7. Security
8. Panel Clearing.

The land cost assumes the land will be leased during the concession period. The land rent cost is based

[20] International Renewable Energy Agency (IRENA), 2024

on the percentage of the land rent compared to the land purchasing price, as regulated by the local government's regulations, where available. If local regulation for the site is unavailable, the land rent cost is based on the percentage available on the nearby local government's regulation as a proxy. The land price was determined by analysing the ZNT ("Zona Nilai Tanah/Land Value Zone") data from ATR/BPN and the real land price from the desktop study for each site. For most sites, the real land price is higher than the ZNT value; hence, the land prices from the desktop study are used for the analysis. The land area requirement is assumed to be 10 hectares (ha), based on the estimation of the existing Cirata floating solar PV land area calculated through Google Earth. The land rent percentage for each site is shown in Table 19.

Table 19 Land rent OPEX assumptions for each site

No	Reservoir name	Land price (IDR/sqm)	Percentage of land rent cost to land price (%)	Data source
1	Waduk Jatiluhur	120,968	5.00%	Purwakarta Regent Regulations No. 114/2021
2	Waduk Cirata	699,888	5.00%	Purwakarta Regent's Regulations No. 114/2021
3	Waduk Gajah Mungkur	120,000	3.33%	Wonogiri Regent's Regulation No. 45/2022
4	Waduk Kedung Ombo	400,000	3.33%	Proxy based on nearest local government regulation
5	Waduk Saguling	346,908	3.33%	Proxy based on nearest local government regulation
6	Waduk Jatigede	1,666,667	3.33%	Sumedang Regent Regulations No. 98/2020,
7	Waduk Karangkates	505,051	3.33%	Proxy based on nearest local government regulation
8	Waduk Wadaslintang	164,537	3.33%	Proxy based on nearest local government regulation
9	Waduk Cacaban	78,261	3.33%	Tegal Regent Regulations No. 22/2020
10	Waduk Malahayu	991,501	3.33%	Proxy based on nearest local government regulation
11	Waduk Mrica	285,000	3.33%	Banjarnegara Regent Regulations No. 61/2019,
12	Waduk Gondang	250,000	3.33%	Proxy based on nearest local government regulation
13	Waduk Widas	1,759,411	3.33%	Proxy based on nearest local government regulation
14	Danau Beratan	2,500,000	3.33%	Proxy based on nearest local government regulation
15	Waduk Darma	428,571	3.33%	Proxy based on nearest local government regulation
16	Waduk Wonorejo	583,333	3.33%	Proxy based on nearest local government regulation

No	Reservoir name	Land price (IDR/sqm)	Percentage of land rent cost to land price (%)	Data source
17	Waduk Pondok	65,000	3.33%	Proxy based on nearest local government regulation
19	Waduk Pacal	98,214	3.33%	Proxy based on nearest local government regulation
20	Waduk Lahor	1,027,778	3.33%	Proxy based on nearest local government regulation
21	Waduk Cengklik	505,051	1.63%	Boyolali Regent's Regulation No. 13/2022

3.6.5. Internal Rate of Return (IRR)

The IRR is a percentage used to evaluate investments. It helps determine if a project or investment is expected to be profitable. Project IRR assesses the overall profitability of a project without considering cash flow related to financing. Equity IRR includes the effects of financing and shows returns to equity investors after covering debt expenses.

According to the desktop study, no law currently regulates the maximum IRR for solar PV projects. Therefore, for this financial feasibility analysis, a target Project IRR of 8.00% and an Equity IRR of 12.00% are applied, which are commonly used by developers in the renewable energy sector. This figure is also validated by discussions with developers in Indonesia, which indicates that the minimum target for the Equity IRR is 12.00%. Projects with a Project IRR above 8% are considered financially feasible, while projects with a Project IRR below 8% are unlikely to be financially feasible for a private developer. This is because the providers of equity capital in the market are likely to assume that they could earn better returns from other types of projects, considering the sector specific risk. PLN could justify financing such projects itself at a lower IRR without using private capital, but the discussion whether to do so would need to take account of many other pros and cons of such options and is outside the scope of this study.

Presidential Regulation no. 14 of 2017 allows for PLN and/or its subsidiaries to form a Special Purpose Company (SPC) with a strategic partner for the projects, which would require PLN and/or its subsidiary to have a minimum 51% equity share. This often leads PLN and/or its subsidiaries to require a certain level of shareholder loan from the strategic partner, which affects the developer's equity IRR. However, the analysis in this Report does not consider the impact of this shareholder loan on the projects' financial feasibility, since the amount of shareholder loan applicable between projects may vary.

3.7. Site Prioritization Methodology

This section outlines the methodology used to determine the final prioritisation of suitable sites through a structured, multi-stage selection process. The approach ensures that only sites meeting key criteria, technical feasibility, environmental and social acceptability, scalability, and financial viability, are shortlisted for further development.

The site screening process integrates three critical technical dimensions:

- Technical suitability and solar resource potential, assessed through geospatial analysis
- E&S risks evaluated via an E&S assessment
- Grid integration potential determined through a preliminary hosting capacity analysis

Reservoir that fails to meet minimum requirements in these areas are excluded from further consideration.

The final ranking is based on a Multi-Criteria Decision Matrix (MCDM), consolidating confirmed technical suitability, E&S factors, estimated maximum PV capacity, and financial viability into a single prioritization score. This score is calculated as a weighted sum of the following four parameters:

1. Geospatial analysis score (30%): Captures the site's technical suitability, including solar resource potential, reservoir conditions, and physical constraints.
2. Environmental and social risk score (20%): This score reflects potential E&S risks and required mitigation measures.
3. Potential PV capacity (5%): This indicates the site's scale based on available reservoir surface area and grid hosting capacity.
4. Financial performance (45%): Measured by the projected Internal Rate of Return (IRR), representing overall project bankability.

The higher weight for financial viability (45%) reflects its decisive role in implementation: no matter how technically feasible a project may be, it must deliver acceptable returns to attract investment. The geospatial score (30%) ensures that technical and physical factors are fully considered, including elements not captured directly in the financial model (e.g., local wind conditions that may affect O&M costs). The E&S score (20%) acknowledges that environmental and social risks are critical but can often be mitigated through careful design and engagement via a comprehensive risks mitigation plan. The relatively low weight for potential capacity (5%) reflects that scalability is already incorporated in the project's financial performance metrics.

4. Data Integration and Site Selection Results

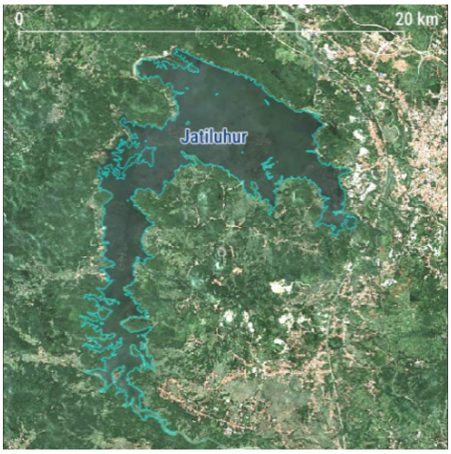
4.1. GIS and Spatial Analysis

Based on the compiled dataset of water reservoirs in the JAMALI region, 51 distinct water bodies were identified with a surface area exceeding 100 hectares. From this group, 21 reservoirs were selected for further analysis. These selected water bodies range from 288 ha to 7,091 ha, measured at their mean water level. The summary of the 21 reservoirs can be found in ANNEX A – Reservoir´s Basic Information The location of the water bodies and their geographic context are presented in Figure 19 and Figure 20 respectively.

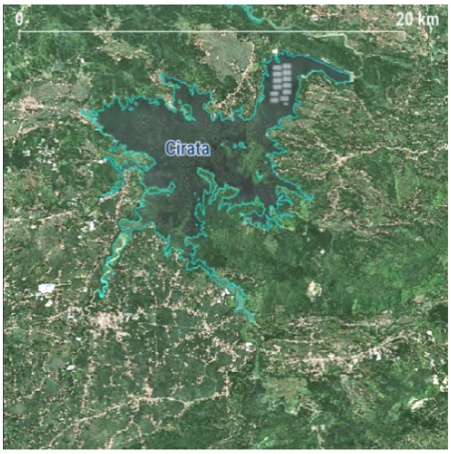
The following criteria, derived based on expert assessment, guided the selection:

- Reservoir size: Preference was given to larger water bodies, as these provide enough space to develop the FPV considering the 20% of the surface area availability limit imposed by local legislation.
- Reservoir type: Artificial (built-up) reservoirs were preferred; natural lakes were excluded, except for Lake Beratan. This is due to the potential impact on the sensitive ecosystems present in natural lakes, which generally do not exist on artificial water bodies.
- Environmental constraints: Water bodies with significant onshore or offshore protected areas were excluded.
- Operational relevance: Preference was given to water bodies identified in the RUPTL, managed or favoured by PLN.
- Year of reservoir filling: preference was given to the reservoirs commissioned after 2015, as this means at least 10 years of satellite data were available for analysis, and parameters such as mean water level area and effective area could be established confidently.

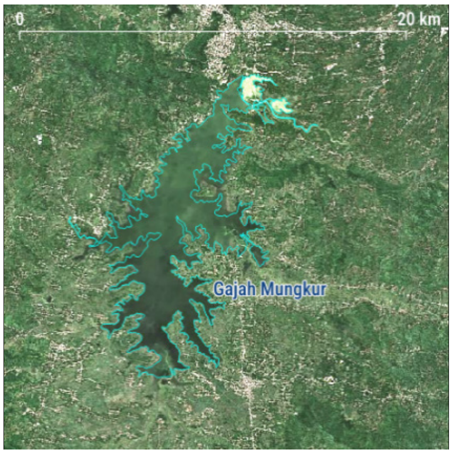
Figure 19 Localization of 21 selected water bodies in the context of river network and other water bodies in JAMALI region



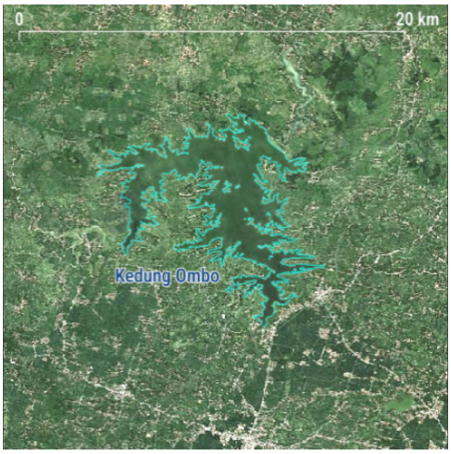
Jatiluhur (7091 ha)



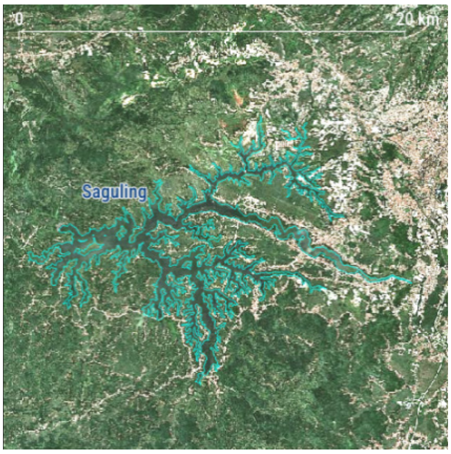
Cirata (5730 ha)



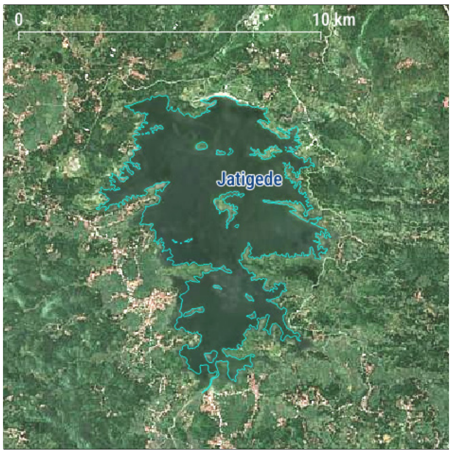
Gajah Mungkur (4849 ha)



Kedung Ombo (3839 ha)

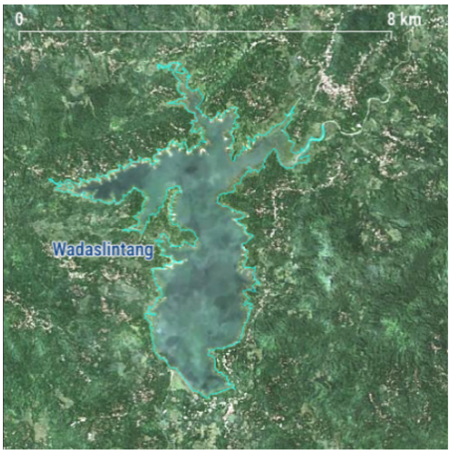


Saguling (3516 ha)

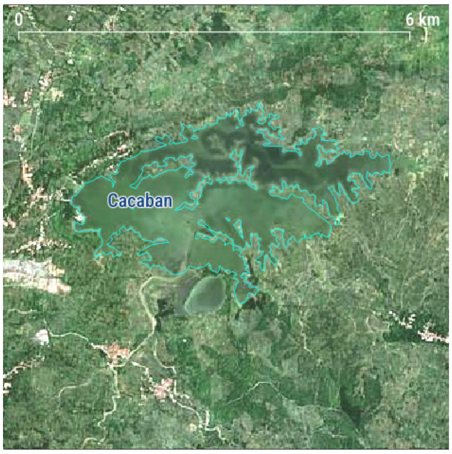


Jatigede (3392 ha)

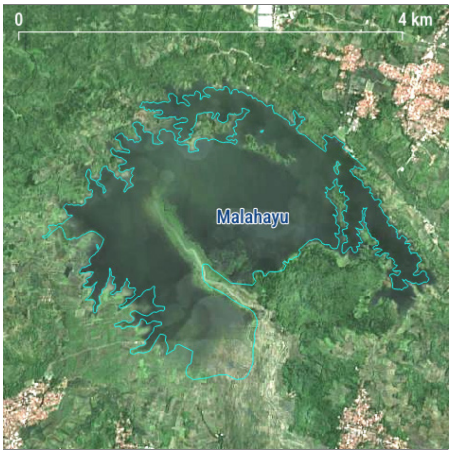
Karangkates (1283 ha)



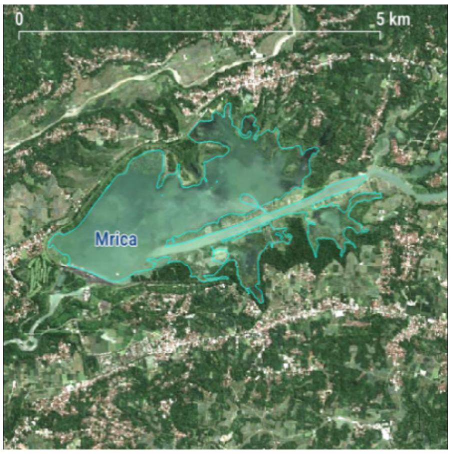
Wadaslintang (1142 ha)



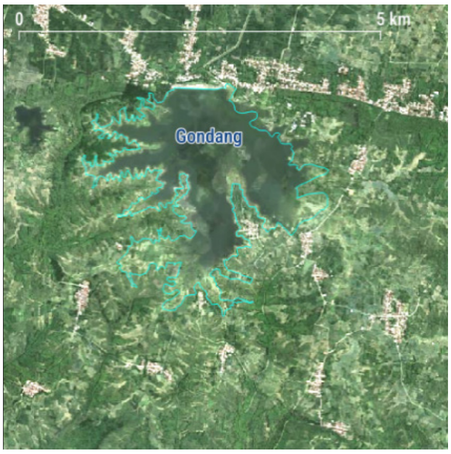
Cacaban (643 ha)



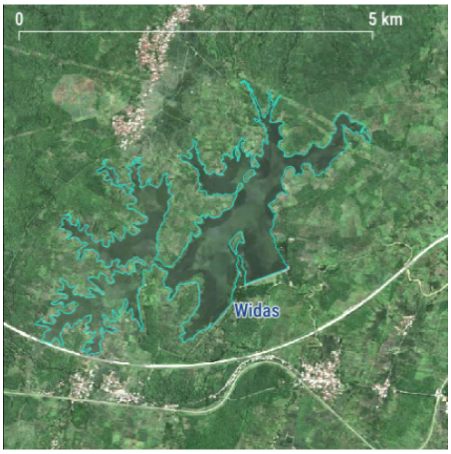
Malahayu (538 ha)



Mrica (487 ha)



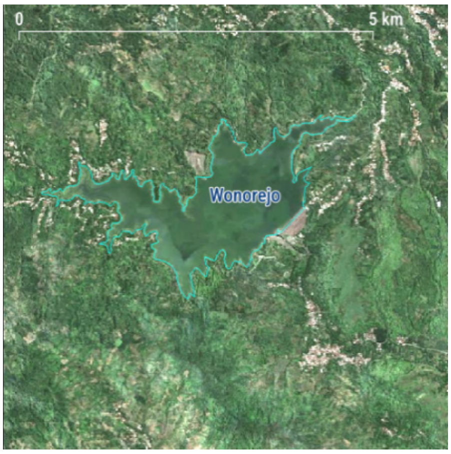
Gondang (485 ha)



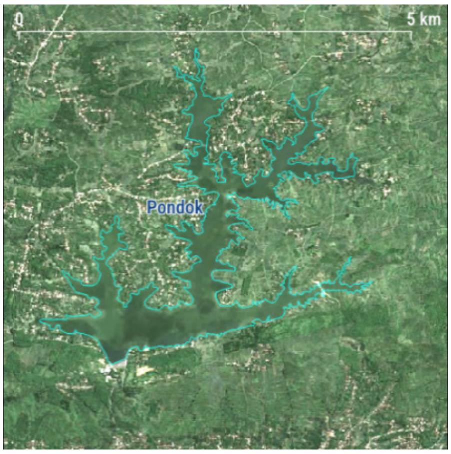
Widas (438 ha)

Beratan (383 ha)

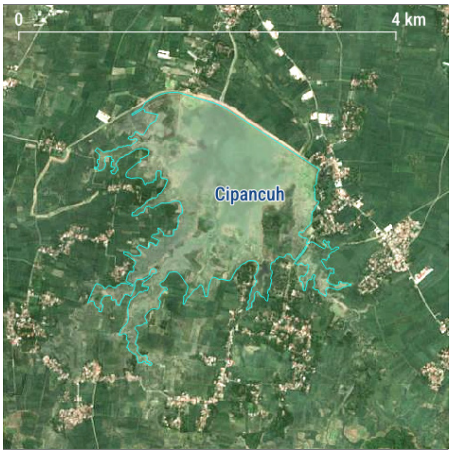
Darma (382 ha)



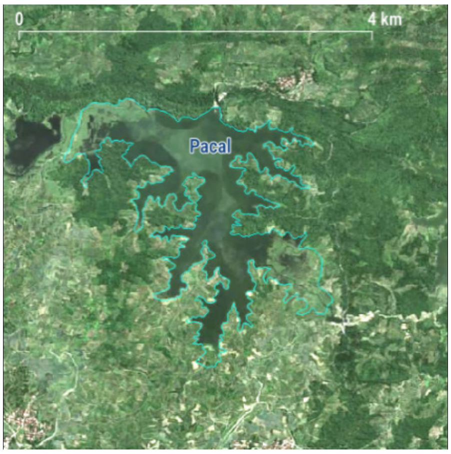
Wonorejo (362 ha)

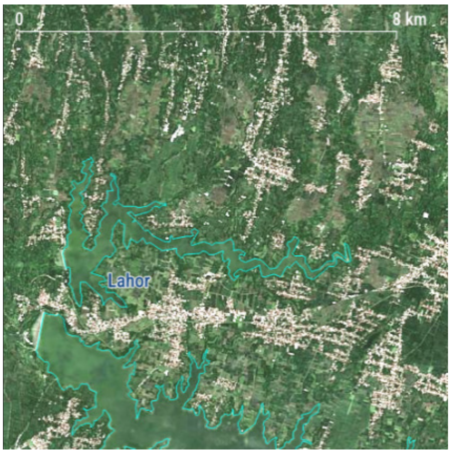


Pondok (332 ha)



Cipancuh (329 ha)





Pacal (317 ha) Lahor (315 ha) Cengklik (289 ha)

Figure 20 Geography of 21 selected water bodies shown on satellite imagery (Sentinel-2 cloudless layer for 2024 by EOX), sorted by mean water level area

The weighted parameters used in the geospatial analysis described above were applied to scoring the individual parameters for each reservoir to obtain a ranked list of the locations based on their technical suitability for FPV development. The full results, including parameter values, weighted scores, and calculation of the final rank, are provided in ANNEX C - Geospatial MCDM Results. Below, an overview of the ranking results based on the geospatial analysis is provided, with a high-level justification of the ranking of each reservoir, commenting on the respective advantages and disadvantages of each location, shown in Table 20.

Table 20 High-level overview of the ranking based on the geospatial analysis

Rank	Reservoir	Advantages	Disadvantages
1	Waduk Kedung Ombo	Good performance across almost all parameters. Very good PVOUT potential with low shading, low basic wind speed, available existing infrastructure (both hydropower and substation)	Medium-scale changes in water extend (effective area). Partially covered by floating net cages, moderately complex shape of the reservoir.
2	Waduk Gajah Mungkur	Good PVOUT potential, low shading, small water extent changes, and good reservoir shape. It is far away from volcanoes, but the existing substation is relatively close by. Floating net cages cover almost nothing. Basic wind speed is low.	No existing hydropower. Low-medium coverage by water hyacinth.
3	Waduk Jatigede	Very low fluctuation of the water extent. Very good reservoir shape. Existing infrastructure (both hydropower and substation). Low coverage by floating net cages, low overage by water hyacinth.	Medium-high basic wind speed, relatively close to a volcano.

Rank	Reservoir	Advantages	Disadvantages
4	Waduk Karangkates	Good PVOUT potential, low shading, moderate water extent changes, medium-low basic wind speed, existing hydropower, and very close to a substation.	Very close to a volcano. High coverage by floating net cages, and medium-high coverage by water hyacinth.
5	Waduk Mrica	Very low fluctuation of the water extent. Existing infrastructure (both hydropower and substation). Medium-low basic wind speed, low shading risk, and no presence of water hyacinth.	Low PVOUT potential and relatively complex reservoir shape. Moderate built-up of the shore.
6	Waduk Wadaslintang	Very low fluctuation of the water extent. Existing infrastructure (both hydropower and substation). Medium-low basic wind speed. Low coverage by floating net cages and water hyacinth.	Low PVOUT potential with moderate to strong shading potential, and relatively complex reservoir shape. Relatively close to a volcano.
7	Waduk Jatiluhur	Very low fluctuation of the water extent. Existing infrastructure (both hydropower and substation).	High coverage by floating net cages and water hyacinth. High basic wind speed. Relatively close to a volcano.
8	Waduk Cirata	Good performance across almost all critical parameters. Existing infrastructure (hydropower and substation), low coverage of the shore by existing buildings, advantageous reservoir shape and only moderate changes in water extent.	Very high coverage by floating net cages and water hyacinth. Moderate PVOUT and potential from terrain shading. Relatively close to a volcano. High basic wind speed.
9	Waduk Widas	Very good PVOUT potential with very low shading. Low basic wind speed. No presence of floating net cages, low built-up of the shoreline, and far from a volcano.	Very severe water extent changes and very complex reservoir shape. No hydropower present and relative far from a substation. Low-medium coverage by water hyacinth.
10	Waduk Cengklik	Very good PVOUT potential with very low shading. Medium-low basic wind speed. Close to an existing substation. Very good reservoir shape.	No existing hydropower, relatively large changes in water extent. High built-up of the shore and very high coverage by water hyacinth. Relatively close to a volcano.
11	Waduk Gondang	Moderately good PVOUT potential, very low shading. Far away from volcanoes. Low basic wind speed. Almost no coverage by floating net cages.	Very severe water extent changes. No existing hydropower and relatively far from a substation. Low-medium coverage by water hyacinth.
12	Waduk Wonorejo	Small water extent changes, and good reservoir shape. Far away from volcanoes. Medium-low basic wind speed. No coverage by floating net cages or water hyacinth.	Relatively far from an existing substation, no existing hydropower. Very strong shading.

Rank	Reservoir	Advantages	Disadvantages
13	Waduk Pacal	Good PVOUT potential, low shading. Low basic wind speed. No coverage by floating net cages. Almost no built-up of shore. Far from volcanos.	Severe water extent changes. Extremely complex reservoir shape. No existing hydropower, substation far away. Low-medium coverage by water hyacinth.
14	Waduk Lahor	Good PVOUT potential, low shading. Very close to a substation. Medium-low basic wind speed. Low coverage by water hyacinth.	Severe water extent changes, and the reservoir shape is extremely complex. Close to a volcano. No existing hydropower. High coverage by floating net cages.
15	Pondok	Good PVOUT potential, low shading. Far away from volcanoes. Medium-low basic wind speed. Almost no coverage by floating net cages, low coverage by water hyacinth.	Severe water extent changes. Extremely complex reservoir shape. No existing hydropower. Unfavourable road access. High built-up of the shore.
16	Waduk Cipancuh	Existing substation close by. Far away from volcanoes. No coverage by floating net cages or water hyacinth.	Extreme water extent changes (up to complete dry-out of the reservoir), water management must be addressed in more detail. No existing hydropower. Medium-high basic wind speed.
17	Waduk Darma	Very low fluctuation of the water extent. Good shape of reservoir. Relatively close to a substation. Low coverage by water hyacinth.	Low PVOUT potential. Medium-high basic wind speed. Very close to a volcano. No existing hydropower. High coverage by floating net cages. High built-up of the shore.
18	Waduk Saguling	Existing infrastructure (both hydropower and substation).	Severe water changes and complex reservoir shape. High basic wind speed. Close to a volcano. High coverage by floating net cages and water hyacinth. High built-up of the shore.
19	Waduk Malahayu	Relatively far from a volcano. No coverage by floating net cages or water hyacinth. Almost no built-up of shore.	Moderate water extent changes. Medium-high basic wind speed. No existing hydropower, very far away from a substation.
20	Waduk Cacaban	No coverage by floating net cages or water hyacinth. Almost no built-up of shore.	Large water extent changes. Medium-high basic wind speed. Close to a volcano. No existing hydropower, and the substation is relatively far away. Only moderate PVOUT potential.
21	Danau Beratan	Very little fluctuation in the water extent, low shape complexity. Very close to an existing substation. Very low coverage by floating net cages and water hyacinth.	Poor PVOUT potential, very strong terrain shading potential. High basic wind speed. No existing hydropower. Highly built-up shore.

Figure 21 Map of the analysed water bodies ranked according to the geospatial analysis

Limitations and recommendations for average water depth and WSE

Two critical factors, water depth and WSE, were not considered in the scoring of the geospatial analysis to assess the reservoir's suitability for FPV. This is due to limited access to consistent data within the SWOT satellite mission, as mentioned in section 3.2.6. The methodology was developed to address the absence of local monitoring, and the workflow is largely automated, scalable, and designed to deliver consistent and comparable results across sites.

For 19 of the 21 reservoirs, WSE was obtained through spatial and attribute-based analysis of geospatial datasets collected between August 2023 and May 2025. On each observation date, water body polygons generated from SWOT data were intersected with reference points for 21 pre-selected reservoirs. Average water depth was obtained for 17 out of the 21 reservoirs.

Despite the robustness of this methodology, biases remain due to variations in data availability. Some reservoirs have significantly more data points than others, and those with more observations tend to show a larger WSE range. This can misleadingly suggest that these reservoirs are more variable because they are better monitored. As a result, any scoring or comparison based on this data would be biased toward data-rich sites.

