Hydropower Sustainability Assessment Protocol (HSAP) Implementation in Indonesia: A mini-review

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ABSTRACT

Sustainability is one of the principles in infrastructure asset management. In a hydropower project, Hydropower Sustainability Tools (HST) is needed in assessing sustainability principles into practice when developing new hydropower projects. International Hydropower Association (IHA) published guidelines consisting of three documents; one of them is Hydropower Sustainability Assessment Protocol (HSAP). This study is a mini-review focusing on the implementation of HSAP in hydropower projects in Indonesia, including the Pelosika project in Southeast Sulawesi, the Ir. H. Juanda project, and the Bendung Perjaya project in South Sumatra. HSAP has its advantages and disadvantages, it covers a variety of topics widely, but the assessment is somewhat subjective, time-consuming, and cost-intensive. HSAP is relatively new in Indonesia; there are not many publications regarding this topic. Future studies are recommended to know more about its potential in increasing the sustainability of hydropower projects.

Keywords : infrastructure asset management, hydropower, sustainable infrastructure, HSAP, IHA, Indonesia.

INTRODUCTION

One of the important aspects of Infrastructure Asset Management is ensuring that the infrastructure always conforms to the sustainability aspect. Various techniques and tools are already in existence (Suprayitno & Soemitro, 2018).

One of Indonesia's goals to achieve the Paris Climate Agreement is to increase renewables' share in its energy mix to 23% by 2025 and 31% by 2050. It is currently heavily reliant on coal and other non-renewable resources. Indonesia has established a very stable fossil fuel-based electricity regime, doing any planning or managing its transition is a challenge (Marquardt, 2014). Hydropower is the country's largest renewable energy source, with more than 5 GW installed. According to the potential hydropower study in the early 1980s, Indonesia has a potential capacity of roughly 75 GW, although according to the recent study, only 8 GW can be built (PwC Indonesia, 2018). Hydropower is power obtained from the force of moving water. It is widely used to produce electricity, among other useful purposes. There are many hydropower types; some of them are reservoir type, pumped-storage, run-of-river, and multipurpose hydropower (Egré & Milewski, 2002).

Apart from the promising performance, hydropower faces a significant challenge in the last decades due to extreme weather events. Climate change has the potential to impact the hydropower sector through changes in rainfall and water availability. Variations of inflow during extreme weather events could eventually affect the operation of the hydropower facilities. This phenomenon brings out reservoir management complexity (Qin et al., 2020). A combination of simulation and optimization models might be needed to predict the operation scenario that works best under climate change circumstances (Chang et al., 2018). The impact of climate change at the global level might be small, even though variations exist in specific locations. The capacity of reservoirs would also play a role during the changing of water resources. Large-scale reservoirs are less vulnerable to climate change (Berga, 2016). Large-scale reservoirs possess more significant environmental and socio-economic impacts if the whole development and operation stages are considered. This aspect includes the change in river ecology, aquatic biodiversity, and the displacement of thousands of people (Moran et al., 2018). Changing of water level and flow in the downstream area is unavoidable. The socio-economic impact is mostly related to mitigation measures and compensation issues (Klimpt et al., 2002). There is also an ongoing trend in developing small-scale hydropower plants (SHP) to have a more sustainable plant even though the size category of 'small' varies across countries (Couto & Olden, 2018).

The basic principle of Infrastructure Asset Management is a task, knowledge, and science to manage the infrastructure through the whole of its life cycle so that the infrastructure can sustainably function effectively, efficiently, and under sustainable principles (Suprayitno & Soemitro, 2019). Infrastructure Asset Management analysis and programming need specific tools. In the case of sustainability of hydropower projects, Hydropower Sustainability Tools (HST) are needed.

The International Hydropower Association (IHA), founded in 1995, published recognized industry guidelines and assessment tools used by the hydropower sector to design, develop and assess sustainable projects. IHA is supporting Indonesia to put sustainability principles into practice when developing new hydropower projects. The publication of the first IHA Sustainability Guidelines in 2004 leads to the Hydropower Sustainability Assessment Forum formation between 2008 and 2010, which delivered the Hydropower Sustainability Assessment Protocol (HSAP). A process of drafting and expert review by leading authorities in their fields took place during 2018, resulting in the 26 chapters presented in the guidelines. The Hydropower Sustainability Guidelines were reviewed and approved by the Hydropower Sustainability Assessment Council (HSAC) through its governance committee, leading to its publication in December 2018. The guidelines provide definitions of good practice following six criteria, covering project assessment, management, stakeholder engagement, stakeholder support, conformance/compliance, and outcomes (IHA, 2018c). The guidelines expand on what is expected by statements on these criteria in two complementary assessment tools, the Hydropower Sustainability Assessment Protocol (HSAP) (IHA, 2018a) and the Hydropower Sustainability Environmental, Social and Governance Gap Analysis Tool (HESG) (IHA, 2018b).