Furthermore, the data collection periods vary across reservoirs, and the overall timeframe is relatively short. Standardizing the timeframe across all sites would reduce the dataset to a limited period, which likely would not reflect true seasonal or annual variations in water levels.

Also, since all water bodies analysed are large (over 100 hectares), any FPV installation would be placed in a specific reservoir section. This section may have a depth significantly different from the average, making it a critical factor in both feasibility assessments and the interpretation of WSE. Therefore, the final FPV location within the reservoir will significantly influence the relevant WSE data and should be carefully considered in further analysis.

Available average water depth and WSE values are reported per reservoir in the ANNEX I - Water Surface Elevation and Average Water Depth Results and to avoid further bias but does not influence the geospatial analysis scoring at this stage.

4.2. E&S Analysis Results

Each of the nine key parameters (land cover, water stress risk, presence of population and potential for physical & economic displacement, areas of high biodiversity value, global critical habitat & trigger species, onshore areas, forestry status, presence of indigenous peoples, cultural heritage sites) was assigned a low, medium, or high-risk rating, corresponding to a score of 1, 2, or 3, respectively. While the theoretical cumulative E&S risk scores could range from 8 (lowest risk) to 24 (highest risk), the scores across the 21 sites fell within a narrower range of 12 to 18. A statistical adjustment was applied to provide a more meaningful classification and reflect the distribution of actual risks. Based on this refined scoring, sites were categorised as follows: High Risk for scores of 16–18 points (above the 67th percentile), Medium Risk for scores of 14–15 points (between the 33rd and 67th percentiles), and Low Risk for scores of 12–13 points (below the 33rd percentile). A detailed scoring result is provided in the ANNEX E - Environmental and Social Analysis Results.

The following section presents the outcomes of the E&S analysis. This assessment aims to rank the sites by evaluating their environmental, social, and biodiversity risks and potential impacts of FPV development. Based on the final scoring, the summary of the E&S is as shown in Table 21:

Table 21 Summary of E&S results

Risk Category	Description
Excluded	Excluded ▸ None among the 21 reservoirs are excluded
Category A	High Risk ▸ 7 reservoirs ▸ Danau Beratan, Waduk Kedungombo, Waduk Malahayu, Waduk Saguling, Waduk Jatigede, Waduk Jatiluhur, and Waduk Darma.
Category B	Moderate Risk ▸ 11 reservoirs ▸ Waduk Cirata, Waduk Gondang, Waduk Pondok, Waduk Lahor, Waduk Cengklik, Waduk Gajahmungkur, Waduk Karangkates, Waduk Wadaslintang, Waduk Mrica, Waduk Cipancuh and Waduk Pacal
Category C	Low Risk ▸ 3 reservoirs ▸ Waduk Cacaban, Waduk Widas, and Wonorejo Reservoir

4.2.1. Excluded sites

No sites were excluded, as none of the potential sites are located within mangrove areas or land moratorium zones.

4.2.2. High-risk sites

Seven reservoirs' sites represent high-risk locations due to elevated social risks, high onshore area biodiversity, and placement within high-risk watersheds. These sites include Danau Beratan, Waduk Kedungombo, Waduk Malahayu, Waduk Saguling, Waduk Jatigede, Waduk Jatiluhur, and Waduk Darma.

- **Danau Beratan**

Danau Beratan presents a high cultural heritage risk due to its location adjacent to Pura Ulun Danu Batur, which UNESCO recognises as part of the World Heritage Subak System. The site shows medium social risk from well-established tourism activities including restaurants, hotels, and viewpoints, though floating structures cover only 1.04% of the water body. Furthermore, natural habitat (primary and secondary dryland forest) is present within 5-km radius from the reservoir, from the nearshore (zone 1) to the outermost radius (zone 3).

Endemic species unique to Bali Island have been specifically identified in Danau Beratan, including Rasbora baliensis, commonly referred to as "nyalian buluh." According to the IUCN Red List, this species is classified as vulnerable (VU). Additionally, other endemic freshwater fish have been documented in the lake, such as Lentipes whittenorum, which is categorized as data deficient (DD) in the IUCN Red List Database[21].

- **Waduk Kedungombo**

Waduk Kedungombo exhibits high cultural heritage significance through the floating tomb of Nyi Ageng Serang located in the middle of the reservoir, which serves as a sacred site and religious tourism destination for local communities. The site presents medium social risk with moderately dense surrounding populations and floating net cages covering 13.85% of the water surface, particularly in Ngartotirto Village.

- **Waduk Malahayu**

Waduk Malahayu demonstrates medium social impact with less dense surrounding populations but features several small islands within the reservoir that serve as tourism photo spots. The site contains no registered cultural heritage locations within the reservoir vicinity, though it is adjacent to historical Dutch colonial ruins of a munitions warehouse (Ruïnes van Munitiemagazijn). Furthermore, natural habitat (primary and secondary dryland forest) is present within 5-km radius from the reservoir, from the nearshore (zone 1) to the outermost radius (zone 3).

- **Waduk Saguling**

Waduk Saguling demonstrates high social risk from densely populated surrounding areas and intensive floating net cage operations covering 68% of the water surface. Under Governor Regulation West Java No. 37/2021 and Presidential Regulation No. 15/2018, around 35,000–37,000 FNC have been identified across Saguling, far above the carrying capacity limits. This overcapacity has led to environmental stress, including water pollution from excess feed and confinement. On the other hand, on the reservoir body, there is a notable cultural heritage area in form of Sirtwo Island where researchers have discovered prehistoric fossils.

In 2021, following local reports, a team from the ITB Geological Engineering Study Program[22] conducted surveys on Sirtwo Island and confirmed the presence of fossils embedded in the rock surface. These fossils, identified as belonging to Bovidae (cattle), Cervidae (deer), and Elephas maximus (elephant), were verified to be prehistoric and not from modern animals.

- **Waduk Jatigede**

Waduk Jatigede shows medium social impact with less dense surrounding populations and limited floating net cage presence covering 12.29% of the water body, but presents high cultural heritage risk due to the submerged historical graveyard (Makam Keramat Prabu Guru Aji Putih) that remains accessible to local communities by boat and several touristic photo spots on small islands within the reservoir.

[21] Arthana, I W., A.R. As-syakur. 2020. Ikan air tawar endemik di Bali, Indonesia (The endemic freshwater fish in the Bali Province, Indonesia)

[22] ITB Team Found Evidence of Ancient Animals Existence while Examining Fossils in Saguling Reservoir - Institut Teknologi Bandung

- **Waduk Jatiluhur**

Waduk Jatiluhur presents high social impact risks with densely populated surrounding areas and intensive aquaculture operations where floating net cages cover 41.83% of the water surface. Furthermore, natural habitat (primary and secondary dryland forest) is present within 5-km radius from the reservoir, from the nearshore (zone 1) to the outermost radius (zone 3).

- **Waduk Darma**

Waduk Darma also exhibits high social risks due to dense populations in nearby areas and intensive floating net cage operations, particularly concentrated in Cipasung and Jagara Villages, covering 52.34% of the water body. Furthermore, natural habitat (primary and secondary dryland forest) is present within 5-km radius from the reservoir, from the nearshore (zone 1) to the outermost radius (zone 3).

4.2.3. Medium-risk sites

Eleven reservoir sites represent medium-risk potential locations, including Waduk Cirata, Waduk Gondang, Waduk Pondok, Waduk Lahor, Waduk Cengklik, Waduk Gajahmungkur, Waduk Karangkates, Waduk Wadaslintang, Waduk Mrica, Waduk Cipancuh and Waduk Pacal. This classification is primarily driven by higher-risk land cover types in the surrounding area, moderate to high water stress, and notable social, cultural, and biodiversity considerations. Despite the riskis evaluated as medium, some aspects have to be considered.

Several sites demonstrate significant cultural heritage considerations. Waduk Pacal and Waduk Gondang exhibit medium cultural heritage risks, with nearby pilgrimage sites including Makam Syeh Nawawi and Situs Makam Dowo located approximately two kilometers from their respective reservoirs. Waduk Gajahmungkur presents high cultural heritage significance due to the submerged historical graveyard (Makam Kuno Setono) that becomes visible seasonally during reservoir drought periods. Waduk Wadaslintang contains medium cultural heritage risk through the nearby graveyard (Makam Syeh Nawawi) that serves as a pilgrimage site for local communities, located approximately two kilometers from the reservoir.

Social impacts characterize several locations through intensive aquaculture operations and population density. Although the overall scoring for Waduk Cirata is medium, this site presents the most intensive social impact with 70% FNC coverage, dense surrounding populations, and numerous fishing spots, kiosks, and restaurants operating on the water surface. Based on Governor Regulation of West Java No. 96 of 2022 and Presidential Regulation No. 15/2018, there is a collaborative effort by the national and provincial government to reduce the number of FNC and other related structures to support the operation of the current reservoir and to overcome pressing environmental issues such as deteriorating water quality and safety considerations. Based on current media screening, it was noted that this reduction effort resulted in social tension on-site, including community rejection, demonstration, arson, and other social issues.

Waduk Lahor demonstrates high social impact through FNC operations covering 60.61% of the water body, particularly concentrated in Kromengan Village. Waduk Karangkates features extensive FNC coverage at 41.54% of the water surface, concentrated in Kalipare and Sumberpucung Villages. Waduk Cengklik is surrounded by densely populated areas with moderate floating net cage presence covering 28.40% of the water body within Ngargorejo Village. Waduk Gajahmungkur shows limited aquaculture activity with FNC covering only 2.59% of the water surface, primarily in Sendang and Gumiwang Lor Villages. Waduk Pondok is characterized by moderately populated surrounding areas. Waduk Mrica and Waduk Cipancuh demonstrate primarily land cover-related risks in their surrounding zones.

Recent biodiversity assessments have led to identifying a rare freshwater species in Waduk Wadaslintang. Notably, researchers from Universitas Airlangga and Universitas Brawijaya have discovered the presence of “ikan mangut” (Lobocheilos falcifer) in this region of Central Java. This finding is particularly significant as the ikan mangut was only documented in Sumatra, Kalimantan, and West Java, including the Cisadane, Ciliwung, and Citarum rivers. The discovery in Wadaslintang extends its known distribution approximately 300 kilometers eastward, representing the first record of the species outside its native range. According to the IUCN Red List, the species is classified as vulnerable. It is important to note that previous records suggest that the species may not rely solely on Waduk Wadaslintang as its primary habitat

4.2.4. Low-risk sites

Three reservoir sites, Waduk Cacaban, Waduk Widas, and Wonorejo Reservoir, represent low-risk potential locations for development consideration.

These locations exhibit mixed land cover risks, as detailed in the ANNEX E - Environmental and Social Analysis Results, Wonorejo Reservoir and Waduk Widas demonstrate moderate risks primarily related to surrounding land cover types. Waduk Widas additionally presents medium forestry status risk due to its intersection with Limited Production Forest and Production Forest areas.

The sites present distinct social and cultural characteristics that require consideration. Waduk Cacaban exhibits medium social risk with less densely populated surrounding areas and no floating net cage presence, though the site supports active tourism activities, including water transport operations. Based on current assessments, Wonorejo Reservoir and Waduk Widas demonstrate fewer notable social or cultural features.

4.2.5. Mitigation actions of E&S risks

The results of the E&S analysis indicated that among the qualified 21 potential sites, 11 sites are exposed to medium risk and 7 to high risk. For future considerations of the site for FPV, the consultants elaborated a high-level list of actions to mitigate the risks. The summary of the analysis, together with the mitigation actions, is presented in Table 22.

Table 22 Mitigation action for E&S risks

Risk Category	Description	Results	Actions point
Category A	**High Risk** The site has potentially significant gaps with relevant international standards of IFC PS 6 and IFC PS5, which might need further detailed study on biodiversity and prolonged, detailed study and complex social restoration management and plan, respectively. The site may pose potential significant adverse impacts (environmental, social, or financial) **that are often diverse, irreversible, or unprecedented.**	**7 Sites**	Should the site be selected, it requires comprehensive & detailed planning documentation such as ESIA and development of ESMP. Projects must comply with the applicable local regulatory framework. Due diligence, including site visits, is required for projects funded or supported by entities under the Equator Principles Financial Institutions (EPFIs), as these projects are subject to international environmental and social standards.

Risk Category	Description	Results	Actions point
Category B	**Moderate Risk** A site with potential significant gaps to IFC PS5 might need a prolonged, detailed study and a complex land acquisition process. **The site may pose potential limited adverse impacts that are fewer, generally site-specific, and mostly reversible or manageable through mitigation measures.**	11 Sites	Should the site be selected, it requires scaled and tailored site-specific risk planning documentation, such as an ESIA and ESMP. Projects must comply with the applicable local regulatory framework. Due diligence with potential site visits is required for projects funded or supported by entities under the **Equator Principles Financial Institutions (EPFIs)**, as these projects are subject to international environmental and social standards.
Category C	**Low Risk** Projects have minimal or no adverse environmental or social risks and impacts.	3 sites	Should the site be selected, it requires compliance with the applicable local regulatory framework.

4.3. Grid Integration Assessment

4.3.1. Maximum Hosting Capacity

The maximum hosting capacity analysis quantifies the upper limit of solar PV that can be integrated at each substation without compromising grid stability. The selected 150 kV substations nearest to each reservoir site serve as the primary connection points. As shown in Table 24. The closest reservoir site to its substation is the Karangkates reservoir, which is only 0.57 km from the Sutami substation. Conversely, the farthest site is the Malahayu reservoir, located 26.87 km from the Brebes substation.

Table 23 Summary of maximum hosting capacity

No	Name	Substation	Distance (km)	Maximum hosting capacity (MW)
1	**Waduk Jatiluhur**	Jatiluhur Baru 150 kV	1.17	521
2	**Waduk Cirata**	Cirata 150 kV	2.52	1853
3	**Waduk Gajah Mungkur**	Wonogiri 150kV	7.94	272
4	**Waduk Kedung Ombo**	Kedungombo 150 kV	0.8	329
5	**Waduk Saguling**	Rajamandala 150 kV	6.73	248
6	**Waduk Jatigede**	Jatigede 150kV	2.92	529.5
7	**Waduk Karangkates**	Sutami 150kV	0.57	487.5
8	**Waduk Wadaslintang**	Wadaslintang 150 kV	0.78	208.5
9	**Waduk Cacaban**	Kebasen 150kV	13.5	599
10	**Waduk Malahayu**	Brebes 150 kV	26.87	406
11	**Waduk Mrica**	Mrica 150kV	1.88	450.5
12	**Waduk Gondang**	Ngimbang 150 kV	13.06	1073
13	**Waduk Widas**	New Nganjuk 150 kV	13.31	731

No	Name	Substation	Distance (km)	Maximum hosting capacity (MW)
14	**Danau Beratan**	Baturiti 150 kV	2.13	413
15	**Waduk Darma**	Kuningan Baru 150kV	7.64	826
16	**Waduk Wonorejo**	Tulungagung 150kV	13.22	1113
17	**Waduk Pondok**	Ngawi 150kV	11.74	1071
18	**Waduk Cipancuh**	Haurgeulis 150 kV	6.12	97
19	**Waduk Pacal**	Bojonegoro 150kV	20.72	418
20	**Waduk Lahor**	Sutami 150kV	1.91	487.5
21	**Waduk Cengklik**	Banyudono 150kV	3.68	1069

The hosting capacity calculations are based on load flow analyses. These analyses progressively increase the solar PV injection at each substation until system constraints are exceeded. Key parameters monitored include voltage levels and component loading. Voltage limits are set at ±5% for the 500 kV system, and a slightly wider range of -10% to +5% for the 150 kV system. Component loading must not exceed 100% of its rated capacity.

The results indicate the lowest hosting capacity is at the Cipancuh reservoir site, connected to the Haurgeulis substation, with a maximum allowable capacity of 97 MW. On the other hand, the highest hosting capacity is observed at the Cirata reservoir site, linked to the Cirata substation, with a maximum capacity of 1,853 MW. Large hosting capacities above 1,000 MW typically correspond to substations with multiple outlet feeders or connections to high-capacity transmission lines and transformers. This allows for more extensive active power evacuation and greater grid flexibility. Additionally, two nearby reservoir sites, Waduk Karangkates and Waduk Lahor, are both expected to be connected to the Sutami 150 kV substation. Therefore, it is necessary to estimate the distribution of the solar PV capacity to each site based on the hosting capacity of the Sutami substation.

4.4. Potential Capacity of Each Site

The final potential capacity for each site is determined by the most limiting factor among three key parameters: the maximum allowable area based on regulatory constraints, the effective water surface area derived from geospatial analysis of historical data, and the grid's maximum hosting capacity. For the hosting capacity assessment, an AC-to-DC ratio of 1.25 is assumed. The resulting potential capacity for each site is summarized in Table 25.

Table 24 Potential capacity of each site Potential capacity of each site

No	Reservoir name	Area (ha)	Capacity_20% areas (MWp)	Capacity eff_water area (MWp)	Maximum Hosting Capacity (MW)	Maximum Hosting Capacity (MWp)	Distance to Substation (km)	PV Capacity (MWp)
1	**Waduk Jatiluhur**	7091.4	1418	5248	521	651	1.17	651
2	**Waduk Cirata**	5729.6	1146	3953	1853	2316	2.52	1146
3	**Waduk Gajah Mungkur**	4849.3	970	2716	272	340	7.94	340
4	**Waduk Kedung Ombo**	3838.6	768	2034	329	411	0.8	411
5	**Waduk Saguling**	3515.6	703	1477	248	310	6.73	310
6	**Waduk Jatigede**	3392.0	678	2646	530	662	2.92	662
7	**Waduk Karangkates**	1283.0	257	616	488	609	0.57	257
8	**Waduk Wadaslintang**	1141.8	228	948	209	261	0.78	261
9	**Waduk Cacaban**	642.6	129	238	599	749	13.5	129
10	**Waduk Malahayu**	538.4	108	226	406	508	26.87	108
11	**Waduk Mrica**	487.0	97	365	451	563	1.88	97
12	**Waduk Gondang**	484.6	97	68	1073	1341	13.06	68
13	**Waduk Widas**	437.7	88	105	731	914	13.31	88
14	**Danau Beratan**	375.0	75	376	413	516	2.13	75
15	**Waduk Darma**	382.1	76	290	826	1033	7.64	76
16	**Waduk Wonorejo**	362.1	72	239	1113	1391	13.22	72
17	**Pondok**	332.1	66	96	1071	1339	11.74	66
18	**Waduk Cipancuh**	329.0	66	0	97	121	6.12	0
19	**Waduk Pacal**	317.3	63	54	418	523	20.72	54
20	Waduk Lahor	263.0	53	101	488	609	1.91	53
21	Waduk Cengklik	253.0	51	107	1069	1336	3.68	51

The table shows that the potential floating PV capacity at Waduk Cipancuh is zero due to its limited effective water area. This suggests that the reservoir's water level drops significantly during the dry season, at times leaving it nearly completely dry. As a result, Waduk Cipancuh will be excluded from further financial analysis and site prioritisation.

4.5. Financial Analysis

The financial feasibility covers the following 2 (two) scenarios as follows:

- Scenario 1 uses the ceiling price of 6.95 cents USD/kWh from year 1 to 10 and 4.17 cents USD/kWh from year 11 to 30, in accordance with Perpes 112/2022.
- Scenario 2 uses the ceiling price of 5.50 cents USD/kWh from year 1 to 10. Ceiling price of Year 11 to 30 follows the ratio of Year 1-10 and Year 11-30 ceiling price, as regulated in Perpres 112/2022. Therefore, a ceiling price of 3.30 cents USD/kWh from year 11 to 30 is used.

Summary of each scenario is provided in Table 25.

Table 25 Tariff for each scenario

Scenario	Ceiling Price (cents USD/kWh)	
	Year 1 to 10	Year 11 to 30
1	6.95	4.17
2	5.50	3.30

4.5.1. Assumption based on the Results of Potential Capacity

Based on the assumption of potential capacity, Table 26 shows the results on 20 potential sites.

Table 26 Assumption based on results of potential capacity

No	Reservoir name	PV capacity (MWp)	Gross energy generated (MWh/year)	Power plant (Million USD)	Evacuation line (Million USD)	Total* (Million USD)	Land rent cost* (Million USD/Year)	Fixed cost* (Million USD/Year)	Variable cost* (USD/Year)
1	**Waduk Jatiluhur**	651	927,186	351.68	1.44	353.12	0.04	8.05	0.46
2	**Waduk Cirata**	1146	1,648,769	618.8	3.11	621.91	0.22	14.16	0.82
3	**Waduk Gajah Mungkur**	340	524,594	187.68	9.8	197.48	0.02	4.2	0.26
4	**Waduk Kedung Ombo**	411	641,484	227.01	0.99	228	0.08	5.08	0.32
5	**Waduk Saguling**	310	450,241	167.40	8.30	175.70	0.07	3.83	0.23
6	**Waduk Jatigede**	662	962,743	357.41	3.6	361.02	0.34	8.18	0.48
7	**Waduk Karangkates**	257	395,442	141.64	0.7	142.35	0.1	3.17	0.2
8	**Waduk Wadaslintang**	261	349,107	143.87	0.96	144.83	0.03	3.22	0.17
9	**Waduk Cacaban**	129	182,298	74.8	16.66	91.46	0.02	1.59	0.09
10	**Waduk Malahayu**	108	157,527	62.67	33.15	95.82	0.2	1.33	0.08
11	**Waduk Mrica**	97	132,962	58.44	2.32	60.76	0.06	1.2	0.07
12	**Waduk Gondang**	68	101,630	41.52	16.11	57.64	0.05	0.84	0.05
13	**Waduk Widas**	88	140,439	52.52	16.42	68.95	0.36	1.08	0.07
14	**Danau Beratan**	75	92,925	45.00	2.63	47.634	0.51	0.93	0.05
15	**Waduk Darma**	76	105,919	45.85	9.43	55.28	0.09	0.94	0.05
16	**Waduk Wonorejo**	72	102,746	44.32	16.31	60.63	0.12	0.9	0.05
17	**Waduk Pondok**	66	102,771	40.65	14.49	55.13	0.01	0.82	0.05
18	**Waduk Cipamcuh**	Not included in the financial analysis. See section 4.4.							
19	**Waduk Pacal**	54	83,033	33.01	25.57	58.58	0.21	0.67	0.04
20	**Waduk Lahor**	53	81,052	32.44	2.36	34.80	0.1	0.76	0.04
21	**Waduk Cengklik**	51	80,012	31.21	4.54	35.78	0.01	0.63	0.04

4.5.2. Base Case Scenario

The results for the financial feasibility analysis of the 20 sites mentioned in Section 3.6 are as shown in Table 27 below:

Table 27 Project IRR and Equity IRR results for all sites – Base assumption

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	7.72%	7.51%	3.59%	0.68%
2	**Waduk Cirata**	1146	8.00%	12.00%	7.85%	7.73%	3.70%	0.84%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	8.19%	8.34%	4.22%	1.77%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	8.97%	9.78%	4.88%	2.76%
5	**Waduk Saguling**	310	8.00%	12.00%	7.43%	7.00%	3.36%	0.36%
6	**Waduk Jatigede**	662	8.00%	12.00%	7.86%	7.76%	3.66%	0.75%
7	**Waduk Karangkates**	257	8.00%	12.00%	8.69%	9.26%	4.57%	2.24%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	6.34%	5.15%	2.14%	-1.63%
9	**Waduk Cacaban**	129	8.00%	12.00%	4.42%	2.26%	0.64%	-3.40%
10	**Waduk Malahayu**	108	8.00%	12.00%	1.97%	-1.26%	-2.21%	-7.59%
11	**Waduk Mrica**	97	8.00%	12.00%	5.10%	3.20%	0.95%	-3.38%
12	**Waduk Gondang**	68	8.00%	12.00%	3.18%	0.53%	-0.54%	-4.84%
13	**Waduk Widas**	88	8.00%	12.00%	3.88%	1.27%	-0.63%	-6.26%
14	**Danau Beratan**	75	8.00%	12.00%	-1.48%	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	3.51%	0.84%	-0.68%	-5.71%
16	**Waduk Wonorejo**	72	8.00%	12.00%	2.19%	-1.00%	-2.07%	-7.58%
17	**Waduk Pondok**	66	8.00%	12.00%	4.04%	1.80%	0.54%	-3.24%
19	**Waduk Pacal**	54	8.00%	12.00%	0.03%	-3.93%	-4.86%	0.00%
20	**Waduk Lahor**	53	8.00%	12.00%	5.90%	4.45%	1.74%	-2.22%
21	**Waduk Cengklik**	51	8.00%	12.00%	6.08%	4.82%	2.44%	-0.73%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above is depicted in Figure 22 below.

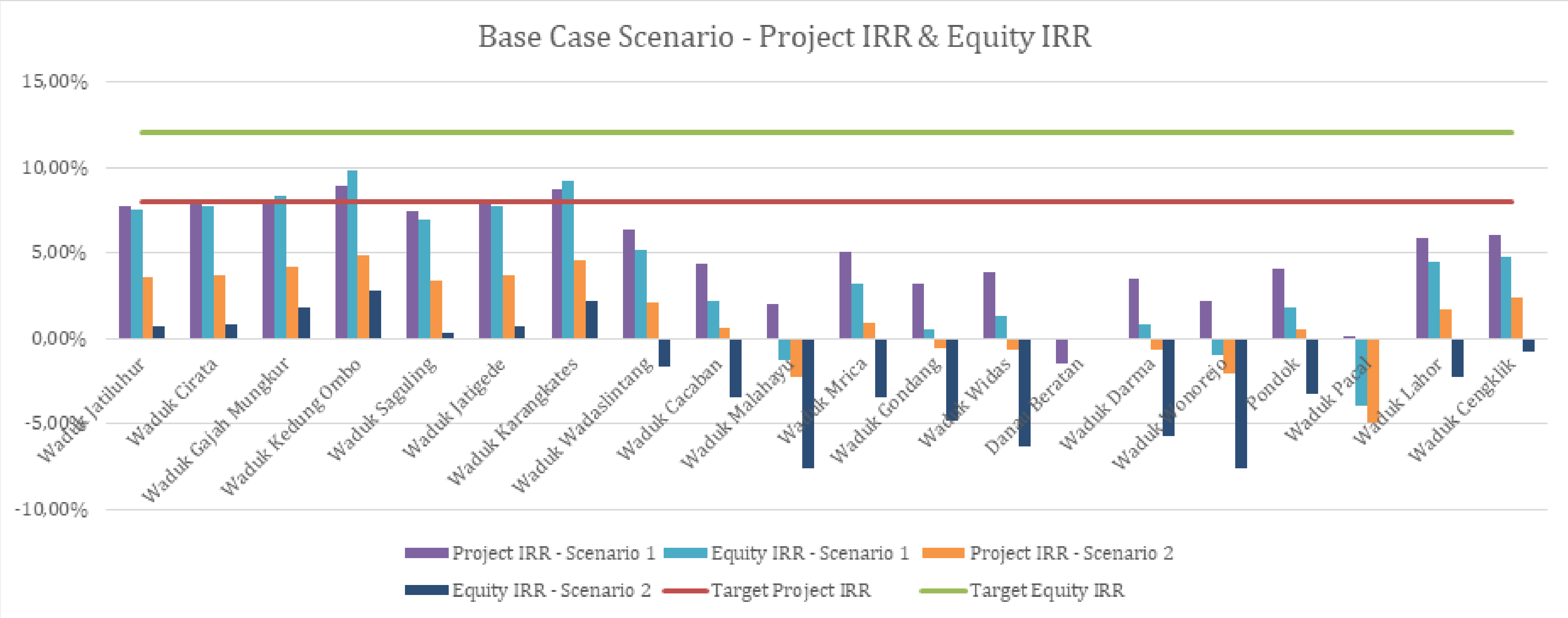


Figure 22 Project IRR and Equity IRR of each site for each scenario – Base scenario

Project IRR and Equity IRR for each site as shown above is depicted in Figure 22 below.

As evident from the chart above, no sites are feasible for either scenario using the target Project IRR of 8.00% and target Equity IRR of 12.00%. These results are due to the tariff used in each scenario (detailed in Table 25), which is insufficient to cover the solar project's CAPEX. Further analyses were conducted to explore the potential to exclude specific CAPEX components, specifically the 150 kV evacuation line, which is usually built by IPP and transferred to PLN right after being constructed. Therefore, it is not included as part of the cost component for tariff calculation.

4.5.3. Additional Analysis: Exclusion of 150 KV Evacuation Line Cost

As mentioned in the previous section, another analysis was performed to see the impact of excluding specific cost components, specifically the 150 kV evacuation lines. In addition to the reason explained in the previous section, as seen in section 3.6, the cost of the corresponding evacuation line depends on its length. It could account for an average of 12.77% of the total CAPEX across 20 sites. The highest-cost evacuation line is for the Waduk Pacal site, accounting for 43.64% of the site's total CAPEX.

The results for the financial feasibility analysis of 20 sites without 150 KV evacuation line CAPEX is in Table 28 as follows:

Table 28 Project IRR and Equity IRR results for all sites – Additional analysis excluding evacuation line cost

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	7.77%	7.60%	3.64%	0.75%
2	**Waduk Cirata**	1146	8.00%	12.00%	7.91%	7.85%	3.76%	0.93%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	8.88%	9.61%	4.80%	2.63%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	9.03%	9.90%	4.93%	2.84%
5	**Waduk Saguling**	310	8.00%	12.00%	8.06%	8.12%	3.91%	1.16%
6	**Waduk Jatigede**	662	8.00%	12.00%	7.99%	8.00%	3.78%	0.92%
7	**Waduk Karangkates**	257	8.00%	12.00%	8.76%	9.38%	4.62%	2.33%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	6.42%	5.28%	2.21%	-1.53%
9	**Waduk Cacaban**	129	8.00%	12.00%	6.73%	5.82%	2.71%	-0.62%
10	**Waduk Malahayu**	108	8.00%	12.00%	6.65%	5.63%	2.22%	-1.75%
11	**Waduk Mrica**	97	8.00%	12.00%	5.56%	3.89%	1.36%	-2.82%
12	**Waduk Gondang**	68	8.00%	12.00%	6.80%	5.94%	2.79%	-0.48%
13	**Waduk Widas**	88	8.00%	12.00%	7.17%	6.50%	2.40%	-1.86%
14	**Danau Beratan**	75	8.00%	12.00%	-0.65%	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	5.60%	3.94%	1.27%	-3.10%
16	**Waduk Wonorejo**	72	8.00%	12.00%	5.58%	3.89%	1.18%	-3.33%
17	**Waduk Pondok**	66	8.00%	12.00%	7.51%	7.15%	3.63%	0.90%
19	**Waduk Pacal**	54	8.00%	12.00%	6.21%	4.84%	1.35%	-3.78%
20	**Waduk Lahor**	53	8.00%	12.00%	6.77%	5.85%	2.50%	-1.14%
21	**Waduk Cengklik**	51	8.00%	12.00%	8.15%	8.28%	4.22%	1.78%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above is depicted in Figure 23 below.

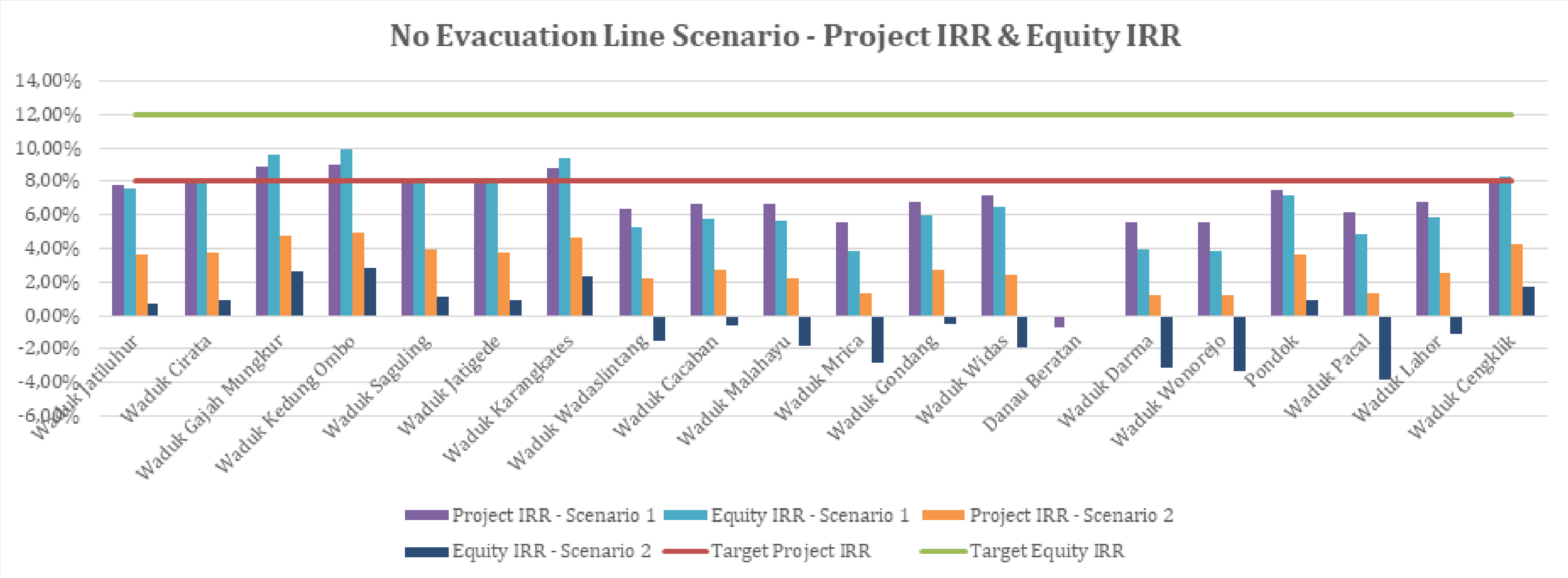


Figure 23 Project IRR and Equity IRR of each site for each scenario – Additional analysis excluding evacuation line cost

As shown from chart above, no sites are feasible for either scenario using the target Project IRR of 8.00% and target Equity IRR of 12.00%. These results are based on the tariff in each scenario (detailed in Table 25). These tariffs are still insufficiently covering the solar project's CAPEX. Despite the CAPEX for the evacuation line has been excluded. However, a slight improvement can be observed under the scenario 1. From the Project IRR perspective 7 sites are feasible against 3 for the base case assumptions. Currently, there is no site that haves an Equity IRR above 120%. The findings demonstrate that evacuation line does not significantly impact the project's overall feasibility. Still, it greatly improves IRR especially for sites with larger percentage of evacuation line CAPEX such as Waduk Pacal (Equity IRR equal to -3.6993% in the base case assumptions vs 4.845.53% without the evacuation line) and Waduk Malahayu (Equity IRR equal to -1.260.97% in the base case assumptions vs 5.63%6.32 without the evacuation line) in Scenario 1. .

To enhance project feasibility, a sensitivity analysis was performed to address some key factors, which are the fixed CAPEX required for the IPP's solar PV development, the maximum allowable tariff, and the target Project IRR and Equity IRR, to better analyse the feasibility of the project for each site.

4.5.4. Sensitivity Analysis

A sensitivity analysis was performed to see the impact of changing several parameters to the financial feasibility. The parameters that were analysed are summarized in Table 29. The sensitivity analysis was then performed with and without the evacuation line in the total CAPEX.

Table 29 Assumptions for sensitivity analysis

Assumptions	Base Scenario	Sensitivity Analysis 1	Sensitivity Analysis 2	Sensitivity Analysis 3
Energy generation	100 % Annual Energy Generation	+- 5% Annual Energy Generation (95% and 105%)	100 % Annual Energy Generation	100 % Annual Energy Generation
Fixed OPEX	12.36 USD per kW per year (10.30 USD per kW per year based on International Renewable Energy Agency (IRENA), 2024, multiplied by 1.2)	USD 12.36 per kW per year	USD 4.80* per kW per year	USD 12.36 per kW per year
Main power plant CAPEX and OPEX	Ground Mounted CAPEX and OPEX multiplied by 1.2.	Ground Mounted CAPEX and OPEX multiplied by 1.2.	Ground Mounted CAPEX and OPEX multiplied by 1.2.	Ground Mounted CAPEX and OPEX multiplied by 1.1.

Notes: *Assumption is based on lowest O&M Cost from IRENA Study multiplied by 1.2

4.5.4.1. Sensitivity analysis including evacuation line

Energy generation sensitivity analysis 1

The results of the sensitivity analysis of 20 sites using 105% of base annual energy generation of is shown in Table 30 as follows

Table 30 Project IRR and Equity IRR Results for all sites – sensitivity analysis 1– energy generation (+5% / 105% / 95%)

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	8.57%	9.04%	4.46%	2.08%
2	**Waduk Cirata**	1146	8.00%	12.00%	8.70%	9.29%	4.57%	2.25%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	9.02%	9.87%	5.04%	3.06%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	9.85%	11.46%	5.72%	4.12%
5	**Waduk Saguling**	310	8.00%	12.00%	8.26%	8.48%	4.22%	1.73%
6	**Waduk Jatigede**	662	8.00%	12.00%	8.73%	9.33%	4.55%	2.18%
7	**Waduk Karangkates**	257	8.00%	12.00%	9.56%	10.91%	5.42%	3.62%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	7.17%	6.55%	3.06%	-0.15%
9	**Waduk Cacaban**	129	8.00%	12.00%	5.15%	3.37%	1.47%	-2.15%
10	**Waduk Malahayu**	108	8.00%	12.00%	2.70%	-0.20%	-1.24%	-6.00%
11	**Waduk Mrica**	97	8.00%	12.00%	5.90%	4.47%	1.87%	-1.87%
12	**Waduk Gondang**	68	8.00%	12.00%	3.87%	1.53%	0.30%	-3.62%
13	**Waduk Widas**	88	8.00%	12.00%	4.69%	2.54%	0.42%	-4.31%
14	**Danau Beratan**	75	8.00%	12.00%	0.32%	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	4.28%	2.00%	0.30%	-4.11%
16	**Waduk Wonorejo**	72	8.00%	12.00%	2.93%	0.09%	-1.07%	-5.90%
17	**Waduk Pondok**	66	8.00%	12.00%	4.72%	2.80%	1.31%	-2.14%
19	**Waduk Pacal**	54	8.00%	12.00%	0.82%	-2.81%	-3.59%	-9.68%
20	**Waduk Lahor**	53	8.00%	12.00%	6.72%	5.80%	2.65%	-0.74%
21	**Waduk Cengklik**	51	8.00%	12.00%	6.83%	6.03%	3.21%	0.42%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above, are depicted in Figure 24 below.

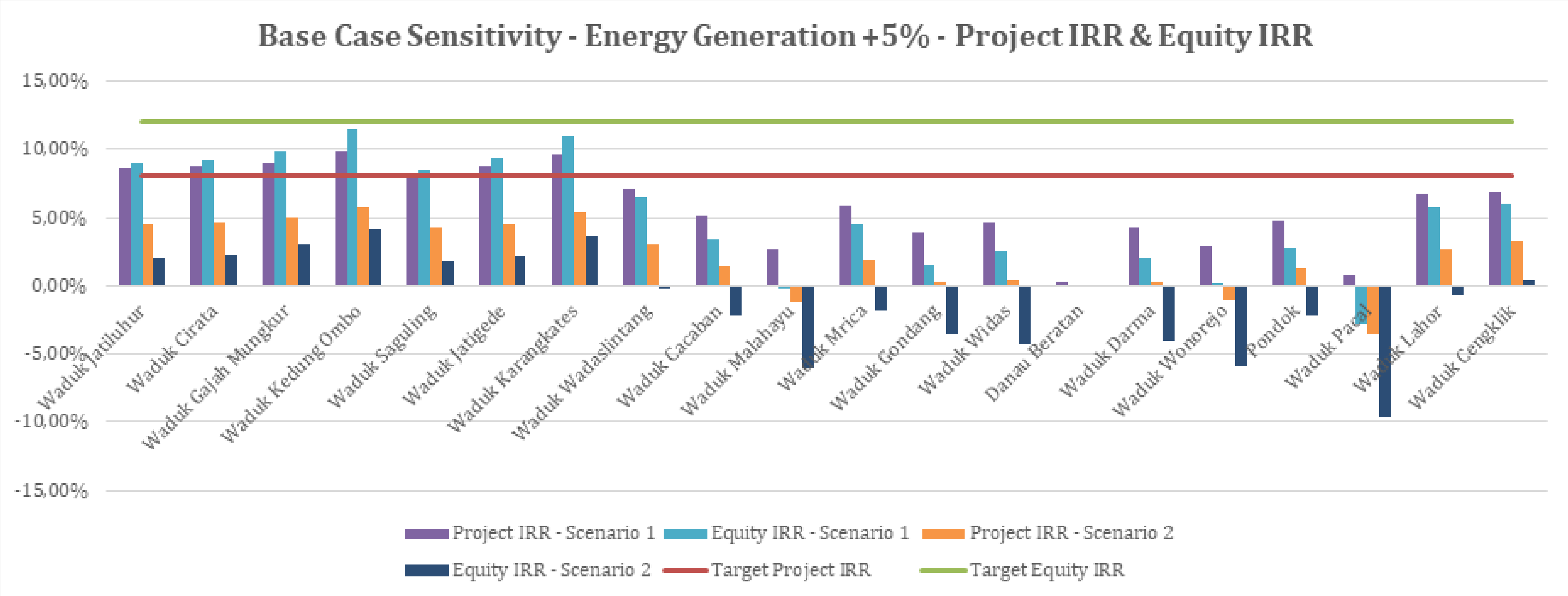


Figure 24 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis – Energy generation (+5% / 105%)

As seen from Table 30 above, by increasing energy generation by 5.00%, resulted in a slightly higher IRR compared to the base case assumptions. By increasing energy generation by 5.00%, one site achieved both Project IRR and Equity IRR target. Waduk Kedung Ombo, achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. Additionally, while the IRR is increased by changing the energy generation assumptions, none of the sites are feasible for scenario 2. This analysis shows that changing the energy generation parameter will increase the overall Project IRR and Equity IRR but still not enough to change affect the financial feasibility of each site.

The sensitivity analysis results of 20 sites using 95% of base annual energy generation is shown in Table 31 as follows:

Table 31 Project IRR and Equity IRR results for all sites – sensitivity analysis 1 – Energy generation (-5% / 95%)

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	6.83%	5.98%	2.64%	-0.86%
2	**Waduk Cirata**	1146	8.00%	12.00%	6.96%	6.18%	2.75%	-0.70%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	7.32%	6.82%	3.34%	0.38%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	8.07%	8.13%	3.98%	1.32%
5	**Waduk Saguling**	310	8.00%	12.00%	6.56%	5.52%	2.42%	-1.14%
6	**Waduk Jatigede**	662	8.00%	12.00%	6.96%	6.19%	2.70%	-0.84%
7	**Waduk Karangkates**	257	8.00%	12.00%	7.79%	7.63%	3.65%	0.77%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	5.47%	3.72%	1.11%	-3.38%
9	**Waduk Cacaban**	129	8.00%	12.00%	3.64%	1.10%	-0.30%	-4.85%
10	**Waduk Malahayu**	108	8.00%	12.00%	1.17%	-2.41%	-3.36%	-9.74%
11	**Waduk Mrica**	97	8.00%	12.00%	4.26%	1.87%	-0.09%	-5.19%
12	**Waduk Gondang**	68	8.00%	12.00%	2.44%	-0.54%	-1.47%	-6.24%
13	**Waduk Widas**	88	8.00%	12.00%	3.00%	-0.09%	-1.92%	-9.38%
14	**Danau Beratan**	75	8.00%	12.00%	-	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	2.69%	-0.40%	-1.81%	-7.80%
16	**Waduk Wonorejo**	72	8.00%	12.00%	1.38%	-2.19%	-3.27%	-9.96%
17	**Waduk Pondok**	66	8.00%	12.00%	3.32%	0.75%	-0.31%	-4.46%
19	**Waduk Pacal**	54	8.00%	12.00%	-0.84%	-5.19%	-6.61%	0.00%
20	**Waduk Lahor**	53	8.00%	12.00%	5.04%	3.06%	0.71%	-3.97%
21	**Waduk Cengklik**	51	8.00%	12.00%	5.31%	3.60%	1.60%	-1.99%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above, is depicted in Figure 25 below.

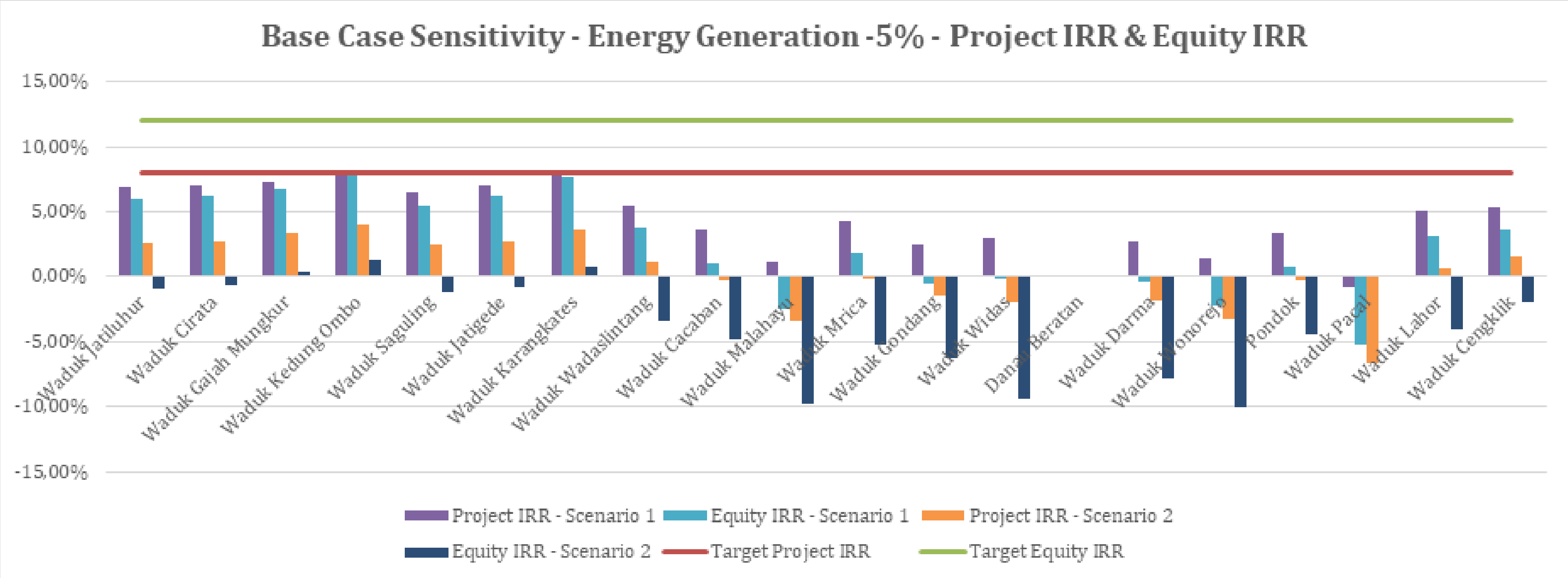


Figure 25 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis 1– energy generation (-5% / 95%)

Decreasing energy generation by 5.00% resulted in a slightly lower IRR compared to the base case assumptions, as detailed in Table 27. By decreasing energy generation by 5.00%, none of the sites from either scenario achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This also decreased the number of sites with feasible Project IRR in scenario 1 from 3 sites to only 1 sites. This analysis shows that changing the energy generation parameter will generally reduce the overall Project and Equity IRR and can affect the financial feasibility of each site..

Fixed OPEX sensitivity analysis 2

The results of the sensitivity analysis of 20 sites using OPEX detailed in the sensitivity analysis 2 in Table 29 are shown in Table 32 as follows:

Table 32 Project IRR and Equity IRR results for all sites – sensitivity analysis 2 – Fixed OPEX

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	9.95%	11.47%	6.67%	5.86%
2	**Waduk Cirata**	1146	8.00%	12.00%	10.06%	11.69%	6.76%	5.99%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	10.20%	11.96%	6.92%	6.25%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	11.01%	13.55%	7.56%	7.28%
5	**Waduk Saguling**	310	8.00%	12.00%	9.59%	10.82%	6.38%	5.41%
6	**Waduk Jatigede**	662	8.00%	12.00%	10.07%	11.71%	6.74%	5.95%
7	**Waduk Karangkates**	257	8.00%	12.00%	10.75%	13.05%	7.33%	6.90%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	8.71%	9.23%	5.64%	4.29%
9	**Waduk Cacaban**	129	8.00%	12.00%	6.55%	5.70%	3.89%	1.87%
10	**Waduk Malahayu**	108	8.00%	12.00%	4.25%	2.35%	1.65%	-1.12%
11	**Waduk Mrica**	97	8.00%	12.00%	7.43%	7.07%	4.55%	2.73%
12	**Waduk Gondang**	68	8.00%	12.00%	5.21%	3.72%	2.70%	0.30%
13	**Waduk Widas**	88	8.00%	12.00%	6.04%	4.86%	3.06%	0.56%
14	**Danau Beratan**	75	8.00%	12.00%	3.89%	1.42%	-0.13%	-4.73%
15	**Waduk Darma**	76	8.00%	12.00%	5.85%	4.62%	3.15%	0.83%
16	**Waduk Wonorejo**	72	8.00%	12.00%	4.54%	2.75%	1.92%	-0.77%
17	**Waduk Pondok**	66	8.00%	12.00%	5.92%	4.76%	3.40%	1.24%
19	**Waduk Pacal**	54	8.00%	12.00%	2.51%	-0.02%	-0.28%	-3.59%
20	**Waduk Lahor**	53	8.00%	12.00%	8.01%	8.03%	4.94%	3.26%
21	**Waduk Cengklik**	51	8.00%	12.00%	7.98%	7.97%	5.11%	3.56%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above are depicted in Figure 26 below.

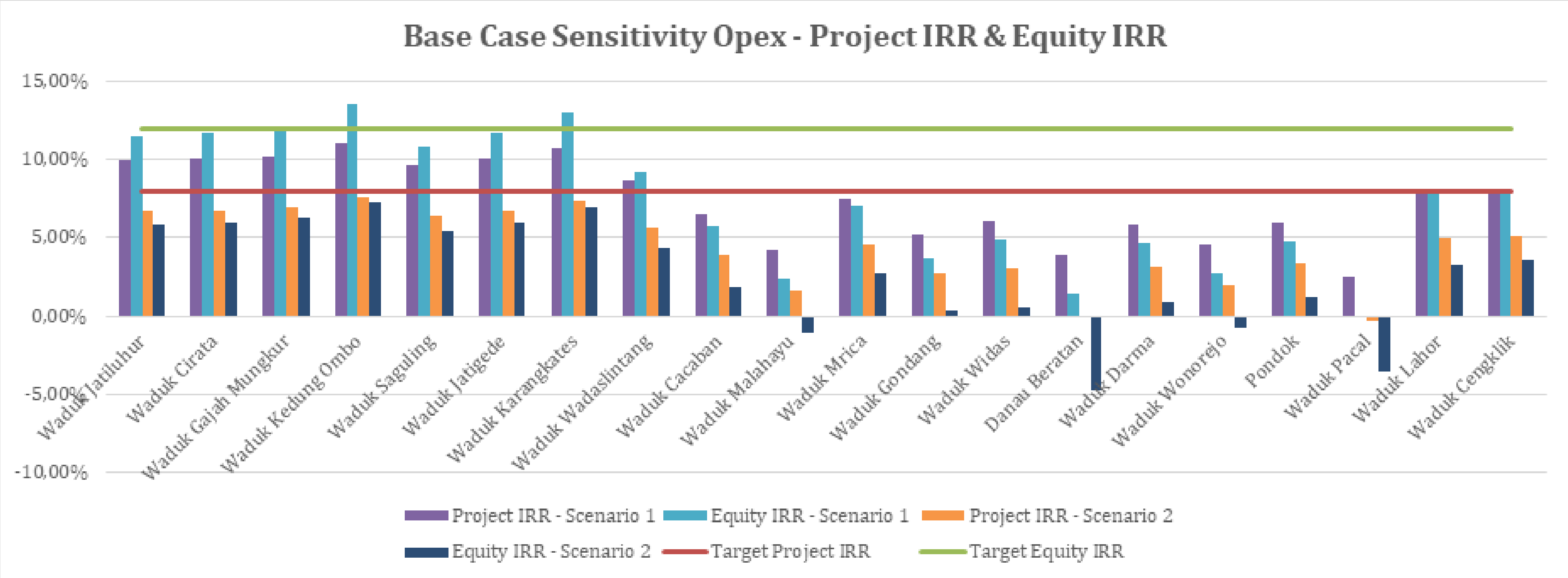


Figure 26 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis 2 – Fixed OPEX

As seen in the figure above, changing fixed OPEX assumptions resulted in higher IRR compared to the base case assumptions as detailed in Table 23. By changing fixed OPEX assumptions, 2 sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This shows improvement from the base case assumptions, where none of the sites are feasible. However, none of sites are feasible for scenario 2. This analysis shows that changing the fixed OPEX assumptions will change the overall Project and Equity IRR and can affect the financial feasibility of each site.

Main power plant CAPEX and OPEX sensitivity analysis 3

The results of the sensitivity analysis of 20 sites using main power plant CAPEX and OPEX assumptions from Table 29 is shown in Table 33 as follows:

Table 33 Project IRR and Equity results for all sites - sensitivity analysis 3 - Main power plant CAPEX and OPEX

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	9.24%	10.30%	5.12%	3.14%
2	**Waduk Cirata**	1146	8.00%	12.00%	9.38%	10.56%	5.23%	3.31%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	9.63%	11.02%	5.62%	3.99%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	10.54%	12.85%	6.36%	5.18%
5	**Waduk Saguling**	310	8.00%	12.00%	8.87%	9.58%	4.82%	2.68%
6	**Waduk Jatigede**	662	8.00%	12.00%	9.39%	10.59%	5.20%	3.23%
7	**Waduk Karangkates**	257	8.00%	12.00%	10.24%	12.26%	6.06%	4.67%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	7.81%	7.67%	3.73%	0.93%
9	**Waduk Cacaban**	129	8.00%	12.00%	5.53%	3.97%	1.92%	-1.45%
10	**Waduk Malahayu**	108	8.00%	12.00%	2.89%	0.10%	-0.92%	-5.47%
11	**Waduk Mrica**	97	8.00%	12.00%	6.46%	5.38%	2.50%	-0.89%
12	**Waduk Gondang**	68	8.00%	12.00%	4.13%	1.93%	0.65%	-3.09%
13	**Waduk Widas**	88	8.00%	12.00%	4.96%	2.96%	0.75%	-3.75%
14	**Danau Beratan**	75	8.00%	12.00%	0.87%	-8.11%	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	4.66%	2.59%	0.78%	-3.32%
16	**Waduk Wonorejo**	72	8.00%	12.00%	3.21%	0.51%	-0.68%	-5.82%
17	**Waduk Pondok**	66	8.00%	12.00%	5.00%	3.22%	1.65%	-1.63%
19	**Waduk Pacal**	54	8.00%	12.00%	0.91%	-2.65%	-3.38%	-9.18%
20	**Waduk Lahor**	53	8.00%	12.00%	7.23%	6.66%	3.19%	0.10%
21	**Waduk Cengklik**	51	8.00%	12.00%	7.28%	6.77%	3.67%	1.12%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site, as shown above, are depicted in Figure 27 below.