This paper aims at presenting a review of the HSAP implementation in Indonesia. The type and profile of hydropower projects using the HSAP will be identified. We discuss future challenges and opportunities in implementing HSAP in hydropower projects in Indonesia, which local researchers and governmental agencies can also use to create more sustainable infrastructures.

RESEARCH METHODS

This study was conducted by following these steps: background statement, research objective statement, research methods, literature review, research analysis, and conclusions. In this paper, the literature review was conducted to compare HSAP implementation studies in different hydropower projects in Indonesia. In the process, we found that there is not much research regarding HSAP usage in Indonesia, so it is only possible to write a mini-review.

LITERATURE REVIEW

Hydropower Sustainability Tools (HST)

To identify impacts (environmental and socio-economic impacts) elevated from developing hydropower projects in all stages and create appropriate adaptation measures, undertaking a sustainability assessment before the project planning is needed, e.g., using Hydropower Sustainability Tools (HST). HST by the International Hydropower Association (IHA) comprises a set of three documents: 1) the Hydropower Sustainability Assessment Protocol (HSAP), 2) the gap analysis tool for environmental, social, and government (HESG) aspects of hydropower, 3) and guidelines on good international industry practice (HGIIP). HSAP can be used for assessing the full range (ESG, business, and economic) of aspects of the hydropower projects in all their lifecycle (Lyon, 2020).

Table 1. HSAP and HESG Comparison

HSAP	HESG
Can be used in all project types (run-off river, storage/reservoir pumped storage)	Can be used in all project types (run-off river, storage/reservoir pumped storage)
Can be used in all project sizes (small < 10 MW, medium < 50 MW, large > 50 MW)	Can be used in all project sizes (small < 10 MW, medium < 50 MW, large > 50 MW)
Can be used in the early stages, preparation, implementation, and operation stages	Can only be used in the preparation, implementation, and operation stages
The average duration of assessment: 3-6 months	The average duration of assessment: 1-2 months
2-4 assessors per assessment	1-2 assessors per assessment
Average assessment costs $ 100K-200K	Average assessment costs $ 20K-50K
Final output: full report	Final output: action plan
Can be used in all countries	Can be used in all countries

Differences between both tools are shown in Table 1. HSAP is more frequently used. It is presumably because the tool can be used in the early stage of the project, unlike HESG, which can only be used later.

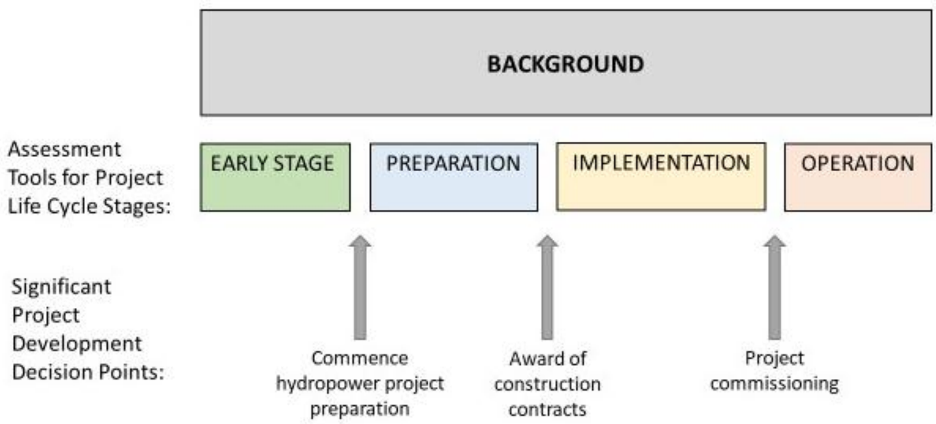

Figure 1. Protocol Assessment Tools and Major Decision Points (IHA, 2018a)

The HSAP is a sustainability assessment framework for hydropower projects and operations which outlines the essential sustainability considerations for a hydropower project and enables producing a sustainability profile. The four Protocol assessment tools – Early Stage, Preparation, Implementation, and Operation – are designed to be stand-alone assessments applied at a particular stage of the project life cycle (IHA, 2018a). The assessment tools and associated decision points are shown in Figure 1, and the topics in each section are shown in Table 2.