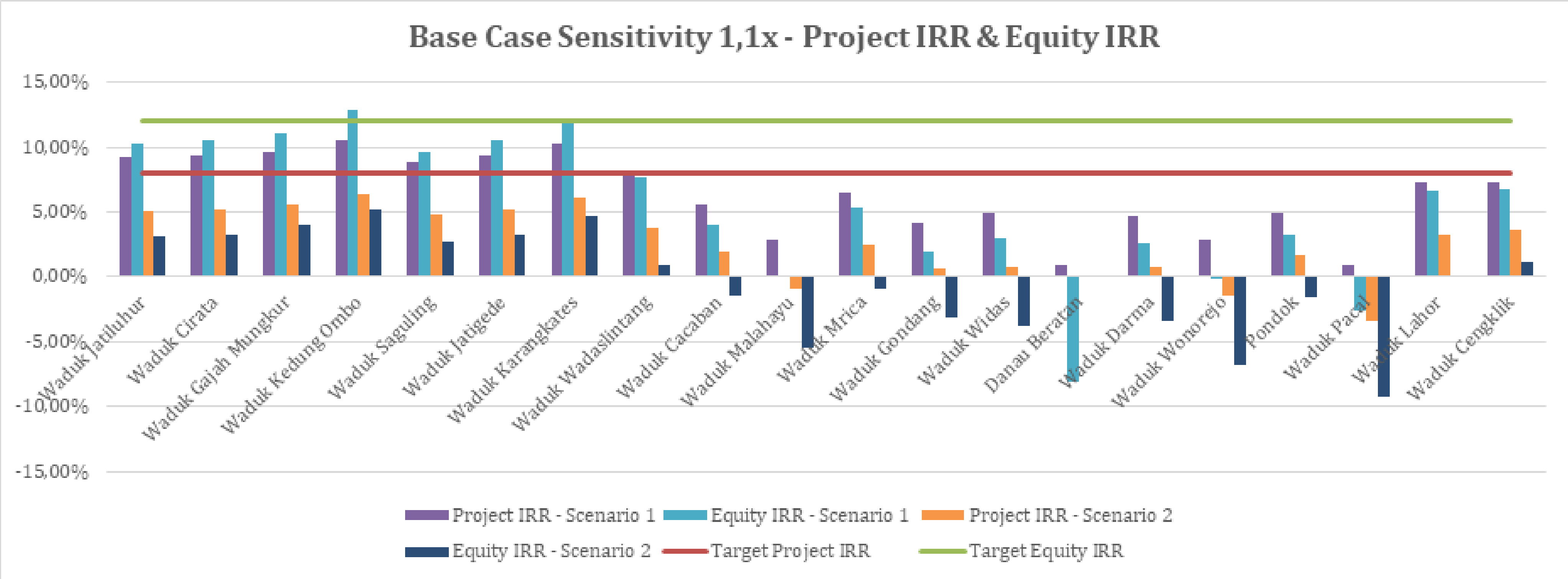


Figure 27 Project IRR and Equity IRR of Each Site for Each Scenario – sensitivity analysis 3 – Main power plant CAPEX and OPEX

As seen from Table 33. above, changing main power plant CAPEX and OPEX assumptions resulted in higher IRR than the base case assumptions. By changing main power plant CAPEX and OPEX assumptions, two sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%, namely Waduk Kedung Ombo and Waduk Karangkate. This shows improvement from the base case assumptions where none of the sites are feasible. However, none of the sites are feasible for scenario 2. This analysis shows that changing the main power plant CAPEX and OPEX assumptions will change the overall Project and Equity IRR and can affect the financial feasibility of each site.

Best Case Scenario

Since most analyses still have not yielded good financial feasibility for all 20 sites, additional analysis has been done to determine the best-case scenario. The assumptions for this scenario can be seen in Table 34 below.

Table 34 Assumptions for Best Case Scenario

Assumptions	Base Scenario	Best Case Scenario
Energy generation	100 % Annual Energy Generation	+5% Annual Energy Generation
Fixed OPEX	USD 12.36 per kW per year (10.30 USD per kW per year based on International Renewable Energy Agency (IRENA), 2024, multiplied by 1.2)	4.80* USD per kW per year
Main power plant CAPEX and OPEX	Ground Mounted CAPEX multiplied by 1.2.	Ground Mounted CAPEX multiplied by 1.1.

Notes: *Assumption is based on lowest O&M Cost from IRENA Study multiplied by 1.2

The results of the sensitivity analysis of 20 sites for best case scenario are shown in Table 35 as follows:

Table 35 Project IRR and Equity IRR results for all sites – Best case scenario

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	11.99%	15.61%	8.35%	8.59%
2	**Waduk Cirata**	1146	8.00%	12.00%	12.12%	15.90%	8.44%	8.76%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	12.20%	16.06%	8.56%	8.95%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	13.18%	18.25%	9.33%	10.34%
5	**Waduk Saguling**	310	8.00%	12.00%	11.54%	14.65%	7.97%	7.96%
6	**Waduk Jatigede**	662	8.00%	12.00%	12.13%	15.94%	8.42%	8.73%
7	**Waduk Karangkates**	257	8.00%	12.00%	12.90%	17.63%	9.08%	9.90%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	10.61%	12.76%	7.20%	6.68%
9	**Waduk Cacaban**	129	8.00%	12.00%	7.97%	7.96%	5.09%	3.53%
10	**Waduk Malahayu**	108	8.00%	12.00%	5.33%	3.87%	2.69%	0.22%
11	**Waduk Mrica**	97	8.00%	12.00%	9.14%	9.99%	5.97%	4.78%
12	**Waduk Gondang**	68	8.00%	12.00%	6.40%	5.47%	3.76%	1.69%
13	**Waduk Widas**	88	8.00%	12.00%	7.44%	7.07%	4.30%	2.28%
14	**Danau Beratan**	75	8.00%	12.00%	5.56%	3.94%	1.61%	-2.19%

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
15	**Waduk Darma**	76	8.00%	12.00%	7.24%	6.76%	4.36%	2.47%
16	**Waduk Wonorejo**	72	8.00%	12.00%	5.72%	4.43%	3.04%	0.67%
17	**Pondok**	66	8.00%	12.00%	7.19%	6.69%	4.48%	2.69%
19	**Waduk Pacal**	54	8.00%	12.00%	3.48%	1.26%	0.73%	-2.35%
20	**Waduk Lahor**	53	8.00%	12.00%	9.78%	11.18%	6.42%	5.44%
21	**Waduk Cengklik**	51	8.00%	12.00%	10.21%	11.96%	6.94%	6.29%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above are depicted in Figure 28 below.

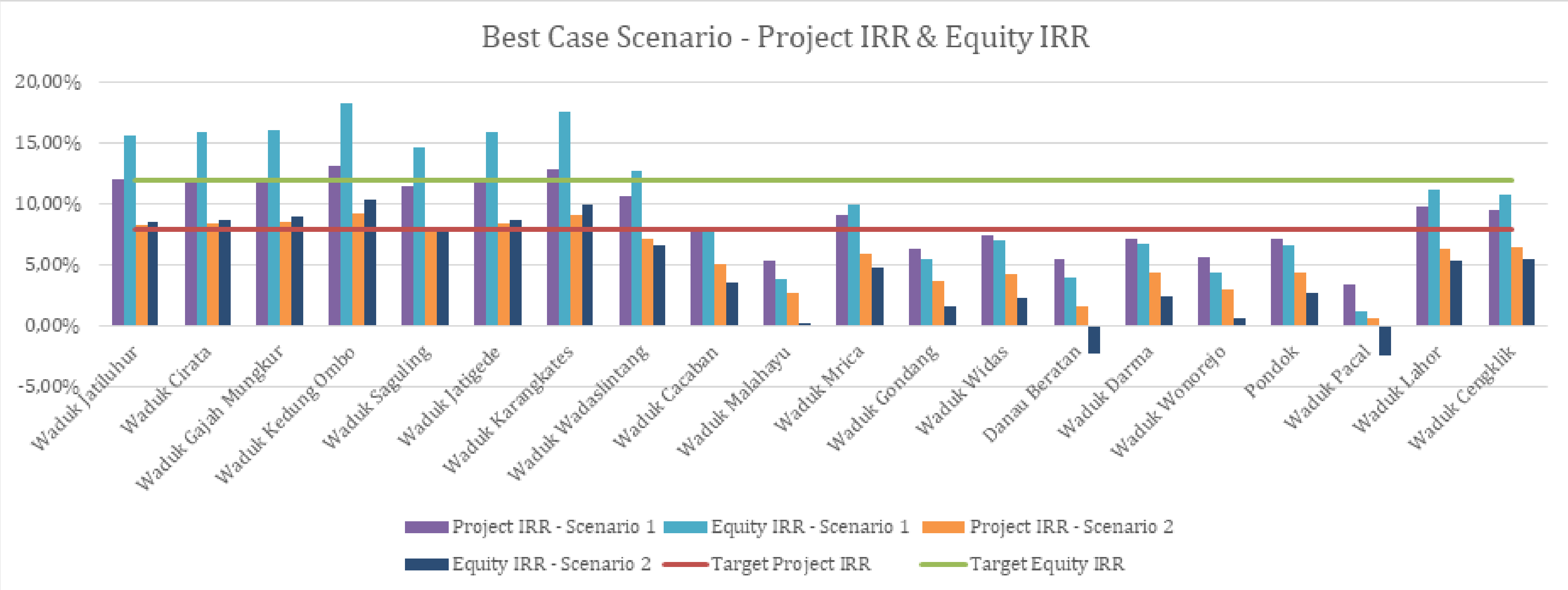


Figure 28 Project IRR and Equity IRR of each site for each scenario – Best case scenario

Total feasible sites are depicted in Figure 29 below.

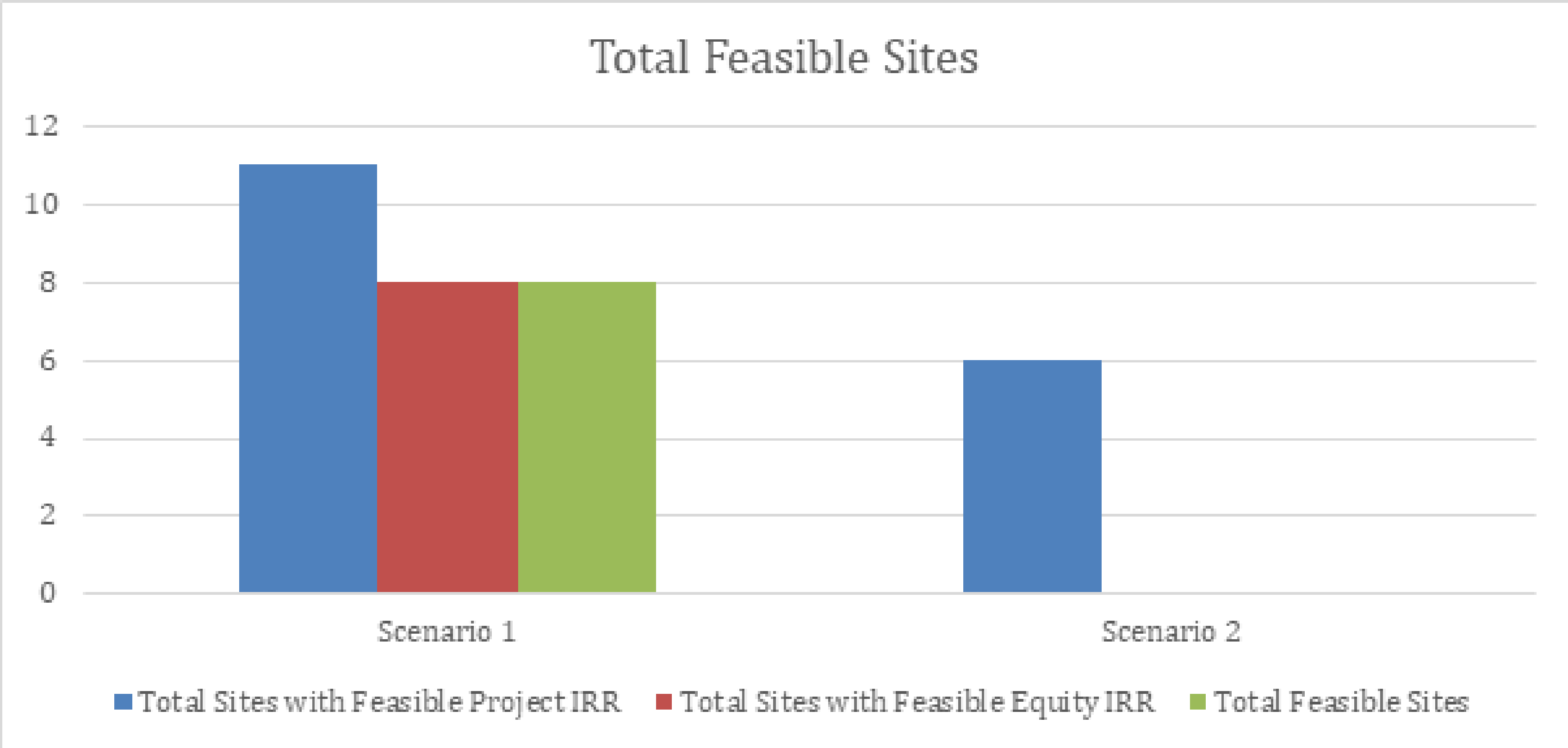


Figure 29 Total feasible sites – Best case scenario

As seen from Table 35 above, by changing the assumptions stated in Table 34, resulting in much higher IRR compared to the base case assumptions as detailed in Table 24. By changing all the assumptions, eight sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This shows great improvement from the base scenario, where none of the sites were feasible. However, none of the sites are feasible for scenario 2.

Project & Equity IRR range

Figure 30 and Figure 31 below shows the project IRR and Equity IRR for the Base Scenario, Best Case Scenario, and Worst Case Scenario (Base Case Scenario with 95% Energy Generation) with the evacuation line.

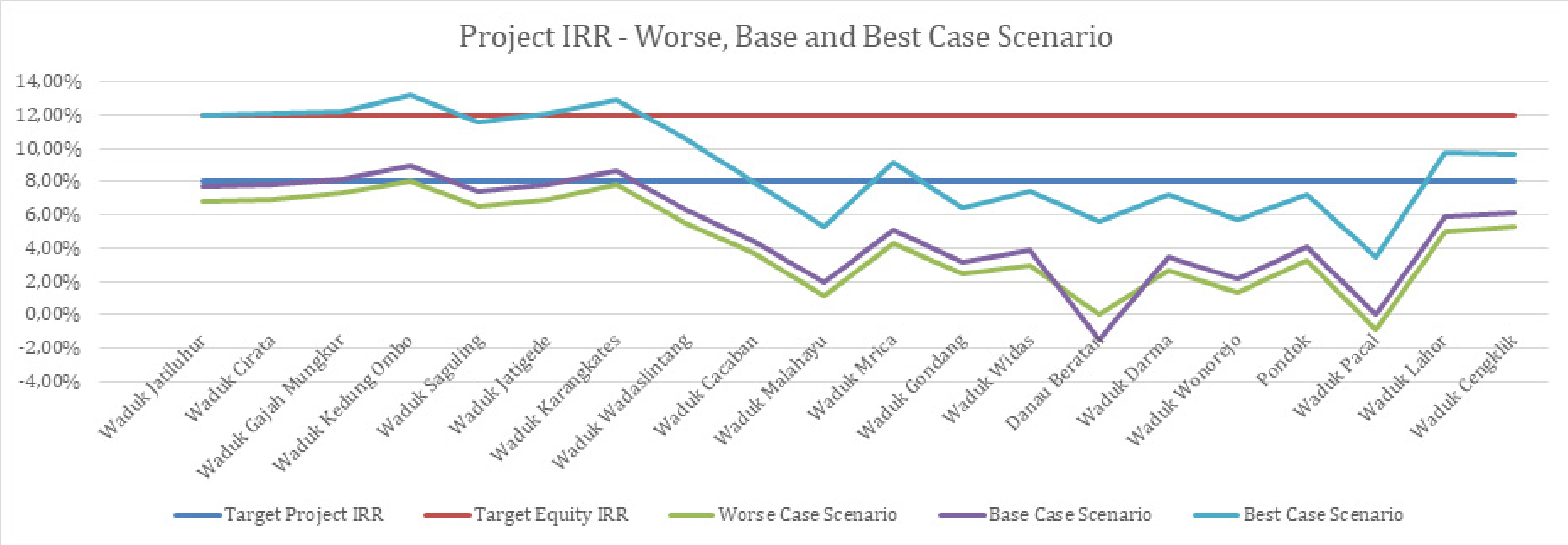


Figure 30 Project IRR Range for all configurations

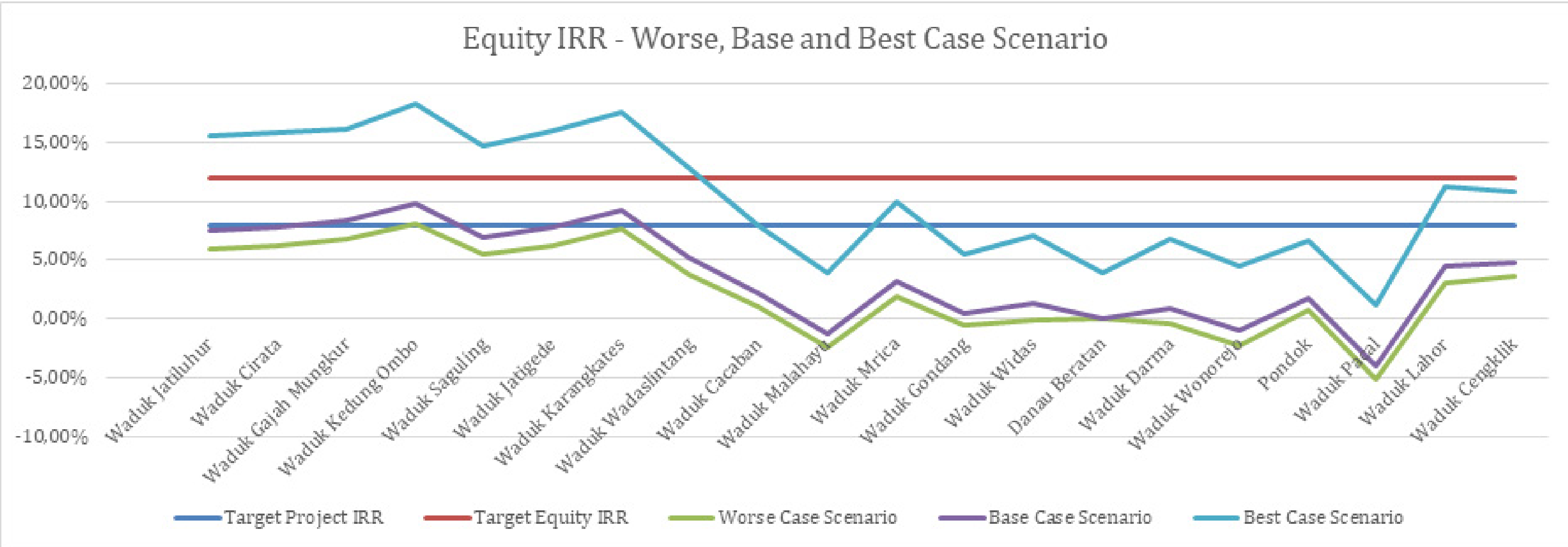


Figure 31 Equity IRR range for all configurations

As seen from Figure 30 and Figure 31 above, there are several sites that demonstrate strong financial potential. While some of these locations may not appear viable under the base case scenario, minor adjustments to key assumptions can render them financially feasible. The sites identified with promising financial feasibility include: Waduk Jatiluhur, Waduk Cirata, Waduk Gajah Mungkur, Waduk Kedung Ombo, Waduk Saguling, Waduk Jatigede, Waduk Karangkates, Waduk Wadaslintang, Waduk Lahor, and Waduk Cengklik. These locations will be prioritized for further analysis.

4.5.4.2. Sensitivity analysis excluding evacuation line

Energy generation sensitivity analysis 1

The sensitivity analysis results of 20 sites using 105% of base annual energy generation and excluding the evacuation line are shown in Table 36 as follows

Table 36 Project IRR and Equity IRR results for all sites – sensitivity analysis 1 – energy generation (+5%) excluding evacuation line

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	8.63%	9.15%	4.51%	2.15%
2	**Waduk Cirata**	1146	8.00%	12.00%	8.77%	9.42%	4.63%	2.33%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	9.75%	11.27%	5.63%	3.99%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	9.91%	11.59%	5.77%	4.20%
5	**Waduk Saguling**	310	8.00%	12.00%	8.93%	9.71%	4.78%	2.57%
6	**Waduk Jatigede**	662	8.00%	12.00%	8.87%	9.60%	4.67%	2.36%
7	**Waduk Karangkates**	257	8.00%	12.00%	9.63%	11.05%	5.48%	3.71%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	7.25%	6.69%	3.13%	-0.04%
9	**Waduk Cacaban**	129	8.00%	12.00%	7.54%	7.21%	3.57%	0.74%
10	**Waduk Malahayu**	108	8.00%	12.00%	7.51%	7.14%	3.19%	-0.10%
11	**Waduk Mrica**	97	8.00%	12.00%	6.37%	5.21%	2.29%	-1.29%
12	**Waduk Gondang**	68	8.00%	12.00%	7.62%	7.34%	3.65%	0.87%
13	**Waduk Widas**	88	8.00%	12.00%	8.09%	8.17%	3.47%	0.09%
14	**Danau Beratan**	75	8.00%	12.00%	1.07%	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	6.43%	5.31%	2.24%	-1.47%
16	**Waduk Wonorejo**	72	8.00%	12.00%	6.41%	5.27%	2.17%	-1.63%
17	**Waduk Pondok**	66	8.00%	12.00%	8.33%	8.58%	4.44%	2.15%

19	**Waduk Pacal**	54	8.00%	12.00%	7.11%	6.42%	2.47%	-1.60%
20	**Waduk Lahor**	53	8.00%	12.00%	7.61%	7.32%	3.43%	0.38%
21	**Waduk Cengklik**	51	8.00%	12.00%	8.56%	9.01%	4.67%	2.52%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site are depicted in the Figure 32 below.

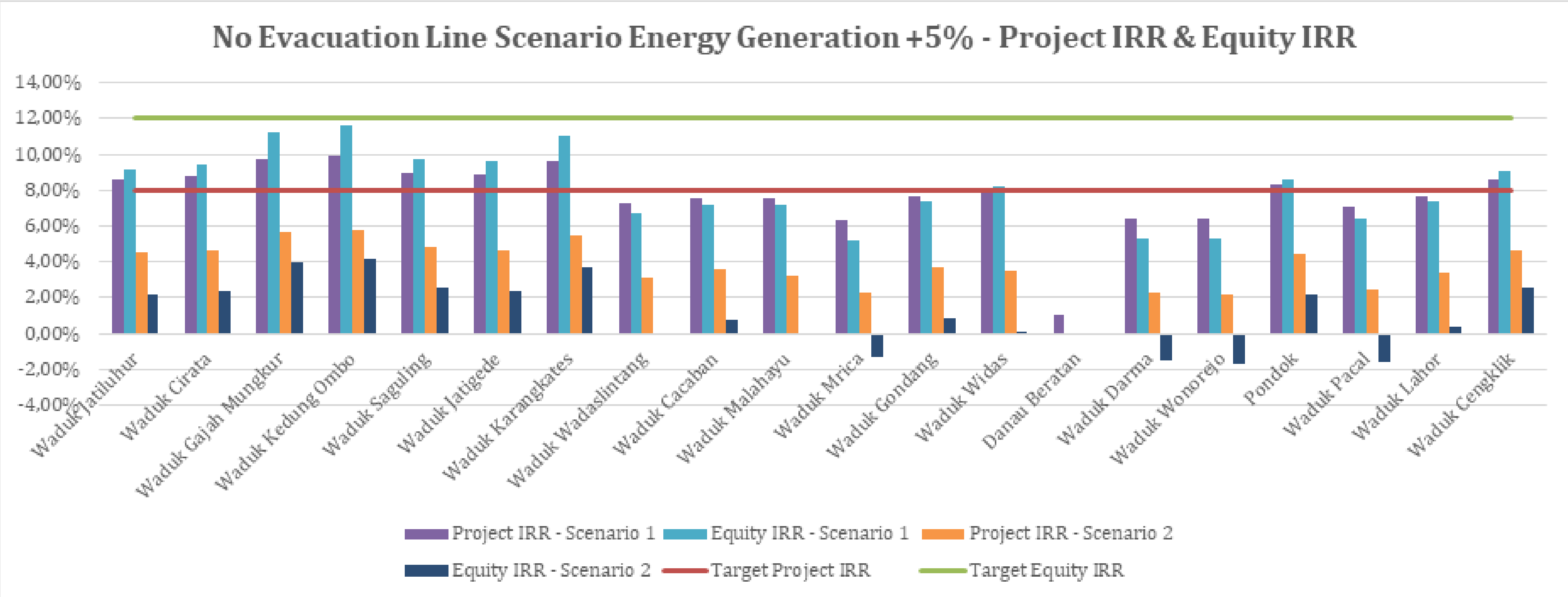


Figure 32 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis 1 – Energy Generation (+5%) excluding evacuation line

As seen from the Table 36 above, increasing energy generation by 5.00%, resulted in slightly higher IRR compared to the base case assumptions as detailed in Table 27. Both in scenario 1 and 2, no site has achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00% by increasing energy generation by 5.00%, however changing the assumptions also increase the number of sites with feasible Project IRR in scenario 1 from no evacuation line scenario from 5 sites to 10 sites. This analysis shows that changing the energy generation parameter will increase the overall Project and Equity IRR and can affect the financial feasibility of each site.

The results of the sensitivity analysis of 20 sites using 95% of the base annual energy generation and without an evacuation line are shown in Table 37 as follows:

Table 37 Project IRR and Equity IRR results for all sites – sensitivity analysis 1– energy generation (-5% / 95%) excluding evacuation line

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	6.89%	6.06%	2.69%	-0.79%
2	**Waduk Cirata**	1146	8.00%	12.00%	7.02%	6.29%	2.81%	-0.62%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	7.98%	7.97%	3.90%	1.20%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	8.13%	8.24%	4.03%	1.40%
5	**Waduk Saguling**	310	8.00%	12.00%	7.17%	6.54%	2.96%	-0.38%
6	**Waduk Jatigede**	662	8.00%	12.00%	7.09%	6.40%	2.81%	-0.68%
7	**Waduk Karangkates**	257	8.00%	12.00%	7.85%	7.74%	3.71%	0.85%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	5.54%	3.84%	1.19%	-3.27%
9	**Waduk Cacaban**	129	8.00%	12.00%	5.88%	4.42%	1.76%	-2.14%
10	**Waduk Malahayu**	108	8.00%	12.00%	5.73%	4.10%	1.11%	-3.77%
11	**Waduk Mrica**	97	8.00%	12.00%	4.70%	2.52%	0.31%	-4.64%
12	**Waduk Gondang**	68	8.00%	12.00%	5.95%	4.54%	1.85%	-1.99%
13	**Waduk Widas**	88	8.00%	12.00%	6.19%	4.80%	1.17%	-4.44%
14	**Danau Beratan**	75	8.00%	12.00%	-	-	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	4.73%	2.53%	0.17%	-5.13%
16	**Waduk Wonorejo**	72	8.00%	12.00%	4.69%	2.45%	0.05%	-5.48%
17	**Waduk Pondok**	66	8.00%	12.00%	6.67%	5.73%	2.75%	-0.46%
19	**Waduk Pacal**	54	8.00%	12.00%	5.24%	3.20%	0.03%	-7.27%
20	**Waduk Lahor**	53	8.00%	12.00%	5.88%	4.36%	1.47%	-2.91%
21	**Waduk Cengklik**	51	8.00%	12.00%	6.90%	6.12%	3.00%	-0.07%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

The Figure 33 below depicts each site's Project IRR and Equity IRR, as shown in Table 37 above.

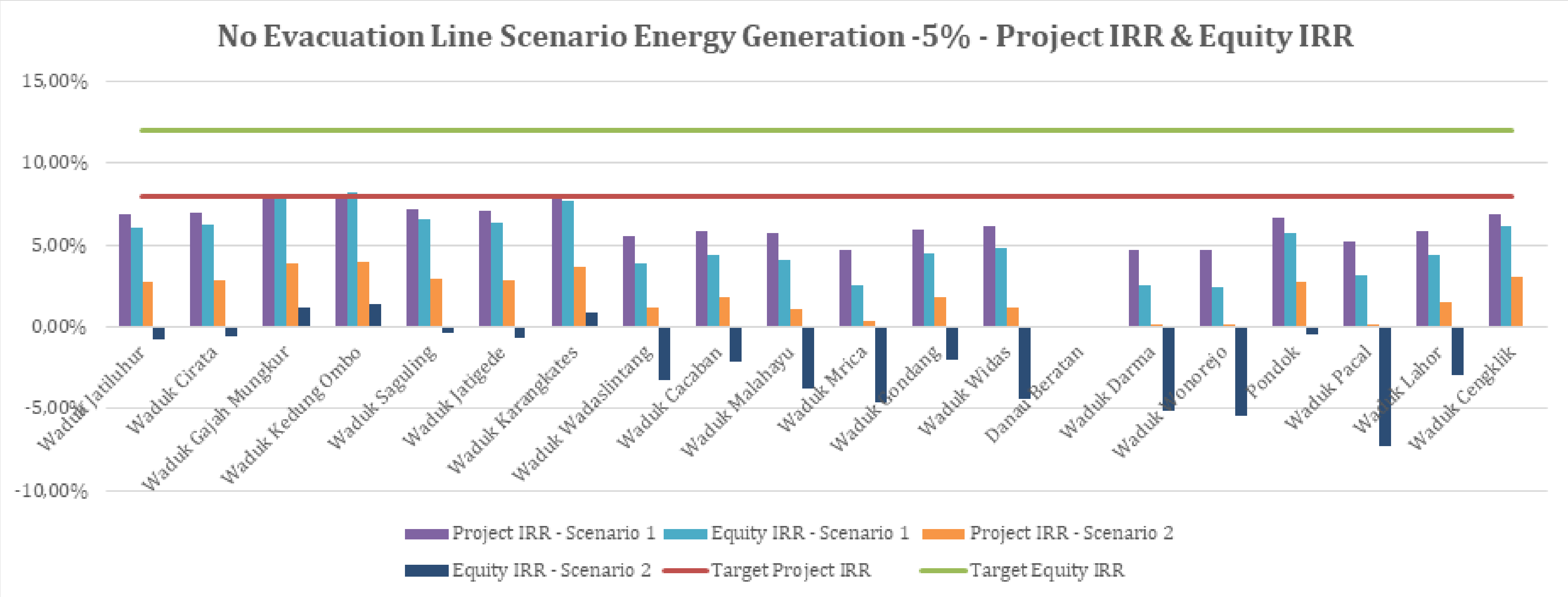


Figure 33 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis 1– energy generation (-5%/ 95%) excluding evacuation line

Decreasing energy generation by 5.00% resulted in slightly lower IRR compared to the base case assumptions as detailed in Table 27. By decreasing energy generation by 5.00%, none of the sites from either scenario achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This also resulted in a decrease in the number of sites with feasible Project IRR from 5 sites to 1 site in Scenario 1. This analysis shows that changing the energy generation parameter will increase the overall Project and Equity IRR and can affect the financial feasibility of each site.

Fixed OPEX sensitivity analysis 2

The results of the sensitivity analysis of 20 sites using OPEX detailed in the sensitivity analysis 2 in Table 29 are shown in Table 38 as follows:

Table 38 Project IRR and Equity IRR results for all sites – sensitivity analysis 2 – Fixed OPEX excluding evacuation line

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	10.00%	11.58%	6.72%	5.93%
2	**Waduk Cirata**	1146	8.00%	12.00%	10.13%	11.82%	6.81%	6.08%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	10.93%	13.39%	7.51%	7.19%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	11.07%	13.68%	7.61%	7.36%
5	**Waduk Saguling**	310	8.00%	12.00%	10.26%	12.08%	6.92%	6.25%
6	**Waduk Jatigede**	662	8.00%	12.00%	10.21%	11.99%	6.85%	6.13%
7	**Waduk Karangkates**	257	8.00%	12.00%	10.83%	13.19%	7.39%	7.00%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	8.80%	9.38%	5.71%	4.40%
9	**Waduk Cacaban**	129	8.00%	12.00%	8.93%	9.61%	5.84%	4.61%
10	**Waduk Malahayu**	108	8.00%	12.00%	8.92%	9.60%	5.66%	4.28%
11	**Waduk Mrica**	97	8.00%	12.00%	7.90%	7.83%	4.93%	3.26%
12	**Waduk Gondang**	68	8.00%	12.00%	8.90%	9.56%	5.78%	4.51%
13	**Waduk Widas**	88	8.00%	12.00%	9.35%	10.42%	5.82%	4.46%
14	**Danau Beratan**	75	8.00%	12.00%	4.50%	2.31%	0.44%	-3.99%
15	**Waduk Darma**	76	8.00%	12.00%	7.96%	7.93%	4.92%	3.23%
16	**Waduk Wonorejo**	72	8.00%	12.00%	7.90%	7.84%	4.83%	3.09%
17	**Waduk Pondok**	66	8.00%	12.00%	9.50%	10.64%	6.34%	5.36%
19	**Waduk Pacal**	54	8.00%	12.00%	8.50%	8.87%	5.10%	3.39%
20	**Waduk Lahor**	53	8.00%	12.00%	8.90%	9.57%	5.67%	4.30%
21	**Waduk Cengklik**	51	8.00%	12.00%	10.13%	11.81%	6.86%	6.15%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site, as shown above are depicted in Figure 34 below.

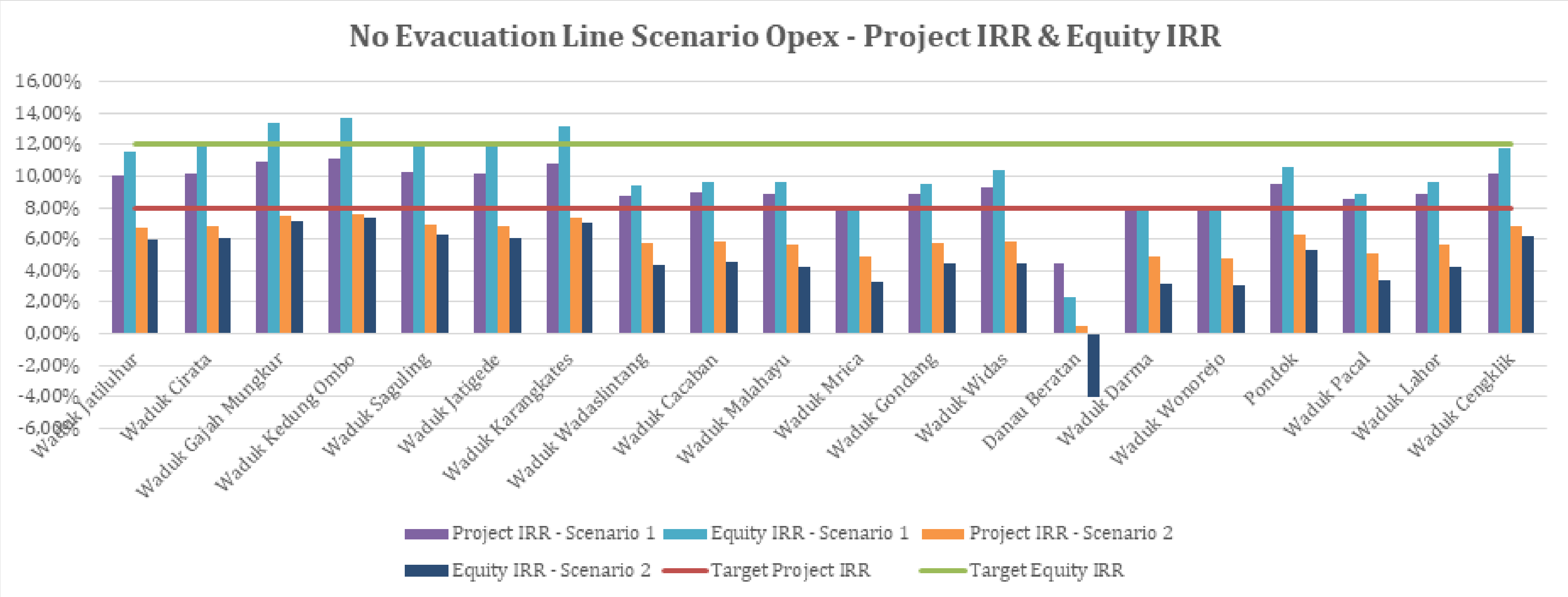


Figure 34 Project IRR and Equity IRR of each site for each scenario – sensitivity analysis 2– Fixed OPEX excluding evacuation line

As seen from the table above, changing fixed OPEX assumptions resulted in higher IRR compared to the base case assumptions as detailed in Table 27. By changing fixed OPEX assumptions, 4 sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This shows major improvement from the base case assumptions, where none of the sites were feasible. However, none of the sites are feasible for scenario 2. This analysis shows that changing the fixed OPEX assumptions will significantly change the overall Project and Equity IRR and can affect the financial feasibility of each site.

Main power plant CAPEX and OPEX sensitivity analysis 3

The sensitivity analysis results of 20 sites using main power plant CAPEX and OPEX assumptions from Table 29 without an evacuation line is shown in Table 39 as follows:

Table 39 Project IRR and Equity IRR Results for all sites – sensitivity analysis 3 – Main power plant CAPEX and OPEX excluding evacuation line

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	9.31%	10.42%	5.17%	3.22%
2	**Waduk Cirata**	1146	8.00%	12.00%	9.46%	10.71%	5.29%	3.41%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	10.44%	12.66%	6.28%	5.05%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	10.61%	13.00%	6.42%	5.27%
5	**Waduk Saguling**	310	8.00%	12.00%	9.61%	11.02%	5.44%	3.64%
6	**Waduk Jatigede**	662	8.00%	12.00%	9.55%	10.90%	5.33%	3.44%
7	**Waduk Karangkates**	257	8.00%	12.00%	10.32%	12.43%	6.12%	4.77%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	7.91%	7.84%	3.81%	1.05%
9	**Waduk Cacaban**	129	8.00%	12.00%	8.19%	8.34%	4.21%	1.76%
10	**Waduk Malahayu**	108	8.00%	12.00%	8.15%	8.27%	3.84%	0.95%
11	**Waduk Mrica**	97	8.00%	12.00%	6.99%	6.25%	2.95%	-0.24%
12	**Waduk Gondang**	68	8.00%	12.00%	8.25%	8.45%	4.27%	1.84%
13	**Waduk Widas**	88	8.00%	12.00%	8.71%	9.33%	4.07%	1.09%
14	**Danau Beratan**	75	8.00%	12.00%	1.69%	-5.51%	-	0.00%
15	**Waduk Darma**	76	8.00%	12.00%	7.05%	6.35%	2.90%	-0.41%
16	**Waduk Wonorejo**	72	8.00%	12.00%	7.02%	6.29%	2.82%	-0.59%
17	**Waduk Pondok**	66	8.00%	12.00%	8.97%	9.76%	5.05%	3.12%
19	**Waduk Pacal**	54	8.00%	12.00%	7.71%	7.48%	3.09%	-0.56%
20	**Waduk Lahor**	53	8.00%	12.00%	8.24%	8.43%	4.04%	1.36%
21	**Waduk Cengklik**	51	8.00%	12.00%	9.21%	10.22%	5.29%	3.49%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site as shown above, are depicted in Figure 35 below.

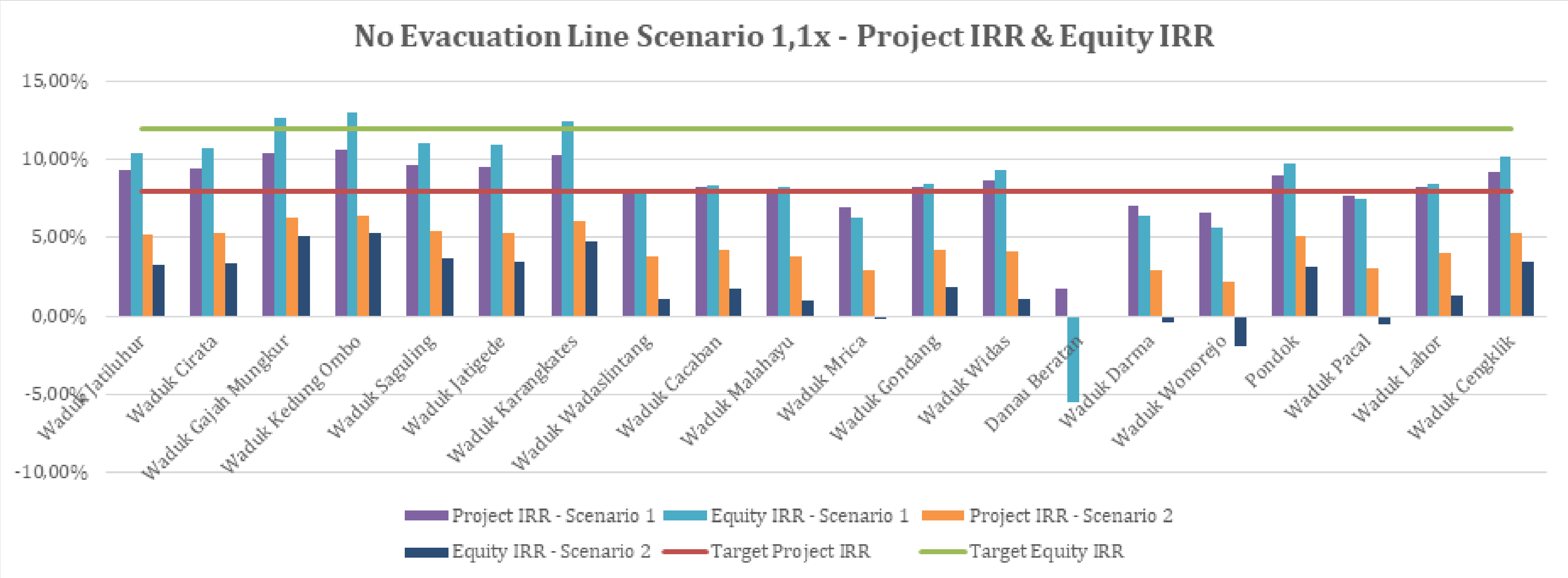


Figure 35 Project IRR and Equity IRR of each site for each Scenario – sensitivity Analysis 3 – Main power plant CAPEX and OPEX excluding evacuation line

As seen from Table 39 above, changing main power plant CAPEX and OPEX assumptions resulted in higher IRR compared to the base case assumptions as detailed in Table 27. By changing the main power plant CAPEX and OPEX assumptions, three sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%. This shows improvement from the base case assumptions, where none of the sites were feasible. However, none of the sites are feasible for scenario 2. This analysis shows that changing the main power plant CAPEX and OPEX assumptions will change the overall Project and Equity IRR and can affect the financial feasibility of each site.

Best case scenario

Since most analyses still have not yielded good financial feasibility for all 20 sites, even without the evacuation line CAPEX, additional analyses have been done to determine the best-case scenario.

The assumptions for the best-case scenario are similar to those for the configuration with the evacuation line and can be seen in the Table 40 below.

Table 40 Assumptions for Best Case Scenario

Assumptions	Base Scenario	Best Case Scenario
Energy generation	100 % Annual Energy Generation	+5% Annual Energy Generation
Fixed OPEX	USD 12.36 per kW per year (10.30 USD per kW per year based on International Renewable Energy Agency (IRENA), 2024, multiplied by 1.2)	4.80* USD per kW per year
Main power plant CAPEX and OPEX	Ground Mounted CAPEX multiplied by 1.2.	Ground Mounted CAPEX multiplied by 1.1.

Notes: *Assumption is based on lowest O&M Cost from IRENA Study multiplied by 1.2

The sensitivity analysis results of 20 sites for the best-case scenario without an evacuation line are shown in Table 41 as follows:

Table 41 Project IRR and Equity IRR results for all sites – Best case scenario excluding evacuation line

No	Reservoir name	Capacity (MWp)	Target project IRR	Target Equity IRR	Scenario 1		Scenario 2	
					Project IRR	Equity IRR	Project IRR	Equity IRR
1	**Waduk Jatiluhur**	651	8.00%	12.00%	12.06%	15.77%	8.40%	8.69%
2	**Waduk Cirata**	1146	8.00%	12.00%	12.20%	16.08%	8.51%	8.88%
3	**Waduk Gajah Mungkur**	340	8.00%	12.00%	13.09%	18.05%	9.27%	10.23%
4	**Waduk Kedung Ombo**	411	8.00%	12.00%	13.26%	18.43%	9.40%	10.46%
5	**Waduk Saguling**	310	8.00%	12.00%	12.35%	16.41%	8.63%	9.09%
6	**Waduk Jatigede**	662	8.00%	12.00%	12.30%	16.32%	8.56%	8.97%
7	**Waduk Karangkates**	257	8.00%	12.00%	12.99%	17.83%	9.16%	10.03%
8	**Waduk Wadaslintang**	261	8.00%	12.00%	10.71%	12.97%	7.28%	6.82%
9	**Waduk Cacaban**	129	8.00%	12.00%	10.85%	13.24%	7.42%	7.05%
10	**Waduk Malahayu**	108	8.00%	12.00%	10.89%	13.38%	7.29%	6.82%
11	**Waduk Mrica**	97	8.00%	12.00%	9.71%	11.04%	6.43%	5.47%
12	**Waduk Gondang**	68	8.00%	12.00%	10.83%	13.21%	7.37%	6.96%

13	**Waduk Widas**	88	8.00%	12.00%	11.43%	14.58%	7.55%	7.24%
14	**Danau Beratan**	75	8.00%	12.00%	6.29%	5.09%	2.26%	-1.30%
15	**Waduk Darma**	76	8.00%	12.00%	9.79%	11.20%	6.45%	5.49%
16	**Waduk Wonorejo**	72	8.00%	12.00%	9.75%	11.13%	6.37%	5.36%
17	**Waduk Pondok**	66	8.00%	12.00%	11.48%	14.53%	7.97%	7.95%
19	**Waduk Pacal**	54	8.00%	12.00%	10.47%	12.60%	6.77%	5.95%
20	**Waduk Lahor**	53	8.00%	12.00%	10.86%	13.31%	7.29%	6.82%
21	**Waduk Cengklik**	51	8.00%	12.00%	12.20%	16.04%	8.55%	8.94%

Note: Numbers in black indicate that the project is financially feasible, while numbers in red indicate that they are not.

Project IRR and Equity IRR for each site, as shown above, are depicted in Figure 36.

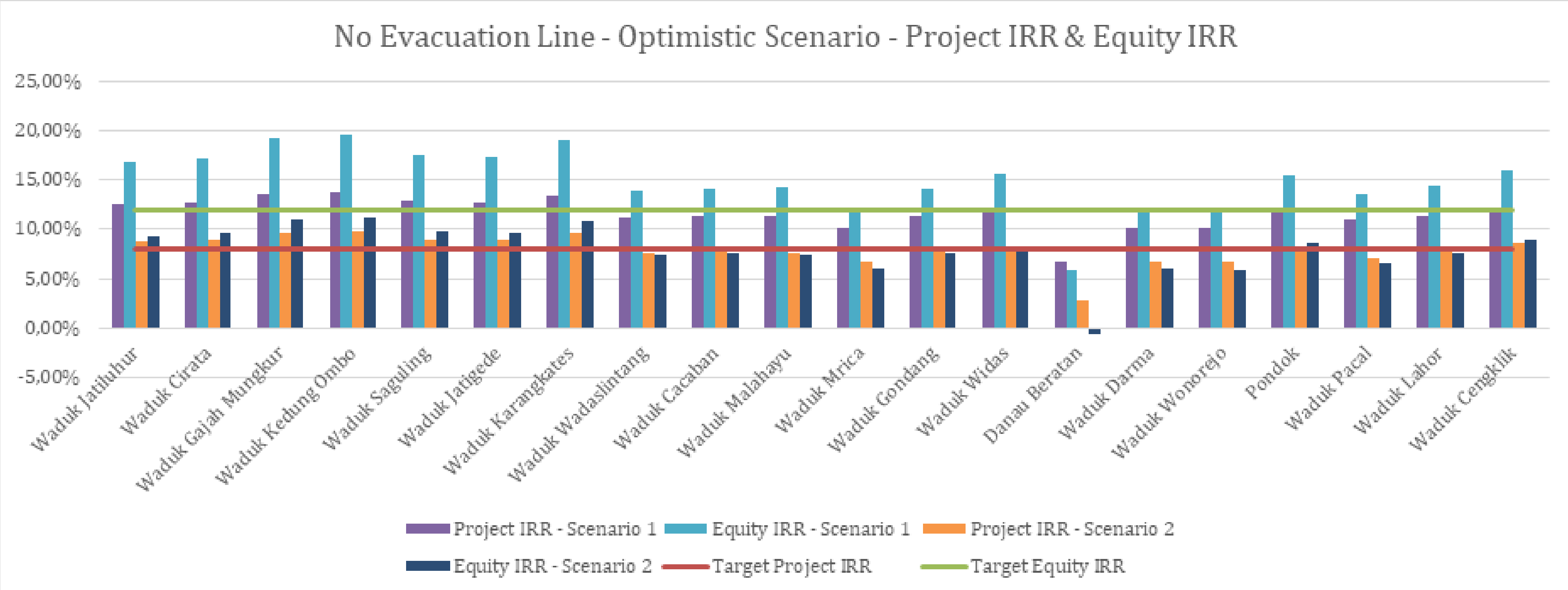


Figure 36 Project IRR and Equity IRR of each site for each scenario – Best case scenario excluding evacuation line

As seen from Table 41 above, applying the assumptions of the best-case scenario without the evacuation line stated in Table 40 resulted in much higher IRR compared to the base case assumptions as detailed in Table 24. By applying these assumptions, 16 sites achieved the targeted Project IRR of 8.00% and Equity IRR of 12.00%, with only one site Danau Beratan that is not feasible if looking at the targeted Project IRR. This shows significant improvement from the base case assumptions where none of the sites were feasible, in that configuration 80% are viable. However, similarly to previous analyses, feasibility is achieved under scenario 1 only, and none of the sites are feasible under scenario 2

Project & Equity IRR range

Project IRR and Equity IRR for Base Scenario, Best Case Scenario and Worst Case Scenario (Exlcuding Evacuation Line Scenario with 95% Energy Generation) with the evacuation line are shown Figure 37 and Figure 38.

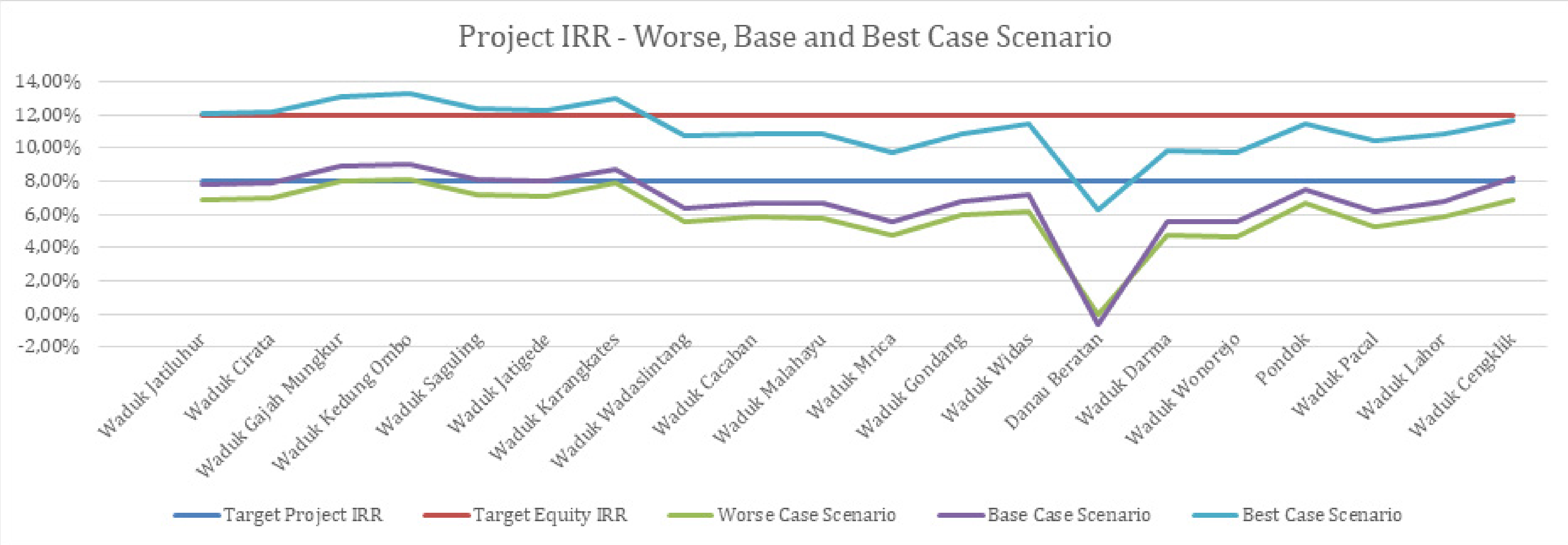


Figure 37 Project IRR Range for all scenario excluding evacuation line

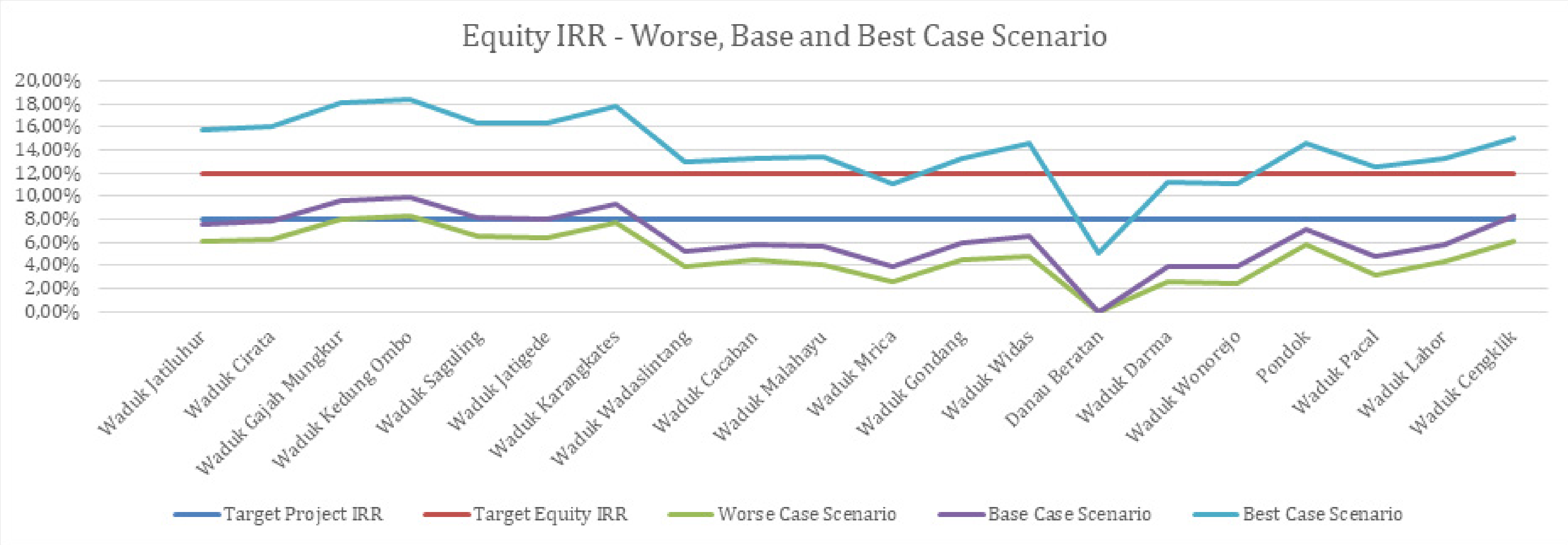


Figure 38 Equity IRR Range for all scenario excluding evacuation line

As seen from Figure 37 and Figure 38, most sites have good financial feasibility if the evacuation line CAPEX is excluded. Even though those sites are not feasible in the base case assumptions, slight changes to the assumptions can make them financially viable. The only site that is not feasible is Danau Beratan. Based on these results, Danau Beratan may need to be removed from the final site list.