Table 2. Hydropower Sustainability Assessment Protocol Topics by Section (IHA, 2018a)

Early Stage	Preparation	Implementation	Operation
ES-1 Demonstrated Need	P-1 Communications and Consultation	I-1 Communications and Consultation	O-1 Communications and Consultation
ES-2 Options Assessment	P-2 Governance	I-2 Governance	O-2 Governance
ES-3 Policies and Plans	P-3 Demonstrated Need and Strategic Fit		
ES-4 Political Risks	P-4 Siting and Design		
ES-5 Institutional Capacity	P-5 Environmental and Social Impact Assessment and Mgmt	I-3 Environmental and Social Issues Mgmt	O-3 Environmental and Social Issues Mgmt
ES-6 Technical Issues and Risks	P-6 Integrated Project Management	I-4 Integrated Project Management	
ES-7 Social Issues and Risks	P-7 Hydrological Resource		O-4 Hydrological Resource
ES-8 Environmental Issues and Risks			O-5 Asset Reliability and Efficiency
ES-9 Economic and Financial Issues and Risks	P-8 Infrastructure Safety	I-5 Infrastructure Safety	O-6 Infrastructure Safety
	P-9 Financial Viability	I-6 Financial Viability	O-7 Financial Viability
	P-10 Project Benefits	I-7 Project Benefits	O-8 Project Benefits
	P-11 Economic Viability		
	P-12 Procurement	I-8 Procurement	
	P-13 Project Affected Communities and Livelihoods	I-9 Project Affected Communities and Livelihoods	O-9 Project Affected Communities and Livelihoods
	P-14 Resettlement	I-10 Resettlement	O-10 Resettlement
	P-15 Indigenous Peoples	I-11 Indigenous Peoples	O-11 Indigenous Peoples
	P-16 Labour and Working Conditions	I-12 Labour and Working Conditions	O-12 Labour and Working Conditions
	P-17 Cultural Heritage	I-13 Cultural Heritage	O-13 Cultural Heritage
	P-18 Public Health	I-14 Public Health	O-14 Public Health
	P-19 Biodiversity and Invasive Species	I-15 Biodiversity and Invasive Species	O-15 Biodiversity and Invasive Species
	P-20 Erosion and Sedimentation	I-16 Erosion and Sedimentation	O-16 Erosion and Sedimentation
	P-21 Water Quality	I-17 Water Quality	O-17 Water Quality
		I-18 Waste, Noise, and Air Quality	
	P-22 Reservoir Planning	I-19 Reservoir Preparation and Filling	O-18 Reservoir Management
	P-23 Downstream Flow Regimes	I-20 Downstream Flow Regimes	O-19 Downstream Flow Regimes
	P-24 Climate Change Mitigation and Resilience	I-21 Climate Change Mitigation and Resilience	O-20 Climate Change Mitigation and Resilience

The implementation of HSAP has been adapted in various countries. Foran et al. (Foran et al., 2010) applied the HSAP from a public interest perspective. They assumed that aquatic ecosystems in the Mekong region are critically crucial for less privileged people. Thailand's electricity planners should consider the distributional and ecological consequences of planning choices on a Mekong regional scale. HSAP has also been implemented in various World Bank Investment projects: Trung Son hydropower project in Vietnam, Kabeli-A hydropower project in Nepal, and Reventazón hydropower project in Costa Rica (Lyon, 2020).

Other international sustainability tools are present such as Low Impact Hydropower Certification by the Low Impact Hydropower Institute (LIHI) and the Green Hydropower Certification by the Swiss Federal Institute of Aquatic Science and Technology (EAWAG) (Xu et al., 2020). Most of these global hydropower sustainability tools use qualitative analysis, except, e.g., indicator system for green-small hydropower stations (Zhang et al., 2020). The use of international hydropower sustainability tools sometimes is not suitable for the local environment. Thus, some countries tend to develop their sustainability tools, e.g., the Systematic Sustainability Assessment (SSA) tool in Malaysia (Turan et al., 2018).

HSAP Implementation in Indonesia

Indonesia added 143.5 MW hydropower capacity in 2019. The government also plans to build the Mentarang Hydroelectric Power Plant in North Kalimantan, the country's largest hydro project with 1,350 MW, in 2020 (IHA, 2020). Large-scale projects with high environmental impacts in Indonesia, including reservoirs and hydropower plants, can only be carried out once the developers or operators submitted and passed the national Environmental Impact Assessment (EIA). There were only a few published studies mentioning the implementation of the HSAP in hydropower projects in Indonesia. This paper will discuss three of them: the Pelosika project in Southeast Sulawesi, the Ir. H. Juanda project, and the Bendung Perjaya project in South Sumatra.

The Pelosika Project

In 2017, Pelosika dam, a newly approved project in southeast Sulawesi, has become the first hydropower project in Indonesia to be assessed using HSAP by the Indonesian Government (IHA, 2018d). The IHA team carried out an independent assessment with funding from the State Secretariat for Economic Affairs of Switzerland (SECO). It was requested by the National Development Planning Agency of Indonesia (Bappenas).