4.6. Site Prioritization Final Results

This section outlines the final results of the site prioritization, identifying which reservoirs stand out as the strongest candidates for floating PV development when technical suitability, environmental and social factors, and financial feasibility are all considered. The complete ranking, along with the combined scores for each site, is presented in Table 42 below, providing a clear basis for comparing sites and supporting decisions for further project planning.

Table 42 Site prioritization results

Rank	Reservoir Name	Geospatial Score	E&S Score	Risk Rating	Potential Capacity (MWp)	Project IRR (Base case)	Total score
1	**Waduk Kedung Ombo**	1.00	17	High	411	8.97%	**8.628**
2	**Waduk Gajah Mungkur**	0.89	14	Medium	340	8.19%	**8.206**
3	**Waduk Karangkates**	0.78	14	Medium	257	8.69%	**8.088**
4	**Waduk Jatigede**	0.79	16	High	662	7.86%	**7.708**
5	**Waduk Cirata**	0.63	15	Medium	1146	7.85%	**7.512**
6	**Waduk Jatiluhur**	0.63	16	High	651	7.72%	**7.153**
7	**Waduk Wadaslintang**	0.64	14	Medium	261	6.34%	**6.596**
8	**Waduk Mrica**	0.76	14	Medium	97	5.10%	**6.329**
9	**Waduk Cengklik**	0.60	15	Medium	51	6.08%	**6.152**
10	**Waduk Saguling**	0.29	16	High	310	7.43%	**5.844**
11	**Waduk Lahor**	0.44	15	Medium	53	5.90%	**5.583**
12	**Waduk Widas**	0.62	13	Low	88	3.88%	**5.487**
13	**Waduk Pondok**	0.39	15	Medium	66	4.04%	**4.623**
14	**Waduk Cacaban**	0.23	13	Low	129	4.42%	**4.595**
15	**Waduk Gondang**	0.51	15	Medium	68	3.18%	**4.594**
16	**Waduk Wonorejo**	0.51	12	Low	72	2.19%	**4.551**
17	**Waduk Darma**	0.35	16	High	76	3.51%	**4.158**
18	**Waduk Malahayu**	0.28	17	High	108	1.97%	**3.177**
19	**Waduk Pacal**	0.45	14	Medium	54	0.03%	**3.093**
20	**Danau Beratan**	0.20	18	High	75	-1.48%	**1.300**
21	**Waduk Cipancuh**	0.37	14	Medium	0	NA	**0.000**

5. Results Analysis

This section presents the consolidated results of the four key components of this study: the geospatial analysis, E&S assessment, grid integration assessment, and financial analysis. Together, these analyses form the basis for identifying and prioritizing suitable sites for floating PV development.

Geospatial Analysis. The geospatial MCDM analysis generated technical scores for the 21 shortlisted reservoirs, ranking each site according to critical technical factors such as solar irradiation potential (PVOUT), shading risk, basic wind speed, seasonal water level fluctuations, reservoir shape complexity, proximity to existing hydropower or substation infrastructure, and the extent of surface coverage by aquaculture operations or aquatic vegetation. In general, sites scoring below 0.5 are likely to present more technical challenges than higher-scoring sites; however, this does not imply infeasibility. Rather, it indicates that additional advanced engineering measures or enhanced operation and maintenance strategies would be necessary to address these challenges.

It is also important to note that the technical viability of an FPV project depends on additional factors such as detailed water level variations, reservoir bathymetry, water depth, and soil conditions. The exact placement of the FPV installation strongly influences the design of critical components such as anchoring and mooring systems, which in turn affect project costs and long-term operation and maintenance requirements. Therefore, a detailed feasibility study for each site is essential to assess and mitigate these factors fully.

E&S Assessment. No sites were excluded outright based on the E&S assessment. However, several sites will require more substantial efforts to manage social and environmental sensitivities, particularly where dense floating net cages (FNC) aquaculture is present. The E&S screening highlights that extensive FNC operations present a significant challenge for several reservoirs. This challenge is leading to social tensions due to ongoing government efforts to reduce overcapacity and related environmental impacts. Overall, managing FNC operations will be essential to mitigate social conflict and ensure the sustainability of FPV development at these locations. It is recommended to provide ESIA and risk mitigations plan for the sites categorized under medium (11 sites) and high risk (7 sites). This highlights the importance of applying internationally recognized E&S standards in any subsequent detailed site-specific studies to ensure responsible development and stakeholder acceptance.

Grid Integration Assessment. While some sites offer extensive water surfaces with significant technical potential for large-scale FPV installations, existing grid limitations often constrain the actual capacity that can be connected. For example, Waduk Jatiluhur has an estimated technically suitable area covering around 20% of the reservoir, which could theoretically support up to approximately 1.4 GWp of installed capacity. However, the current grid infrastructure in the area can only accommodate up to 521 MW by 2030, effectively limiting the capacity that can be integrated in the near term. This illustrates that to fully maximize the potential of FPV at such sites, grid upgrades and expansion will be necessary to increase the hosting capacity and enable the integration of larger volumes of solar PV generation.

Financial Analysis. The financial analysis indicates that while most sites yield only moderate returns with some conditions, FPV projects are not inherently unviable. Notably, although some sites achieve project IRRs that suggest potential feasibility, none would reach the typical minimum equity IRR threshold of 12%

based on this preliminary modelling alone. In addition, in most configurations, the analyses demonstrate feasible sites solely under the tariff scenario of ceiling price equal to 6.95 USD cents from year 1 to 10. These results underscore the importance of exploring supportive financial mechanisms, risk-mitigation measures, or tariff adjustments to strengthen project bankability.

Nevertheless, FPV remains an attractive complement to ground-mounted solar, as it makes productive use of existing reservoir areas and helps mitigate the land availability constraints that often limit solar expansion in Indonesia. Additionally, based on a sensitivity analysis excluding the evacuation line cost from the total CAPEX, the financial analysis shows that many sites demonstrate encouraging economic potential. Similar to ground-mounted PV, excluding evacuation line costs can enhance the financial viability of FPV projects.

However, a detailed, site-specific bankability assessment must still be undertaken for each location to ensure alignment with the requirements of independent power producers, lenders, and project investors on a case-by-case basis.

Site Prioritization. The final site prioritization integrates the geospatial technical suitability, E&S risk profile, site-specific potential capacity, and financial viability to identify the most promising locations for floating PV development.

- Top-ranked sites are Waduk Kedung Ombo, Waduk Gajah Mungkur, Waduk Karangkates, and Jatigede lead the final list with strong overall scores driven by a balanced combination of favorable technical characteristics, manageable E&S risks, and solid financial returns.
  - Waduk Kedung Ombo remains the highest-ranked site overall. It achieves the top geospatial score and demonstrates a strong project IRR with a large potential capacity of 411 MWp. Although classified as high risk due to cultural heritage sensitivity and moderate floating net cage coverage, its technical strengths and robust financials make it highly feasible for development with appropriate mitigation measures.
  - Waduk Gajah Mungkur, ranked second, combines good solar potential, low shading, low E&S risk, and a respectable IRR for an estimated 340 MWp capacity. Its medium-risk profile and stable reservoir conditions strengthen its viability, despite the absence of hydropower infrastructure.
  - Waduk Karangkates, in third place, maintains a strong balance between good PVOUT, accessible infrastructure, and a competitive IRR. However, moderate E&S risks such as proximity to a volcano and notable aquaculture presence will require management.
  - Waduk Jatigede ranks fourth due to its large technical capacity and relatively sound financial return. Overall, it shows a high risk, especially its cultural heritage aspects must be addressed through proper stakeholder engagement.
- Medium-ranked sites such as Waduk Cirata, Waduk Jatiluhur, Wadaslintang, Mrica, and Saguling offer attractive technical potential and sizeable capacity (e.g., Cirata with the highest single-site potential capacity). However, social complexities, high aquaculture coverage, or medium to high E&S risks, especially at Cirata, Jatiluhur, and Saguling, highlight the need for conflict-sensitive approaches and coordination with local communities. Waduk Mrica, although technically stable, has a relatively lower IRR, which reduces its competitiveness.
- Lower-ranked sites such as Waduk Lahor, Widas, Pondok, Cacaban, Gondang, and Wonorejo show moderate technical feasibility but face limitations due to either lower financial return or high E&S risks. These sites may present niche opportunities under favourable conditions but would generally require higher development effort and costs to become viable.
- At the bottom of the list, sites like Waduk Darma, Malahayu, Pacal and Danau Beratan have very low financial viability combined with high or medium E&S risks, limiting their suitability for near-term development. Danau Beratan, in particular, scores the lowest with a negative IRR and high

social-cultural constraints due to its location next to a UNESCO heritage area and vulnerable endemic species.

In summary, the final ranking clearly shows that only sites combining strong technical scores, moderate E&S risk, and sound financial returns are truly viable for near-term FPV deployment. Reservoirs like Waduk Kedung Ombo, Gajah Mungkur, Karangkates, and Jatigede stand out as priority sites, while medium-tier options can be further explored with robust risk mitigation plans. Sites with poor financial feasibility and/or high environmental and cultural risks should be deprioritized for FPV in the immediate term.

It is important to emphasise that this high-level assessment serves only as an initial screening and does not replace the need for a detailed, site-specific feasibility study. Any future FPV project at these reservoirs must be preceded by a comprehensive feasibility study considering each site's unique technical, environmental, social, regulatory, and financial circumstances. This should include acquiring site-specific bathymetric data, identifying the exact placement for the FPV installation, and conducting real-time water level and weather measurements. In addition, detailed grid connection studies, stakeholder engagement, and a thorough evaluation of commercial viability and bankability, aligned with the requirements of potential investors and lenders, are all essential to ensure successful implementation.

ANNEX A – Basic Information of Considered Water Bodies

Table 43 below lists all 51 water bodies considered for analysis, together with their location, area, and the potential size of the FPV power plant that could be developed, considering the legal limit of 20% area utilisation and hypothetical full utilisation of the water body's effective area. The hypothetical FPV size at effective area utilisation is only quantified for the analysed water bodies, as the effective area was only calculated during the analysis, not in the pre-selection stage (see Chapter 3.2.4). The table also indicates whether the water body was selected for the analysis, and if not, what was the reason.

Table 43 Details of the 51 water bodies considered in the study

Water body name	Location		Water body area - satellite [ha]	FPV size at 20% area utilization [MWp]	FPV size at effective area utilization [MWp]	Selected for analysis
	Latitude	Longitude				
Waduk Jatiluhur	-6.524443	107.387258	7091.4	1418	5248	Y
Waduk Cirata	-6.694342	107.343667	5729.6	1146	3953	Y
Waduk Gajah Mungkur	-7.867614	110.914364	4849.3	970	2716	Y
Waduk Kedung Ombo	-7.264272	110.841669	3838.6	768	2034	Y
Waduk Saguling	-6.91295	107.36644	3515.6	703	1477	Y
Waduk Jatigede	-6.857998	108.096392	3392	678	2646	Y
Waduk Karangkates	-8.163637	112.446938	1283	257	616	Y
Waduk Wadaslintang	-7.604168	109.779799	1141.8	228	948	Y
Waduk Cacaban	-7.0082	109.2042	642.6	129	238	Y
Waduk Malahayu	-7.0356	108.808428	538.4	108	226	Y
Waduk Mrica	-7.385556	109.621111	487	97	365	Y
Waduk Gondang	-7.202231	112.270255	484.6	97	68	Y
Waduk Widas	-7.544572	111.798375	437.7	88	105	Y
Danau Beratan	-8.272039	115.174092	383.4	77	376	Y
Waduk Darma	-7.006269	108.41177	382.1	76	290	Y
Waduk Wonorejo	-8.01998	111.80451	362.1	72	239	Y

Water body name	Location		Water body area - satellite [ha]	FPV size at 20% area utilization [MWp]	FPV size at effective area utilization [MWp]	Selected for analysis
	Latitude	Longitude				
Pondok	-7.410323	111.563313	332.1	66	96	Y
Waduk Cipancuh	-6.494439	107.954568	329	66	0	Y
Waduk Pacal	-7.363416	111.870708	317.3	63	54	Y
Waduk Lahor	-8.1467	112.45223	315.1	63	101	Y
Waduk Cengklik	-7.516646	110.732733	288.7	58	107	Y
Danau Batur	-8.255931	115.411511	1643.7	329	n/a	N - lake
Rawa Pening	-7.292542	110.43575	1626.5	325	n/a	N - lake
Danau Buyan	-8.244811	115.121092	478.9	96	n/a	N - lake
Waduk Karian	-6.412274	106.283376	1024	205	n/a	N - filled in 2024
Waduk Cipanas	-6.66578	108.02728	390.3	78	n/a	N - filled in 2023
Waduk Sadawarna	-6.587789	107.851034	349.1	70	n/a	N - filled in 2023
Waduk Semantok	-7.49801	111.88347	281.9	56	n/a	N - still under construction
Waduk Gongseng	-7.363834	111.901586	275.8	55	n/a	N - filled in 2022
Waduk Selorejo	-7.872111	112.356313	240.2	48	n/a	N - small size (<50 MWp)
Waduk Sempor	-7.566042	109.487457	201.7	40	n/a	N - small size (<50 MWp)
Waduk Pidekso	-8.036605	110.997822	187.4	37	n/a	N - small size (<50 MWp)
Ranu Grati	-7.728556	113.009617	187.1	37	n/a	N - small size (<50 MWp)
Waduk Kuningan	-7.063161	108.704117	175.7	35	n/a	N - small size (<50 MWp)
Rawa Jombor	-7.76039	110.62627	164.5	33	n/a	N - small size (<50 MWp)
Waduk Prijetan	-7.216151	112.211057	162.7	33	n/a	N - small size (<50 MWp)
Waduk Setupatok	-6.782768	108.570035	159.9	32	n/a	N - small size (<50 MWp)
Situ Cipanunjang	-7.210522	107.555172	159.6	32	n/a	N - small size (<50 MWp)
Danau Tamblingan	-8.25615	115.096969	153.9	31	n/a	N - small size (<50 MWp)

Water body name	Location		Water body area - satellite [ha]	FPV size at 20% area utilization [MWp]	FPV size at effective area utilization [MWp]	Selected for analysis
	Latitude	Longitude				
Situ Cileunca	-7.191258	107.552558	153.7	31	n/a	N - small size (<50 MWp)
Telaga Ngebel	-7.804792	111.632716	145.5	29	n/a	N - small size (<50 MWp)
Waduk Sermo	-7.824332	110.123467	138.7	28	n/a	N - small size (<50 MWp)
Waduk Sangiran	-7.415734	111.609873	132.1	26	n/a	N - small size (<50 MWp)
Waduk Bendo	-7.93374	111.583671	125.7	25	n/a	N - small size (<50 MWp)
Randugunting	-6.872635	111.255991	120.6	24	n/a	N - small size (<50 MWp)
Waduk Seloromo	-6.694594	110.958521	117.3	23	n/a	N - small size (<50 MWp)
Kalampes	-7.107643	113.220872	115	23	n/a	N - small size (<50 MWp)
Waduk Krakatau Steel	-6.012661	106.026531	113.6	23	n/a	N - small size (<50 MWp)
Waduk Mulur	-7.689525	110.877611	106.2	21	n/a	N - small size (<50 MWp)
Waduk Penjalin	-7.327182	109.054631	106	21	n/a	N - small size (<50 MWp)
Waduk Logung	-6.757306	110.922538	102.1	20	n/a	N - small size (<50 MWp)

ANNEX B – Reservoir Prioritization Results

Table 44 Site prioritization results

Rank	Reservoir name	Geospatial Score	E&S Score	Risk Rating	Potential Capacity (MWp)	Project IRR (Base Case)	Equity IRR (Base Case)	Total score
1	**Waduk Kedung Ombo**	1.00	17	High	411	8.97%	9.78%	8.628
2	**Waduk Gajah Mungkur**	0.89	14	Medium	340	8.19%	8.34%	8.206
3	**Waduk Karangkates**	0.78	14	Medium	257	8.69%	9.26%	8.088
4	**Waduk Jatigede**	0.79	16	High	662	7.86%	7.76%	7.708
5	**Waduk Cirata**	0.63	15	Medium	1146	7.85%	7.73%	7.512
6	**Waduk Jatiluhur**	0.63	16	High	651	7.72%	7.51%	7.153
7	**Waduk Wadaslintang**	0.64	14	Medium	261	6.34%	5.15%	6.596
8	**Waduk Mrica**	0.76	14	Medium	97	5.10%	3.20%	6.329
9	**Waduk Cengklik**	0.60	15	Medium	51	6.08%	4.82%	6.152
10	**Waduk Saguling**	0.29	16	High	310	7.43%	7.00%	5.844
11	**Waduk Lahor**	0.44	15	Medium	53	5.90%	4.45%	5.583
12	**Waduk Widas**	0.62	13	Low	88	3.88%	1.27%	5.487
13	**Waduk Pondok**	0.39	15	Medium	66	4.04%	1.80%	4.623
14	**Waduk Cacaban**	0.23	13	Low	129	4.42%	2.26%	4.595
15	**Waduk Gondang**	0.51	15	Medium	68	3.18%	0.53%	4.594
16	**Waduk Wonorejo**	0.51	12	Low	72	2.19%	-1.00%	4.551
17	**Waduk Darma**	0.35	16	High	76	3.51%	0.84%	4.158
18	**Waduk Malahayu**	0.28	17	High	108	1.97%	-1.26%	3.177
19	**Waduk Pacal**	0.45	14	Medium	54	0.03%	-3.93%	3.093
20	**Danau Beratan**	0.20	18	High	75	-1.48%	-	1.300
21	**Waduk Cipancuh**	0.37	14	Medium	0	NA	NA	0.000

ANNEX C - Geospatial MCDM Results

Table 45 MCDM Inputs – Natural criteria

No	Reservoir name	NATURAL					
		effective_area_%	shape_km_per_ha	PVOUT_mean_kWhKwp	GHI_shd_mean_%	basicWindSpeed_ms	volcano_closest_km
1	Waduk Jatiluhur	74	0.031	1424	0.32	33	30
2	Waduk Cirata	69	0.033	1439	0.24	33	30
3	Waduk Gajah Mungkur	56	0.043	1543	0.12	30	60
4	Waduk Kedung Ombo	53	0.055	1560	0.13	30	44
5	Waduk Saguling	42	0.114	1452	0.24	33	20
6	Waduk Jatigede	78	0.037	1455	0.3	32	30
7	Waduk Karangkates	48	0.056	1541	0.12	31	30
8	Waduk Wadaslintang	83	0.048	1339	0.48	31	36
9	Waduk Cacaban	37	0.076	1418	0.3	32	23
10	Waduk Malahayu	42	0.065	1463	0.29	32	45
11	Waduk Mrica	75	0.07	1365	0.28	31	40
12	Waduk Gondang	14	0.068	1498	0.08	30	80
13	Waduk Widas	24	0.119	1604	0.09	30	70
14	Danau Beratan	98	0.021	1239	1.96	33	36
15	Waduk Darma	76	0.043	1386	0.4	32	12
16	Waduk Wonorejo	66	0.058	1419	0.7	31	55
17	Waduk Pondok	29	0.149	1547	0.1	31	100
18	Waduk Cipancuh	0	0.07	1475	0.16	32	65
19	Waduk Pacal	17	0.105	1539	0.12	30	75
20	Waduk Lahor	32	0.109	1529	0.18	31	26
21	Waduk Cengklik	37	0.038	1569	0.1	31	31
Score weight		**0.7**	**0.2**	**0.8**	**0.5**	**0.5**	**0.2**

Table 46 MCDM Outputs – Natural criteria

No	Reservoir name	NATURAL					
		effective_area_%	shape_km_per_ha	PVOUT_mean_kWhKwp	GHI_shd_mean_%	basicWindSpeed_ms	volcano_closest_km
1	**Waduk Jatiluhur**	0.70	0.20	0.33	0.34	0.00	0.09
2	**Waduk Cirata**	0.69	0.19	0.37	0.38	0.00	0.09
3	**Waduk Gajah Mungkur**	0.50	0.17	0.65	0.44	0.50	0.20
4	**Waduk Kedung Ombo**	0.46	0.14	0.69	0.44	0.50	0.17
5	**Waduk Saguling**	0.31	0.01	0.41	0.38	0.00	0.03
6	**Waduk Jatigede**	0.70	0.18	0.41	0.35	0.17	0.09
7	**Waduk Karangkates**	0.39	0.14	0.64	0.44	0.33	0.09
8	**Waduk Wadaslintang**	0.70	0.16	0.11	0.26	0.33	0.12
9	**Waduk Cacaban**	0.24	0.10	0.32	0.35	0.17	0.05
10	**Waduk Malahayu**	0.31	0.12	0.43	0.35	0.17	0.17
11	**Waduk Mrica**	0.70	0.11	0.17	0.36	0.33	0.14
12	**Waduk Gondang**	0.00	0.11	0.53	0.46	0.50	0.20
13	**Waduk Widas**	0.06	0.00	0.80	0.45	0.50	0.20
14	**Danau Beratan**	0.70	0.20	0.00	0.00	0.00	0.12
15	**Waduk Darma**	0.70	0.17	0.23	0.30	0.17	0.00
16	**Waduk Wonorejo**	0.64	0.14	0.32	0.15	0.33	0.20
17	**Waduk Pondok**	0.13	0.00	0.66	0.45	0.33	0.20
18	**Waduk Cipancuh**	0.00	0.11	0.47	0.42	0.17	0.20
19	**Waduk Pacal**	0.00	0.03	0.64	0.44	0.50	0.20
20	**Waduk Lahor**	0.17	0.02	0.61	0.41	0.33	0.06
21	**Waduk Cengklik**	0.24	0.18	0.72	0.45	0.33	0.09

Table 47 MCDM Inputs – Technical criteria

No	Reservoir name	TECHNICAL					
		road_access_CAT	hydropower_CAT	substation_150kV_km	fishfarm_%	builtup_325m_%	waterhyacinth_CAT
1	Waduk Jatiluhur	0	2	1.17	42	7.5	1
2	Waduk Cirata	0	3	2.52	72	12.2	3
3	Waduk Gajah Mungkur	0	0	7.94	3	9.7	1
4	Waduk Kedung Ombo	0	1	0.8	14	8.8	0
5	Waduk Saguling	0	3	5.9	69	32.4	2
6	Waduk Jatigede	0	2	2.92	12	12.1	0
7	Waduk Karangkates	0	2	0.57	42	19.6	2
8	Waduk Wadaslintang	0	1	0.78	8	12.5	0
9	Waduk Cacaban	0	0	13.5	0	2.9	0
10	Waduk Malahayu	0	0	26.87	0	1.2	0
11	Waduk Mrica	0	2	1.88	7	16.9	0
12	Waduk Gondang	0	0	13.06	2	7.6	1
13	Waduk Widas	0	0	13.31	0	2.9	1
14	Danau Beratan	0	0	2.13	1	29	0
15	Waduk Darma	0	0	7.64	52	36.5	0
16	Waduk Wonorejo	0	0	13.22	0	9.9	0
17	Pondok	1	0	11.74	5	23.6	0
18	Waduk Cipancuh	0	0	6.12	0	12.3	0
19	Waduk Pacal	0	0	20.72	0	0.6	1
20	Waduk Lahor	0	0	1.91	61	17.1	0
21	Waduk Cengklik	0	0	3.68	28	38.6	3
Score weight		0.2	0.4	0.5	0.2	0.1	0.1

Table 48 MCDM Outputs – Technical criteria

No	Reservoir name	NATURAL					
		effective_area_%	shape_km_per_ha	PVOUT_mean_kWhKwp	GHI_shd_mean_%	basicWindSpeed_ms	volcano_closest_km
1	Waduk Jatiluhur	0.20	0.27	0.50	0.09	0.09	0.07
2	Waduk Cirata	0.20	0.40	0.47	0.00	0.07	0.00
3	Waduk Gajah Mungkur	0.20	0.00	0.37	0.20	0.08	0.07
4	Waduk Kedung Ombo	0.20	0.13	0.50	0.19	0.08	0.10
5	Waduk Saguling	0.20	0.40	0.41	0.00	0.00	0.03
6	Waduk Jatigede	0.20	0.27	0.46	0.19	0.07	0.10
7	Waduk Karangkates	0.20	0.27	0.50	0.09	0.04	0.03
8	Waduk Wadaslintang	0.20	0.13	0.50	0.20	0.07	0.10
9	Waduk Cacaban	0.20	0.00	0.26	0.20	0.10	0.10
10	Waduk Malahayu	0.20	0.00	0.00	0.20	0.10	0.10
11	Waduk Mrica	0.20	0.27	0.48	0.20	0.05	0.10
12	Waduk Gondang	0.20	0.00	0.27	0.20	0.09	0.07
13	Waduk Widas	0.20	0.00	0.26	0.20	0.10	0.07
14	Danau Beratan	0.20	0.00	0.48	0.20	0.00	0.10
15	Waduk Darma	0.20	0.00	0.37	0.06	0.00	0.10
16	Waduk Wonorejo	0.20	0.00	0.26	0.20	0.08	0.10
17	Waduk Pondok	0.00	0.00	0.29	0.20	0.03	0.10
18	Waduk Cipancuh	0.20	0.00	0.40	0.20	0.07	0.10
19	Waduk Pacal	0.20	0.00	0.12	0.20	0.10	0.07
20	Waduk Lahor	0.20	0.00	0.48	0.03	0.05	0.10
21	Waduk Cengklik	0.20	0.00	0.45	0.14	0.00	0.00

Table 49 Geospatial MCDM final ranking

No	Reservoir name	FINAL_RANK	FINAL_SCORE_NORM
1	Waduk Jatiluhur	7	0.63
2	Waduk Cirata	8	0.63
3	Waduk Gajah Mungkur	2	0.89
4	Waduk Kedung Ombo	1	1
5	Waduk Saguling	18	0.29
6	Waduk Jatigede	3	0.79
7	Waduk Karangkates	4	0.78
8	Waduk Wadaslintang	6	0.64
9	Waduk Cacaban	20	0.23
10	Waduk Malahayu	19	0.28
11	Waduk Mrica	5	0.76
12	Waduk Gondang	11	0.51
13	Waduk Widas	9	0.62
14	Danau Beratan	21	0.2
15	Waduk Darma	17	0.35
16	Waduk Wonorejo	12	0.51
17	Pondok	15	0.39
18	Waduk Cipancuh	16	0.37
19	Waduk Pacal	13	0.45
20	Waduk Lahor	14	0.44
21	Waduk Cengklik	10	0.6

ANNEX D - IFC Standard Performances Table

Table 50 IFC standard performances

Performance standards (PSs)	Key Requirements
PS 1: Assessment and Management of Environmental and Social Risk and Impacts	IFC PS1 requires identifying and assessing any project's environmental and social risks and impacts. It shall cover all relevant environmental and social risks and potential effects outlined in PS 2 through 8. The Project must adopt a mitigation hierarchy to anticipate and avoid, or where avoidance is not possible, minimize, and where residual impacts remain, compensate/offset for risks and impacts to workers, affected communities, and the environment. IFC PS1 promotes improved E&S performance of clients through the effective use of Environmental and Social Management Systems (ESMS). In addition to meeting the IFC PS 1 requirements, the Project must comply with applicable national law, including those laws implementing host country obligations under international law.
PS 2: Labour and Working Conditions	The key elements for compliance with IFC PS2 include human resources policy and its management; direct and contractual worker management; working conditions and terms of employment; retrenchment; freedom to form and join workers' organizations; internal grievance mechanism; protection of workforce to avoid child labour and forced labour; non-discrimination and equal opportunity considerations (including local hiring preferences); occupational health and safety procedures and mechanisms; and procedure for managing contractors and suppliers.
PS 3: Resource Efficiency and Pollution Prevention	IFC PS 3 outlines a Project-level approach to resource efficiency and pollution prevention and control in line with internationally disseminated technologies and practices. Critical compliance elements in IFC PS3 include greenhouse gas emissions, water consumption, air and water emissions, noise, ambient air quality, waste management, hazardous materials management, and pesticide use and management.
PS 4: Community Health, Safety, and Security	The two key aspects of IFC PS4 concern community health and safety and security personnel requirements. IFC PS4 requires the Project to evaluate the potential for community impacts associated with the Project and avoid or minimize risks/effects on community health and safety, particularly with regards to infrastructure, equipment, hazardous materials safety, natural resource issues related to the ecosystem services utilization, and exposure to disease. The performance standard also requires the assessment of risks posed by its security arrangements to those within and outside the project site.
PS 5: Land Acquisition and Involuntary Resettlement	Essential requirements of the IFC PS 5 include Compensation and Benefits for Displaced Persons, Community Engagement, resettlement and Livelihood Restoration Planning and Implementation, and a Grievance Mechanism for Physical and economic displacement.

Performance standards (PSs)	Key Requirements
PS 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	To ensure that biodiversity is protected and conserved, and that sustainable management and use of natural resources is used wherever feasible throughout the Project lifecycle. The key concerns required by the IFC PS6 include the protection and conservation of biodiversity through assessment and management of modified and natural habitats, critical habitat, legally protected and internationally recognized areas and invasive alien species; management of ecosystem services; management, living natural resources, and supply chain management.
PS 7: Indigenous People	Require the Project to anticipate and avoid adverse impacts on the Indigenous People, including People screening and impact assessment, maintain relationships based on Informed Consultation and participation (ICP), obtain FPIC if the Project significantly affects the Indigenous People, and promote sustainable development benefits and opportunities.
PS 8: Cultural Heritage	IFC PS8 requires sites to make efforts to protect cultural heritage from any adverse impacts of Project activities and to support its preservation. In this case, the implications of IPs are being assessed.

ANNEX E - Environmental and Social Analysis Results

Table 51 E&S scoring results

No	Site	Land cover accumulated score	Environmental	PS 5	PS 6				PS 7	PS 8	Total score	Site Rating
			Water Stress Risk	Presence of Population, physical and economical displace	High biodiversity value area (WHS, AZE, IBA, KBA, PA, WDPA)	UNEP WCMC Global Critical Habitat, triggers critical habitat	Onshore Area	Forestry Status	Presence of Indigenous People	Cultural Heritage Site		
14	**Danau Berantan**	Low	High	Medium	Medium	Medium	High	Low	Low	High	18	High
4	**Waduk Kedungombo**	Low	High	Medium	Low	Medium	High	Low	Low	High	17	High
10	**Waduk Malahayu**	Medium	High	Medium	Low	Medium	High	Low	Low	Medium	17	High
5	**Waduk Saguling**	Low	High	High	Low	Medium	Low	Low	Low	Low	16	High
6	**Waduk Jatigede**	Medium	High	Medium	Low	Medium	Low	Low	Low	High	16	High
1	**Waduk Jatiluhur**	Low	High	High	Low	Medium	High	Low	Low	High	16	High
15	**Waduk Darma**	Low	High	High	Low	Medium	High	Low	Low	Low	16	High
2	**Waduk Cirata**	Low	High	High	Low	Medium	Low	Low	Low	Medium	15	Medium
12	**Waduk Gondang**	High	High	Low	Low	Medium	Low	Low	Low	Medium	15	Medium
17	**Waduk Pondok**	High	High	Medium	Low	Medium	Low	Low	Low	Low	15	Medium
20	**Waduk Lahor**	High	Medium	High	Low	Medium	Low	Low	Low	Low	15	Medium
21	**Waduk Cengklik**	High	High	Medium	Low	Medium	Low	Low	Low	Low	15	Medium

No	Site	Land cover accumulated score	Environmental	PS 5	PS 6				PS 7	PS 8	Total score	Site Rating
			Water Stress Risk	Presence of Population, physical and economical displace	High biodiversity value area (WHS, AZE, IBA, KBA, PA, WDPA)	UNEP WCMC Global Critical Habitat, triggers critical habitat	Onshore Area	Forestry Status	Presence of Indigenous People	Cultural Heritage Site		
8	**Waduk Wadaslintang**	Medium	High	Low	Low	Medium	Low	Low	Low	Medium	14	Medium
11	**Waduk Mrica**	High	High	Low	Low	Medium	Low	Low	Low	Low	14	Medium
18	**Waduk Cipancuh**	High	High	Low	Low	Medium	Low	Low	Low	Low	14	Medium
19	**Waduk Pacal**	Medium	High	Low	Low	Medium	Low	Medium	Low	Low	14	Medium
9	**Waduk Cacaban**	Low	High	Medium	Low	Medium	Low	Low	Low	Low	13	Low
13	**Waduk Widas**	Medium	Medium	Low	Low	Medium	Low	Medium	Low	Low	13	Low
16	**WadukWonorejo**	Medium	Medium	Low	Low	Medium	Low	Low	Low	Low	12	Low

The Table 52 below breaks down the results obtained per site for the criteria linked with the three social analyses, namely PS5, PS7, and PS8.

Table 52 Social screening results

No	Site	Presence of population, physical and economical displacement (PS 5)	Risk rating	Presence of Indigenous People (PS 7)	Risk rating	Cultural heritage & culturally important site (PS 8)	Risk rating
14	**Danau Berantan**	The surrounding area is well-known for its tourism activity, which includes several restaurants, hotels, and viewpoints, but there are very limited floating structures on the water body seen from the aerial view (only 1.04% of the water body is covered by floating structures).	Medium	No registered Indigenous people within the area	Low	Located adjacent to the Pura Ulun Danu Batur, which is recognized as part of World Heritage Subak System by UNESCO	High
7	**Waduk Karangkates**	There are intensives floating net cages in the area especially in Kalipare and Sumberpucung Village (41.54% of water body is covered with FNC)	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
20	**Waduk Lahor**	There are intensive presence of floating net cages in the area especially in Kromengan Village (60.61% of water body is covered with FNC)	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
16	**Waduk Wonorejo**	There is a less densely populated area nearby with no physical structure built on water bodies	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
3	**Waduk Gajahmungkur**	There are several floating net cages present in Sendang and Gumiwang Lor Village but is limited compared to the whole area of the reservoir (only 2.59% of water body is covered with FNC).	Low	No registered Indigenous people within the area	Low	There is no registered cultural heritage sites, but there is a presence of old graveyard (Makam Kuno Setono) that is inundated by the Reservoir Construction and this graveyard can be seen seasonaly during reservoir drought	High

No	Site	Presence of population, physical and economical displacement (PS 5)	Risk rating	Presence of Indigenous People (PS 7)	Risk rating	Cultural heritage & culturally important site (PS 8)	Risk rating
8	**Waduk Wadaslintang**	There are several floating net cages present in Sumberejo and Sumbersari Village but is limited compared to the whole area of Reservoir (only 8.05% of water body is covered by FNC).	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites, but there is a graveyard (Makam Syeh Nawawi) that is used as pilgrimage sites for local community (approx 2 kms from Reservoir).	Medium
13	**Waduk Widas**	There is less densely populated area nearby with no physical structure built on water bodies.	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of the reservoir.	Low
21	**Waduk Cengklik**	The surrounding area is densely populated, and there is a moderate presence of floating net cages on the reservoir body within Ngargorejo Village (28.40% of the water body is covered with FNC).	Medium	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
17	**Waduk Pondok**	The area surrounding are moderately populated with limited presence of floating net cages on reservoir body (only 4.51% of water body is covered with FNC).	Medium	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
11	**Waduk Mrica**	There is less densely populated area nearby with very limited physical structure built on water bodies (only 6.98% of water body is covered with FNC)	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low
19	**Waduk Pacal**	There is less densely populated area nearby with no physical structure built on water bodies.	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of reservoir.	Low

No	Site	Presence of population, physical and economical displacement (PS 5)	Risk rating	Presence of Indigenous People (PS 7)	Risk rating	Cultural heritage & culturally important site (PS 8)	Risk rating
4	**Waduk Kedungombo**	There is moderately dense populated area nearby with intensive presence of FNC and fishing spots, especially in Ngartotirto Village (13.85% of water body is covered with FNC).	Medium	No registered Indigenous people within the area	Low	There is no cultural heritage site; however, there is a floating tomb of Nyi Ageng Serang in the middle of the reservoir. The local community considers this tomb sacred, and it has become one of the religious tourism sites visited by many people.	High
12	**Waduk Gondang**	There is less densely populated area nearby with very limited floating net cages built on water bodies (only 2.47% of area is covered with FNC).	Low	No registered Indigenous people within the area	Low	There is no cultural heritage sites, but there is a presence of graveyard (Situs Makam Dowo) that is used as pilgrimage sites for local community (approx 2 kms from reservoir).	Medium
10	**Waduk Malahayu**	There is a less densely populated area nearby, but several small islands within the reservoir are used as photospots for tourism.	Medium	No registered Indigenous people within the area	Low	There are no cultural heritage sites within the vicinity of the reservoir, but there is a historical Dutch colonial site, the Ruins of the Munitions Warehouse (Ruïnes van Munitiemagazijn), adjacent to the reservoir.	Medium
15	**Waduk Darma**	There are densely populated areas nearby and intensive floating net cages in the area, especially in Cipasung and Jagara Village (52.34% of the water body is covered with FNC).	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of the reservoir.	Low
9	**Waduk Cacaban**	There is less densely populated area nearby with no presence of floating net cages, but there are tourism activity which includes water transport	Medium	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of the reservoir.	Low

No	Site	Presence of population, physical and economical displacement (PS 5)	Risk rating	Presence of Indigenous People (PS 7)	Risk rating	Cultural heritage & culturally important site (PS 8)	Risk rating
5	**Waduk Saguling**	There are densely populated areas nearby with intensive presence of floating net cages (68% of water body is covered with FNC Structure)	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the reservoir's vicinity. However, a specific site known as Sirtwo Island within the reservoir area has been discovered to contain prehistoric fossils.	High
6	**Waduk Jatigede**	There are less densely populated area nearby and limited floating net cages presence (12.29% of water body is covered by FNC Structure); but there are several touristic photospots in small island within reservoir	Medium	No registered Indigenous people within the area	Low	There are no registered heritage sites, but there is an old graveyard (Makam Keramat Prabu Guru Aji Putih) that is inundated by Reservoir Construction. The local community still visits these graveyards using boats.	High
2	**Waduk Cirata**	There is a densely populated area nearby with an intensive presence of floating net cages, fishing spots, kiosks, and restaurants on top of the water body (70% of the water body is covered with FNC structures).	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage Sites within the vicinity of the reservoir, but a graveyard (Makam Gunung Kuda) is adjacent to it and is being used as a pilgrimage site for the local community.	Medium
1	**Waduk Jatiluhur**	There are densely populated areas nearby with an intensive presence of floating net cages (41.83% of water body is covered with FNC)	High	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of the reservoir.	Low
18	**Waduk Cipancuh**	There is a less densely populated area nearby with no physical structure built on water bodies.	Low	No registered Indigenous people within the area	Low	There are no registered cultural heritage sites within the vicinity of the reservoir.	Low

The Table 53 below breaks down the results obtained per site for the environmental screening especially regarding the presence of species, ecosystem general condition and disaster risk assessment.

Table 53 Biodiversity screening result

No	Site	Species or ecosystem general condition	Risk Rating	Reference
14	**Danau Berantan**	Endemic species restricted to Bali Island and found in Danau Beratan, i.e., Rasbora baliensis or locally known as "nyalian buluh". This species is categorised as vulnerable (VU) in the IUCN Red List. Other endemic freshwater fish, i.e., Lentipes whittenorum, were also identified, categorized as data deficient (DD). The environmental condition of Danau Beratan overall is good, with good nilai kecerahan.	High	Arthana, I W., A.R. As-syakur. 2020. Ikan air tawar endemik di Bali, Indonesia (The endemic Syakti, L. Adrianto (eds). Ikan natif dan endemic Indonesia: Biologi, konservasi dan pemanfaatan. Bandar Publishing, Banda Aceh. freshwater fish in the Bali Province, Indonesia). In: Z. A. Muchlisin, Agustiana, B. Amin, A.D.
7	**Waduk Karangkates**	‣ Waterbirds in Waduk Karangkates are categorised as generalist species, and none of the identified birds were identified as threatened species (critically endangered/CR, endangered/EN, or vulnerable/VU) according to the IUCN Red List. ‣ The area is considered to have a moderate biodiversity index (H' < 2). Due to the presence of FNC, invasive fish species are present within the reservoir. ‣ The reservoir is categorized as mildly polluted with low freshwater biodiversity index (H' < 2).	Low	Tyas, Novika & Ery Rahayu, Sofia & Sumberartha, I Wayan. (2022). Eksplorasi antara Komunitas Jenis Burung Air dengan Kondisi Lingkungan pada Musim Kemarau di Waduk Karangkates. Jurnal Ilmu Hayat. 6. 8. 10.17977/um061v6i12022p8-19. IMAM DARY SUPRIYADI PUTRA (2018) KUALITAS AIR DAN KEANEKARAGAMAN IKAN YANG TERTANGKAP DENGAN CAST NET DI WADUK KARANGKATES DAN SUNGAI KALI JAGIR TAHUN 2016. Skripsi thesis, Universitas Airlangga.
20	**Waduk Lahor**	The presence of FNC influences the water conditions in Waduk Lahor. Activities related to FNC at the mouth of the Lahor River, based on several biotic indices from diatoms, have contributed to a decline in water quality indicated by nutrient status shifting to eutrophic to hyper-eutrophic levels (as measured by Trophic Diatom Index/TDI) and light to moderate organic pollution (as indicated by %PTV).	Low	Dwie Zesta Viani, Catur Retnaningdyah. 2018. "Evaluasi Status Trofik Dan Pencemaran Bahan Organik Di Waduk Lahor Malang Menggunakan Bioindikator Diatom". Biotropika: Journal of Tropical Biology 6 (1): 10-15. https://doi.org/10.21776/ub.biotropika.2018.006.01.4.

No	Site	Species or ecosystem general condition	Risk Rating	Reference
16	**Waduk Wonorejo**	Only macroinvertebrate diversity was found with H' values ranging from 1.81 to 2.20, indicating moderate to high diversity and low pollution levels. The water quality in Wonorejo Reservoir is not heavily polluted; however, elevated nutrients and organic matter (indicated by phosphate and BOD) suggest some eutrophication pressure, likely from human activities such as aquaculture and agriculture.	Low	Fauziyyah, Itsna (2012) Keanekaragaman makroinvertebrata sebagai bioindikator kualitas perairan Waduk Wonorejo Kecamatan Pagerwojo Kabupaten Tulungagung. Undergraduate thesis, Universitas Islam Negeri Maulana Malik Ibrahim
3	**Waduk Gajahmungkur**	Generalist freshwater fish species were identified, common as commodity for the FNC fisherfolks. Moderate biodiversity index (H' < 2) were identified within the inlets and outlets of the reservoir.	Low	Sriwidodo DEW, Budiharjo A, Sugiyarto. 2013. Diversity of fish species on the inlet and outlet area of Gajah Mungkur Reservoir Wonogiri. Bioteknologi 10: 43-50.
8	**Waduk Wadaslintang**	A rare freshwater species was identified in Waduk Wadaslintang. A notable recent finding is the discovery of "ikan mangut" (Lobocheilos falcifer) in Waduk Wadaslintang, Central Java, by researchers from Universitas Airlangga and Universitas Brawijaya. This is significant because ikan mangut was previously only recorded in Sumatra, Kalimantan, and West Java (e.g., Cisadane, Ciliwung, Citarum rivers). Its presence in Wadaslintang extends its known distribution approximately 300 km eastward, marking the first record outside its native range. The status of the species is vulnerable according to IUCN Red List.	Medium	Hasan V, Soemarno, Widodo SW, Wiadnya DGR, Mukti AT, Irawan B (2019) Distribution extension and first record of Lobocheilos falcifer (Cypriniformes, Cyprinidae) in Central JavaProvince, Indonesia. Eco. Env. & Cons. 25 (July Suppl. Issue): S158-S161.
13	**Waduk Widas**	Generalist freshwater fish species were identified, which were common as commodity for the fisherfolks. All species are classified as Least Concern (LC) according to IUCN Red List, and most of them are identified as invasive.	Low	Sutriyanti, Sutriyanti (2019) Keanekaragaman jenis ikan di Waduk Bening Widas, Kabupaten Madiun. Undergraduate thesis, Universitas Katolik Widya Mandala Madiun.
21	**Waduk Cengklik**	Generalist freshwater fish species were identified, which were common as commodity for the fisherfolks. These species represent a mix of native and introduced freshwater fish, with some (like Oreochromis niloticus and koi) having known invasive tendencies. Aquatic biota community is unstable, which correlates with poor water quality and heavy pollution in the reservoir.	Low	Roziaty, Efri & Aksiwi, Daniek & Setyowati, Nur. (2018). KERAGAMAN PLANKTON DI WILAYAH PERAIRAN WADUK CENGKLIK BOYOLALI JAWA TENGAH. Bioeksperimen: Jurnal Penelitian Biologi. 4. 69. 10.23917/bioeksperimen.v4i1.5935.

No	Site	Species or ecosystem general condition	Risk Rating	Reference
17	**Waduk Pondok**	Waduk Pondok has historically supported the stocking of various fish species such as nila (Oreochromis niloticus), lele (Clarias sp.), tombro (Cyprinus carpio), and bandeng (Chanos chanos). All of the species are categorized as Least Concerned (LC) according to IUCN Red List, and most of them are identified as invasive. Phytoplankton diversity and abundance indicate the reservoir is in moderate ecological condition, but pollution in the water may threaten ecosystem stability.	Low	Fadhilah Ratna Arindri, AAni Sulistyarsi. 2018. IDENTIFIKASI KERAGAMAN DAN KEMELIMPAHAN FITOPLANKTON DI WADUK PONDOK KABUPATEN NGAWI. Prosiding Seminar Nasional SIMBIOSIS. Vol 3 (2018)
11	**Waduk Mrica**	Introduced fish species were identified in Waduk Mrica. Sediment suspension, which may contribute to the quality of freshwater habitat, was also identified.	Low	Mubarik, A. L., Rosyadi, H., Latrianto, A., Farahdilla, N., Empra, D. E. P., Nurfaiz, A., & Damanik, W. F. (2021). Komunitas iktiofauna di zona litoral Waduk Mrica, Banjarnegara, Jawa Tengah. Program Studi Biologi, Fakultas Matematika dan Ilmu Pengetahuan Alam, Universitas Sebelas Maret, Indonesia; PT. Indonesia Power Mrica PGU, Banjarnegara, Indonesia.
19	**Waduk Pacal**	No information on species present within this area. Waduk Pacal experiences sedimentation at a rate of 200,000 cubic meters per year. Although regular dredging is carried out, it only removes about 50,000 cubic meters annually, just 25% of the total sediment accumulation. Because of this imbalance, it is reasonable to conclude that Waduk Pacal should no longer be operated. The water quality of Pacal Reservoir was classified as unpolluted.	Low	Khotimah, M.H., Purnomo, T., & Wisanti (2016). Analisis Keanekaragaman Plankton di Waduk Pacal Desa Kedungsumber Kecamatan Temayang Kabupaten Bojonegoro.
4	**Waduk Kedungombo**	Generalist freshwater fish species were identified, which were commonly used as commodities by the fisherfolk. According to the IUCN Red List, all species are classified as Least Concerned (LC), and most are identified as invasive.	Low	Purnomo, Eko & Chika, Syifara. (2022). POTENSI KERAGAMAN IKAN DI WADUK KEDUNG OMBO SEBAGAI PENYEDIA KEBUTUHAN PANGAN BERKELANJUTAN. Jurnal Biogenerasi. 7. 99-107. 10.30605/biogenerasi.v7i1.1679.
12	**Waduk Gondang**	There is no information on species present within this area. Waduk Gondang is a modified reservoir that has the potential to become ecotourism. Waterbirds may occasionally visit this area.	Low	Rohman, N., & Marlina. (2024). Pembangunan pariwisata berkelanjutan: Studi kasus wisata alam Waduk Gondang di Kabupaten Lamongan. Triwikrama: Jurnal Multidisiplin Ilmu Sosial, 3(6).

No	Site	Species or ecosystem general condition	Risk Rating	Reference
10	**Waduk Malahayu**	No information on species present within this area. Waduk Malahayu is a modified reservoir which has the potential to become an ecotourism destination. Waduk Malahayu is home to various freshwater fish species, including catfish (ikan lele), snakehead fish (ikan gabus), and other unspecified fish types.	Low	https://visitjawatengah.jatengprov.go.id/id/artikel/merasakan-kedamaian-alam-dan-sejarah-di-waduk-malahayu-brebes#:~:text=Kesimpulan,betah%20berlama%2Dlama%20di%20sini!
15	**Waduk Darma**	This reservoir is used for fishing activities, and there is no information on the overall species present within the area. The reservoir is dominated by tilapia fish (Nile and Mozambique).	Low	Tjahjo, Didik Wahju. (2017). BIOLIMNOLOGI DAN POTENSI PRODUKSI IKAN DI PERAIRAN WADUK DARMA, JAWA BARAT. Jurnal Penelitian Perikanan Indonesia. 6. 10. 10.15578/jppi.6.3-4.2000.10-23.
9	**Waduk Cacaban**	The biodiversity garden was established in December 2024. The species are generalist fruit species. No information on existing condition within the reservoir; however, it is noticed that the onshore area of this reservoir is categorised as critical land.	Low	https://setda.tegalkab.go.id/2024/12/07/taman-kehati-strategi-pemulihan-lahan-kritis-waduk-cacaban/#:~:text=Kedungbanteng%20%E2%80%93%20Pemerintah%20Kabupaten%20Tegal%20melalui%20Dinas,di%20sekitar%20Waduk%20Cacaban%20pada%20Kamis%2C%20(05/12/2024).
5	**Waduk Saguling**	There is no information on the species present within this area. The water quality is considered poor due to pollution from organic material in the fishing cages. Furthermore, the area is dominated by invasive species as a commodity for the FNCs.	Low	Tjahjo, D.W.H. & A. Suman. 2008. PENGELOLAAN PERIKANAN WADUK SAGULING, CIRATA, DAN IR. H. DJUANDA, JAWA BARAT. J. Kebijak. Perikan. Ind. Vol.1 No.2 Nopember 2009:113-120
6	**Waduk Jatigede**	There is no information on the species present within this area. Although the water quality in Waduk Jatigede remains suitable for supporting fish life, the low plankton biodiversity indicates a less stable aquatic ecosystem.	Low	Djunaidah, Iin & Supenti, Lilis & Sudinno, Dinno & Suhrawardhan, Hendria. (2017). Kondisi Perairan dan Struktur Komunitas Plankton di Waduk Jatigede. Jurnal Penyuluhan Perikanan dan Kelautan. 11. 79-93. 10.33378/jppik.v11i2.87.
2	**Waduk Cirata**	There is no information on species present within this area. The water quality is considered poor due to water pollution from organic material in the fishing cages. Furthermore, the area is dominated by invasive species as a commodity for the FNCs. Water hyacinth is extensive in this reservoir.	Low	Tjahjo, D.W.H. & A. Suman. 2008. PENGELOLAAN PERIKANAN WADUK SAGULING, CIRATA, DAN IR. H. DJUANDA, JAWA BARAT. J. Kebijak. Perikan. Ind. Vol.1 No.2 Nopember 2009:113-120

No	Site	Species or ecosystem general condition	Risk Rating	Reference
1	**Waduk Jatiluhur**	No information on species present within this area. These reservoir ecosystems face pollution threats from heavy metals released by surrounding residential, urban, and industrial activities. Sediments act as the main sink for these pollutants, while fish gradually accumulate the toxins, posing long-term ecological risks. Current heavy metal levels remain within the permissible limits for freshwater aquaculture under regulation. Cirata has the highest contamination, followed by Saguling and Jatiluhur.	Low	Sutrisno, Koesoemadinata, S., & Taufik, I. (2007). Tingkat pencemaran logam berat pada ekosistem waduk di Jawa Barat (Saguling, Cirata, dan Jatiluhur). Jurnal Riset Akuakultur, 2(1), 103–115.
18	**Waduk Cipancuh**	No information on species present within this area. Waduk Cipancuh is a modified reservoir which main purpose is for irrigation and freshwater source. Waduk Cipancuh is home to various freshwater fish species and terrestrial species.	Low	https://cikoneng-ciamis.desa.id/melindungi-hutan-untuk-menjaga-keanekaragaman-hayati#:~:text=Kawasan%20ini%20memberikan%20perlindungan%20bagi%20habitat%20satwa,pada%20upaya%20konservasi%20skala%20yang%20lebih%20besar.

Table 54 Disaster risk assessment

No	Reservoir name	Earthquake	Landslide	Tsunami	Volcanic eruption	Liquefaction	Flood	Extreme weather	Land and forest fires	Drought
1	**Waduk Jatiluhur**	Low - Medium	No Risk	No Risk	No Risk	No Risk	No Risk	Low - High	No Risk	Low
2	**Waduk Cirata**	Low - High	No Risk	No Risk	No Risk	No Risk	No Risk	Low - High	No Risk	Low
3	**Waduk Gajahmungkur**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - Medium	Low - Medium	No Risk	Low - Medium
4	**Waduk Kedungombo**	Low	No Risk	No Risk	No Risk	No Risk	Low - High	Low - High	No Risk	Low - Medium
5	**Waduk Saguling**	Low	No Risk	No Risk	No Risk	No Risk	No Risk	Low	No Risk	Low - Medium
6	**Waduk Jatigede**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - Medium	Low - High	No Risk	Low - Medium
7	**Waduk Karangkates**	Low - High	No Risk	No Risk	No Risk	No Risk	No Risk	Low - High	No Risk	Low - Medium
8	**Waduk Wadaslintang**	Low	No Risk	No Risk	No Risk	No Risk	Low	Low	No Risk	Low
9	**Waduk Cacaban**	Low	No Risk	No Risk	No Risk	No Risk	Low - High	Low - High	No Risk	Low - High
10	**Waduk Malahayu**	Low	No Risk	No Risk	No Risk	No Risk	Low	Low - High	No Risk	Low
11	**Waduk Mrica**	Low	No Risk	No Risk	No Risk	No Risk	Low - High	Low - High	No Risk	Low - High
12	**Waduk Gondang**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - Medium	Low - High	No Risk	Low - High
13	**Waduk Widas**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - High	Low - Medium	No Risk	Low - High
14	**Danau Beratan**	Low - High	No Risk	No Risk	No Risk	No Risk	Low - Medium	Low-High	No Risk	Low - Medium
15	**Waduk Darma**	Low - Medium	No Risk	No Risk	No Risk	No Risk	No Risk	Low - Medium	No Risk	Low - High
16	**Waduk Wonorejo**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - High	Low	No Risk	Low - High
17	**Waduk Pondok**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - High	Low - Medium	No Risk	Low - High
18	**Waduk Cipancuh**	Low	No Risk	No Risk	No Risk	No Risk	Low	Low - Medium	No Risk	Low - Medium

No	Reservoir name	Earthquake	Landslide	Tsunami	Volcanic eruption	Liquefaction	Flood	Extreme weather	Land and forest fires	Drought
19	**Waduk Pacal**	Low	No Risk	No Risk	No Risk	No Risk	Low - High	Low	No Risk	Low - Medium
20	**Waduk Lahor**	Low - High	No Risk	No Risk	No Risk	No Risk	No Risk	Low - High	No Risk	Low - Medium
21	**Waduk Cengklik**	Low - Medium	No Risk	No Risk	No Risk	No Risk	Low - Medium	Low - Medium	No Risk	Low - Medium

ANNEX F - Preliminary Grid Integration Analysis

Table 55 Summary of maximum hosting capacity

No	Name	Substation	Distance (km)	Maximum hosting capacity (MW)
1	**Waduk Jatiluhur**	Jatiluhur Baru 150 kV	1.17	521
2	**Waduk Cirata**	Cirata 150 kV	2.52	1853
3	**Waduk Gajah Mungkur**	Wonogiri 150kV	7.94	272
4	**Waduk Kedung Ombo**	Kedungombo 150 kV	0.8	329
5	**Waduk Saguling**	Rajamandala 150 kV	6.73	248
6	**Waduk Jatigede**	Jatigede 150kV	2.92	529.5
7	**Waduk Karangkates**	Sutami 150kV	0.57	487.5
8	**Waduk Wadaslintang**	Wadaslintang 150 kV	0.78	208.5
9	**Waduk Cacaban**	Kebasen 150kV	13.5	599
10	**Waduk Malahayu**	Brebes 150 kV	26.87	406
11	**Waduk Mrica**	Mrica 150kV	1.88	450.5
12	**Waduk Gondang**	Ngimbang 150 kV	13.06	1073
13	**Waduk Widas**	New Nganjuk 150 kV	13.31	731
14	**Danau Beratan**	Baturiti 150 kV	2.13	413
15	**Waduk Darma**	Kuningan Baru 150kV	7.64	826
16	**Waduk Wonorejo**	Tulungagung 150kV	13.22	1113
17	**Waduk Pondok**	Ngawi 150kV	11.74	1071
18	**Waduk Cipancuh**	Haurgeulis 150 kV	6.12	97
19	**Waduk Pacal**	Bojonegoro 150kV	20.72	418
20	**Waduk Lahor**	Sutami 150kV	1.91	487.5
21	**Waduk Cengklik**	Banyudono 150kV	3.68	1069

Table 56 Potential capacity of each site

No	Reservoir name	Area (ha)	Capacity_20% areas (MWp)	Capacity_eff water area (MWp)	Maximum Hosting Capacity (MW)	Maximum Hosting Capacity (MWp)	Distance to Substation (km)	PV Capacity (MWp)
1	**Waduk Jatiluhur**	7091.4	1418	5248	521	651	1.17	651
2	**Waduk Cirata**	5729.6	1146	3953	1853	2316	2.52	1146
3	**Waduk Gajah Mungkur**	4849.3	970	2716	272	340	7.94	340
4	**Waduk Kedung Ombo**	3838.6	768	2034	329	411	0.8	411
5	**Waduk Saguling**	3515.6	703	1477	248	310	6.73	310
6	**Waduk Jatigede**	3392.0	678	2646	530	662	2.92	662
7	**Waduk Karangkates**	1283.0	257	616	488	609	0.57	257
8	**Waduk Wadaslintang**	1141.8	228	948	209	261	0.78	261
9	**Waduk Cacaban**	642.6	129	238	599	749	13.5	129
10	**Waduk Malahayu**	538.4	108	226	406	508	26.87	108
11	**Waduk Mrica**	487.0	97	365	451	563	1.88	97
12	**Waduk Gondang**	484.6	97	68	1073	1341	13.06	68
13	**Waduk Widas**	437.7	88	105	731	914	13.31	88
14	**Danau Beratan**	383.4	75	376	413	516	2.13	77
15	**Waduk Darma**	382.1	76	290	826	1033	7.64	76
16	**Waduk Wonorejo**	362.1	72	239	1113	1391	13.22	72
17	**Pondok**	332.1	66	96	1071	1339	11.74	66
18	**Waduk Cipancuh**	329.0	66	0	97	121	6.12	0
19	**Waduk Pacal**	317.3	63	54	418	523	20.72	54
20	**Waduk Lahor**	315.1	53	101	488	609	1.91	63
21	**Waduk Cengklik**	288.7	51	107	1069	1336	3.68	58

ANNEX G – List of Relevant Regulations Affecting the Location Selection

Table 57 List of relevant regulations affecting location selection and E&S screening

No	Policies / Regulations	Key Summary	Recommendations on E&S Screening
Environmental			
National			
1	**Law No. 32 of 2009 on Environmental Protection and Management**	This Law aims to create an environmentally sustainable development through means of environmental planning policy, and rational exploitation, development, maintenance, restoration, supervision and control of the environment.	This regulation serves as one of the main references considered to determine the necessary actions based on a high-level assessment of the potential environmental and social risks of a potential site. It is not used directly to determine the risk assessment, as at this study stage there is no project-specific data available to enable a deeper review of the regulatory requirements.
2	**Government Regulation No. 22 of 2021 on the Implementation of Environmental Protection and Management**	This regulation governs the framework for different components of the environment and its proper management: Environmental Approvals; Water Quality Protection and Management; Air Quality Protection and Management; Seawater Quality Protection and Management; Environmental Damage Control; Waste Management; Guarantee Fund for Environmental Function Restoration; Environmental Information System; Guidance and supervision; Administrative Sanctions and transitional provisions	
3	**Ministry of Environmental and Forestry Regulation No.04 of 2021 on the List of Business and/or Activities required to have Environmental Impact Analysis, Environmental Management Efforts, and Environmental Monitoring Efforts or Statement of Environmental Management and Monitoring Ability**	This regulation defines the criteria and list of businesses and activities that are mandatory to have EIA/AMDAL, UKL-UPL, and SPPL. Under the regulation, PLTS projects ≥50 MW generally require the highest level of environmental assessment, while those between 1 MW and <50 MW have proportionate requirements based on potential impacts. Projects <1 MW require an in-depth study on planning, safety standards, and operational complexity.	

4	**the Ministry of Public Works and Housing Regulation Number 27/PRT/M/2015 on Dams, as amended by Regulation Number 7 of 2023**	In accordance with the Ministry of Public Works and Housing Regulation Number 27/PRT/M/2015 on Dams, as amended by Regulation Number 7 of 2023, the use of reservoir surfaces must not compromise the primary functions of the dam. As guided by applicable technical standards and prevailing practice in Indonesia, the maximum allowable coverage for floating PV systems is limited to 20% of the reservoir's surface area to ensure that water resource management and dam operations remain secure and effective	Maximizing the 20% limit for the FPV utilisation.
5	**Law No 1 Year 2014 Concerning Amendment to Law No 27 Year 2007 concerning** **Management of Coastal Zone and Small Islands**	This regulation provides guidelines for utilising coastal zones by owning a Location Permit (now Suitability of Space Utilization Activity Permit or KKPR) in Article 16 Paragraph 1. In Article 35, it is explained that in the utilization of coastal areas and small islands, everyone is directly or indirectly prohibited from using tools, methods and other methods that damage the ecosystems of coral reefs, mangroves and seagrass beds that are not in accordance with the characteristics of the area; carry out conversion of mangrove ecosystems in cultivation areas or zones; carry out physical development that causes environmental damage and/or harms the surrounding community	This regulation is taken into consideration by the Consultant when conducting E&S Screening to exclude sites located in mangrove areas
6	**Government Regulation No. 7 of 1999** **Minister of Environmental and Forestry Regulation No. P.106/ MENLHK/SETJEN/KUM.1/8 of 2018 on Second Amendment on Minister Regulation No. P.20/ MENLHK/SETJEN/KUM.1/6 of 2018**	Concerning Preservation of wild Plant and Animals, Flora and Fauna Conservation, and Flora Fauna Protection Species This regulation provides list of flora fauna identified as protected species in Indonesia.	This regulation is a reference for the Consultant in carrying out E&S Screening to assess the risk of potential sites according to the presence of protected species in Indonesia.
7	**MoEF Regulation No P.94/MENLHK/SETJEN/ KUM.1/12/2016**	Invasive Species This regulation provides list of flora fauna identified as invasive species in Indonesia.	This regulation is a reference for the Consultant in carrying out E&S Screening to assess the risk of potential sites according to the presence of invasive species in Indonesia.

8	**Government Regulation No. 23 of 2021 concerning Forestry Management**	To comply with forest protection according to Chapter VII, the regulation describes the holders of forest utilization approvals. Forest Protection should be carried out by the business (or permit holders) in their working areas. The scope of protection includes landscapes, vulnerability of endemic flora and fauna, protection of HCV, fragmentation of fauna corridors, and mangrove or peatland.	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are located in.
9	**Government Regulation No. 23 of 2021 concerning Forestry Management**	Regarding Social Forestry (Indicative Map and Utilization Permit) Social Forestry is a system of sustainable Forest management implemented within the State Forest or Private Forest/Customary Forest Area implemented by the local community or Customary Law Community as the main actor to improve their welfare, the environmental balance and socio-cultural dynamics in the form of Village Forest, Community Forest, Community Crop Forest, Customary Forest, and Forestry partnerships. Social forestry indicative map is established from protection forest and production forest that is not managed by local forestry agencies, locally known as Peta Indikatif Areal Perhutanan Sosial or PIAPS. Social forestry utilization permit is obtained through MoEF approval, managed by local forestry management unit, and utilized by village-based forest farmer community."	
10	**Government Regulation No. 23 of 2021 concerning Forestry Management**	"Regarding forest utilization permit for forestry and non-forestry uses: Forest utilization approval (PPKH) is an approval for the use of part of a Forest Area for development purposes outside Forestry activities without changing the function and designation of the Forest Area. Business Licensing for Forest Utilization (Perizinan Berusaha Pemanfaatan Hutan or PBPH) is the Business Licensing granted to Business Actors to start and operate Forest Utilization businesses and/or activities. PBPH and PPKH holders cannot share their forest utilization permit to other parties without MoEF approval."	

11	**Presidential Regulation No. 121 Year 2012 concerning Rehabilitation of Coastal Zone and Small Islands**	This regulation regulates the rehabilitation of coastal and small island ecosystems which are considered to have exceeded the criteria for ecosystem and population damage due to the utilisation of coastal areas and small islands. One of these rehabilitations was also carried out on mangroves. This regulation describes the criteria for damage to the ecosystem or population in question which require rehabilitation, rehabilitation stages, monitoring and evaluation, participation, and financing.	This regulation is taken into consideration when conducting E&S Screening to exclude sites located in mangrove areas
12	**Presidential Regulation No. 120 Year 2020 concerning Peatland and Mangrove Restoration Body (Badan Restorasi Gambut dan Mangrove or BRGM)**	The regulation stipulates the Peatland and Mangrove Restoration Body as the body to facilitate the acceleration of peatland restoration in 7 provinces and implement the acceleration of mangrove rehabilitation in 9 provinces.	This regulation is taken into consideration when conducting E&S Screening to exclude sites located in mangrove areas
13	**Ministry of Environment and Forestry Regulation No. 7 of 2021 concerning Forestry Planning, Changes of Designation in Forest Area, and Changes of Function in Forest Area, and Forest Utilization**	"The regulation stipulates the definition of forest based on status, area, functions, and guidelines for forest inventory as the basis of forestry planning and designation. The regulation provides guidelines to change and utilize forest area outside forestry activities including guidelines to obtain forest utilization approval (PPKH). The use of Forest Area with the mechanism of Forest Area Utilization Approval by the decision of the Minister includes electricity supply, including power generation installations, transmission, electricity distribution, substations, as well as new and renewable energy technologies"	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are situated in.

14	**Ministry of Agrarian Affairs and Spatial Planning/National Land Agency (ATR/BPN) Regulation No. 1589 of 2021 concerning Map of the designation of protected rice fields**	“Protected rice fields are designated to fulfill the national staple needs of rice and accelerate the determination of sustainable agricultural land. According to the regulation, protected rice fields are distributed in several provinces. Relevant areas to the project area of interest are Banten, West Java, Central Java, DI Yogyakarta, East Java, and Bali. The regulation stipulates that initiatives of industrial areas and strategic national policy situated within the protected rice fields can be omitted from the protected rice fields area. If the project wants to utilise the protected rice fields area, a land use change recommendation from the Ministry of Agrarian Affairs and Spatial Planning/National Land Agency is needed.	This regulation is the Consultant´s recommendation to exclude potential sites in rice fields.
15	**Presidential Instruction No. 5 of 2019 concerning Termination Of Granting New License and Governance Improvement for Primary Forest and Peatlands**	This regulation focuses on the moratorium on new licenses for primary natural forest and peatland conversion. It's relevant to peatland and mangroves as they fall within the scope of primary natural forests. It is also relevant to area with forestry status (conservation, protection, and production forest).	This regulation is a reference in conducting E&S Screening to exclude potential sites located on moratorium land.
16	**Ministry of Environment and Forestry Decree No. SK. 3554/ MENLHK-PKTL/IPSDH/PLA.1 3/2023 of 2023 and Forestry Decree No. SK.12764/MENLHK-PKTL/IPSDH/ PLA. 1/ 11/2023 dated 22 November 2023 concerning Determination of an Indicative Map for Cessation of Granting Business Permits, Approvals for Use of Forest Areas, or New Forest Area Allocation Requirements for Primary Natural Forest and Peatland in 2023 Period I and Period II**	The ministerial decree explains indicative areas of termination to grant business permits, approval for use of forest areas, or changes to the designation of new forest areas, including business permits for the utilization of protected forests. The permitted location could be proposed as a revision to the PIPPIB Map. The permitting agency should report to MoEF bi-annually (3rd decree and 12th decree).	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the type of forestry category the sites are situated in.

17	**Keputusan Menteri Lingkungan Hidup dan Kehutanan SK. 8/Menlhk-PKTL/REN/ PLA.0/1/2023 tentang Peta Indikatif dan Areal Perhutanan Sosial (Revisi VIII)**	This regulation stipulates that the Indicative Map of Social Forestry Areas, hereinafter abbreviated as PIAPS, is a map containing state forest areas reserved for social forestry. Social forests include social forests that can be located in production forests, protected forests, indicative areas of customary forests, and definitive social forestry and customary forest areas.	This regulation is a reference in carrying out E&S Screening to assess the risk of potential sites according to the presence of social forest surrounding it.
18	**Key Biodiversity Area concerning Key Biodiversity Area**	Key biodiversity area is one of high biodiversity value areas which is recognized by international standards, i.e., IFC PS 6 and ADB Environmental Safeguards.	This regulation is a reference to exclude potential sites located in high biodiversity areas.
19	**Ministry of Education, Culture, Research, and Technology concerning Cultural Heritage Database**	The database provides information such as coordinates, administrative locations, name and shape of the cultural heritage nationwide. However, it does not provide the map of cultural heritage distribution, and there is some missing information in some of the data list.	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
20	**Registration Body of Indigenous Area (Badan Registrasi Wilayah Adat) concerning Indigenous territory map**	The database is from national NGO covering Indigenous area and people. Each indigenous area has different status, i.e., registered, verified, and certified. No information available regarding the details of each status, however, some policies and regulations were added to some of the indigenous area as additional information.	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
21	**Minister of Internal Affairs Regulation No. 52 Year 2014 on Customary Law Community Recognition**	This regulation defines the recognition process for Masyarakat Hukum Adat (Customary Law Communities) and provides criteria for legal acknowledgment and protection of their rights, territories, and governance systems.	This regulation is a reference to identify project areas potentially overlapping with customary territories. Screening should include verifying community recognition status and ensuring early engagement and consent-based approaches. The Consultant will use the Ministrial Data database to assess the presence of Customary Law Communities as recognized Indigenous People within and surrounding site selection area and include them in MCDM Analysis.

22	**Presidential Decree No. 186 Year 2014 concerning Empowerment of Remote Indigenous Communities**	Provides a framework for empowering and protecting Remote Indigenous Communities (Komunitas Adat Terpencil), including support for livelihoods, housing, education, and land tenure.	This regulation is a reference to identify if a project site affects vulnerable or remote Indigenous communities, requiring tailored livelihood support, relocation safeguards, and inclusive consultation processes. The Consultant will use database from Ministrial Data to assess the presence of Remote Indigenous Communities within and surrounding sites selection area and include into MCDM Analysis.
23	**Law No. 11 of 2010 concerning Cultural Preservation**	The law stipulates criteria of cultural heritage and conservation cultural heritage in general. Cultural heritage shall be conserved and protected, and it is prohibited to prevent and obstruct efforts to preserve cultural heritage intentionally.	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.
24	**Law No. 5 of 2017 concerning Cultural Advancement**	This regulation outlines the advancement and protection of intangible cultural heritage such as local knowledge, traditional crafts, language, rituals, and community practices.	This regulation is a reference to assess potential non-physical cultural impacts from project activities, including on traditional customs, oral traditions, and community rituals. Stakeholder engagement must include cultural bearers and local knowledge holders.
25	**Government Regulation No. 1 of 2022 concerning National Registry and Conservation of Cultural Heritage**	"The regulation acts as an implementation of Law No. 11 of 2010 concerning Cultural Heritage. GR 1/2022 gives authority to the government and community participation in managing cultural heritage so that a good managerial system of planning, implementation and evaluation can be achieved regarding the protection, development and utilization of cultural heritage as a cultural resource for broad interests. Various aspects of cultural heritage conservation, i.e., registration, preservation, area management, incentives and compensation, supervision to funding are stipulated in this regulation. It is stated that every person who owns or controls an Object of Alleged Cultural Heritage (Objek Diduga Cagar Budaya or ODCB) is required to register with the regent/mayor free of charge. Anyone who finds an ODCB is also obliged to report their findings to the competent authority in the field of culture, the Indonesian National Police, and/or related agencies in the area where the object was found."	This regulation is a reference to provide recommendations for potential sites not located in cultural heritage zones. Geospatial analysis is carried out in the MCDM process by following this recommendation.

Regional			
26	**Governor of West Java Decree No 96 of 2022 on Management of Floating Net Cage (FNC) in the Area of Cirata, Saguling and Jatiluhur dam**	This governor's decree defines the management of Floating Net Cages (FNC) in the reservoir areas of three dams in the Citarum River basin. The operational guidelines for FNC include the organisation of FNC, policies and strategies for managing FNC, and their utilisation. This regulation includes the calculation of FNC and the number of units in 2021, with baseline data showing 7,204 units in Cirata Reservoir, 3,282 units in Saguling Reservoir, and 11,306 units in Jatiluhur Reservoir; however, these numbers have increased based on current conditions.	This regulation is considered when conducting E&S screening to categorize the size of the FNC and assess the associated social risk implications.

ANNEX H - Detailed List of Relevant Regulations for FPV Implementation

In addition to the regulations that directly related as input for developing MCDM criteria, as outlined in Chapter 2.4 , regulations that do not directly affect the MCDM processes but are relevant for the other aspects of this Project were also assessed, such as potential financing sources, required permits for FPV development, and available government support for solar PV development. The detailed list is provided in Table 58 below.

Table 58 List of relevant regulations for FPV implementation

No	Policies / Regulations	Key summary	Recommendations on E&S screening
Environmental			
National			
1	**Law No. 2 of 2012 on the Land Acquisition for Development in the Public Interest**	It conferred upon the state the legal authority to acquire privately held land for the purpose of economic development, and it established a statutory process for the determination of compensation as well as clearly defined procedural requirements.	This regulation is a reference to identify land parcels that may be subject to acquisition and assess potential social risks such as displacement, loss of assets or income sources. Screening should include reviewing land tenure status, compensation eligibility, and history of land ownership or disputes in the project-affected area.
2	**Government Regulation No. 21 of 2010 concerning Protection of Marine Environment**	“Discharge prohibition Chapter VII Article 33, paragraph (2)i: waste disposal in waters can only be carried out at specific locations determined by the minister after fulfilling the requirements: mangrove area is excluded”	It is not directly related to the geospatial analysis carried out during the site selection process in E&S screening.
3	**Presidential Regulation Number 78 of 2023 on the Amendment to Presidential Regulation Number 62 of 2018 on the Management of Social Impacts in the Context of Land Acquisition for National Development**	This regulation governs the management of social impacts related to land acquisition for national development projects, including electricity infrastructure. It includes stipulations to clarify community land ownership and usage requirements, define the types and mechanisms of compensation, and establish technical procedures for implementing social impact mitigation.	This regulation is a reference for understanding eligibility identification, types of compensation, and roles and responsibilities in managing the social-related impact of national development projects.

4	**Presidential Regulation No. 112 of 2022**	- The latest regulation concerning the acceleration of renewable energy development for the provision of electricity is one measure to entice investments and accelerate the RE mix target, as well as reduce GHG emissions. - For financial feasibility, it helps details how PLN determines electricity purchase prices. The prices are negotiated based on a maximum benchmark price set by the government, which considers various factors such as the type of renewable energy technology and the power plant's location. This regulation includes a ceiling price for renewable energy, including solar PV.	The ceiling price stipulated in this regulation is used as tariff assumption in the financial analysis
5	**Ministry of Finance Regulation No. 5 of 2025**	Stipulates a government guarantee and risk mitigation mechanism to accelerate the development of renewable energy projects for electricity supply in Indonesia, including solar PV power plants.	Not used in the analysis, but is considered in the proposed investment mechanism options that will be provided in the Final Report (D6)
6	**Ministry of Environment Regulation No. 17 of 2012**	Guidelines for community engagement in the environmental impact analysis process and environmental permit. It mandates meaningful stakeholder engagement during the Environmental Impact Assessment (EIA) process, including disclosure, consultation, and public involvement in decision-making.	This regulation is a reference to ensure that stakeholder mapping and consultation processes are inclusive, transparent, and documented from the screening phase onward, especially for affected communities and vulnerable groups.
7	**Ministry of Home Affairs Regulation No. 7 of 2024**	This outline covers the rent charged for regional government assets, including the base rent tariff and the rent adjustment factor, including for power plant projects.	Used as the basis to assume a IDR 0 rent charge for a government-owned land
8	**Government Regulation No. 39 of 2023 on the Implementation of Land Acquisition for Development in the Public Interest**	This regulation amends the regulation of the Government of the Republic of Indonesia no. 19 of 2021 on implementing land acquisition for development in the public interest. The amendments concern various articles of the main Regulation and focus on the phases of the process of land acquisition, the roles and responsibilities of various parties involved in the process, procedures for changing the status and obtaining permission for land acquisition from different types of land.	This regulation is a reference to ensure that project planning aligns with the most updated legal procedures for land acquisition, including required permits and institutional clearances. Screening should assess whether project activities could trigger complex land tenure issues or require engagement with multiple government agencies and customary right holders and identify procedural delays or contestation risks.

<table>
<tr><th colspan="4">Regional</th></tr>
<tr>
<td>9</td>
<td>Presidential Regulation No 15 of 2018 on Acceleration of Pollution Control and Damage of Citarum Watershed</td>
<td>This regulation outlines the restoration plan for the Citarum River Basin (DAS Citarum), including the establishment of the Citarum Pollution and Environmental Damage Control Task Force (Tim DAS Citarum). The task force is composed of a Steering Committee and an Operational Unit, with the following key positions:
Commander: Governor of West Java
Deputy Commander for Ecosystem Management I: Commander of the Military Regional Command III/Siliwangi
Deputy Commander for Ecosystem Management II: Commander of the Military Regional Command Jayakarta
Deputy Commander for Legal Prevention and Enforcement I: Chief of the West Java Regional Police and Head of the West Java High Prosecutor’s Office
Deputy Commander for Legal Prevention and Enforcement II: Chief of the Jakarta Metropolitan Police
The regulation also highlights the strategic importance of the Cirata, Saguling, and Jatiluhur Dams, embankment dams located along the Citarum River in West Java.</td>
<td rowspan="2">This regulation impacts the Environmental and Social (E&S) Screening criteria by acknowledging and considering that stricter environmental standards and permitting requirements.

Under its implementing regulation (Permen PUPR No. 7/2023), the use of reservoir inundation areas is restricted to:
Tourism
Sports
Aquaculture
Floating solar power generation
The use of reservoir buffer zones is limited to:
Research and scientific development
Water resources infrastructure
Access roads, bridges, and docks
Gas and drinking water pipelines
Power and telecommunication lines
Tourism, sports, and religious facilities
Sanitation infrastructure
Electricity infrastructure
Activities that maintain the buffer zone’s function
If FPV occupies more than 20% of the reservoir’s surface area at normal water level, a technical study and recommendation from the Dam Safety Commission is required.

The Consultant will incorporate this insight into the E&S considerations, particularly regarding potential environmental and social implications associated with shared use of the inundation and buffer zone areas.</td>
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<tr>
<td>10</td>
<td>Governor of West Java Decree No 37 of 2021 on the Revision of the West Java Governor No 28 of 2019 concerning Action Plan on the Pollution and Damage Control of Citarum River Basin 2019 – 2025</td>
<td>This regulation covers the Revision of the Pollution and Damage Control Action Plan for the Citarum Watershed from 2021 to 2025.</td>
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11	**Purwakarta Regent's Regulations No. 114/2021**	Stipulated the formula to calculate the land rent price for sites located within and nearby the Purwakarta regency	The land rent price estimation in the financial analysis is based on the formula stipulated in the regulations for sites located within and nearby the regencies as applicable
12	**Wonogiri Regent Regulation No. 45/2022**	Stipulated the formula to calculate the land rent price for sites located within and nearby the Wonogiri regency	
13	**Sumedang Regent's Regulations No. 98/2020**	Stipulated the formula to calculate the land rent price for sites located within and nearby the Sumedang regency	

ANNEX I - Water Surface Elevation and Average Water Depth Results

Table 59 Summary of water surface elevation and average water depth results

No	Water Body Name	Depth Avg. (m)	Min WSE (m)	Max WSE (m)	WSE Range	Range > depth?	Eff. Area (%)	WSE Recordings
1	**Waduk Jatiluhur**	36.3	89.214	107.074	17.86	no	74	53
2	**Waduk Cirata**	60.2	207.802	220.545	12.743	no	69	53
3	**Waduk Gajah Mungkur**	8.1	127.385	137.824	10.439	no	56	30
4	**Kedung Ombo Reservoir**	20.3	72.458	89.515	17.057	no	53	51
5	**Waduk Saguling**	27.3	629.212	657.411	28.199	no	42	53
6	**Waduk Jatigede**	0	242.953	263.815	20.862	yes	78	47
7	**Waduk Karangkates**	32.4	272.621	272.621	0	no	48	1
9	**Waduk Cacaban**	6.1	69.157	77.689	8.532	no	37	35
10	**Waduk Malahayu**	9.5	49.703	56.81	7.107	no	42	23
12	**Waduk Gondang**	5.5	32.581	40.732	8.151	no	14	23
13	**Waduk Widas**	10.4	102.337	112.025	9.688	no	24	50
14	**Danau Beratan**	15.5	1229.506	1232.809	3.303	no	98	38
15	**Waduk Darma**	7.9	695.169	704.132	8.963	no	76	43
16	**Waduk Wonorejo**		168.424	168.424	0	no	66	1
17	**Pondok**	6	97.35	108.292	10.942	yes	29	27
18	**Waduk Cipancuh**	1.5	24.638	35.094	10.456	yes	0	20
19	**Waduk Pacal**	11.5	109.145	117.97	8.825	no	17	24
20	**Waduk Lahor**	17.9	273.4	279.67	6.27	no	32	2
21	**Waduk Cengklik**	3.5	138.403	142.569	4.166	no	37	30