Pelosika dam is located in the Konaweeha watershed, the largest watershed in Sulawesi, with the Konaweeha river as the main river. The dam is financed by a loan from China (PwC Indonesia, 2018). The hydropower plant will be placed to generate electricity with a capacity of 21 MW (Poindexter, 2018). The raw water flow amounts to 0.75 m3 s-1. It is expected to irrigate around 16,358 Ha of agricultural areas. The project is one of the nine projects listed in the list of medium-term planned external loans for 2015-2019 (Bappenas, 2015).

There is a flood issue in Konaweeha Watershed, which caused fatalities, damage to infrastructure and public facilities, and lower agricultural production (Sidik, 2016). Pelosika Dam's construction as a multipurpose dam is one of the government's efforts to cope with the flooding problem in the Konaweeha Watershed. With its multiple uses, the Pelosika Dam can drive regional development and improve the local population's livelihoods while increasing the national share of renewable energy. Early stages assessment using HSAP in Pelosika Dam aims to help the project team measure performance and identify opportunities to improve the Pelosika Dam (Costa, 2018). It is also suggested that the development of Pelosika Dam has a higher impact on flood control performance than the other dams in their watershed (Sidik, 2016). Unfortunately, there is no published report mentioning the detail of the HSAP results of the Pelosika project nor the progress of the project development.

The Ir. H. Juanda Project

Although the Pelosika project was the first project to be assessed officially as a part of the government project with the IHA team, there was already a study explaining the hydropower sustainability assessment in 2016 for Ir. H. Juanda project. Ir. H. Juanda dam, or Jatiluhur dam, is located in the Citarum watershed in West Java. There are three dams in the Citarum watershed in total: Jatiluhur, Saguling, and Cirata. Ir. H. Juanda dam was started to be built in 1957 and began its operation in 1967. It is the largest dam in Indonesia, with a hydropower capacity of 187.5 MW (Bappenas, 2014).

The multipurpose dam functions as one source of irrigation water, domestic water supply for the capital city, and power generator. Fish cages floating on the dam also attract tourists to come (Bahri, 2020). The Ir. H. Juanda hydropower plant's operation was assessed by a master's student from the UNESCO-IHE Institute for Water Education for the master thesis. Conducting the multiple aspects assessment through the HSAP on Juanda hydropower reservoir can help address some critical issues of hydropower sustainability that are still unidentified during its operational time since 1967 (Gama, 2016). The sustainability assessment using the HSAP was used to assess aspects covered in the operation stage suggested by the protocol. A total of 13 out of 19 given topics provided high relevance to the given condition (see IHA, 2018a). In general, the level of the sustainability performance of Ir. H. Juanda reservoir and HEPP is satisfying (Gama, 2016). The facility performs good basic practice (a score of 3) on seven topics; Environmental & Social Issues Management; Asset Reliability & Efficiency; Financial Viability; Labor & Working Conditions; Erosion & Sedimentation; Water Quality; Downstream Flow Regimes. There are even two topics that meet proven best practices at level five i.e., governance and hydrological resource.

The aspect that does not meet the good practice was biodiversity and invasive species. It is related to the inadequate efforts in preserving endemic fish species. The absence of fish ladders in the Ir. H. Juanda dam could lead to the disconnecting of fish species from upstream to downstream (Gama, 2016). The sudden death of fish due to excessive cultivated fisheries was reported in other studies (Astuti et al., 2016; Bahri, 2020; Pratiwi, 2009). Water quality and sediment are also required attention. The Jatiluhur reservoir has multiple functions, such as hydro power supply and water supply for different end-users. Multiple functions and multiple users mean there are tradeoffs in fulfilling the needs of different end-users. Bahri (2020) found that growth engines such as industrial development and residential development support industrial and residential sectors. However, water availability will be a crucial issue as water supply can bound the growth engines. Fulazzaky and Abdul Gany (2009) predicted that most developing countries, particularly Indonesia, will be facing sludge pressure problems in the next decades due to the increased water demands. Consequently, they will also be facing the challenges of soil erosion and sludge management as well as erosion and sedimentation. In conclusion, the environment is an important area that needs to be improved in maintaining the Ir. H. Juanda reservoir's sustainability function and must be noticed seriously.

The Perjaya Dam Project

Both HSAP dan HSEG tools can be used in all project sizes, so the implementation is not only on hydropower plant projects but also on micro-hydro powerplant projects. Due to environmental concerns and substantial capital costs, a large hydropower station has less attraction in the present world economy. Nonetheless, micro-hydro power has a relatively large potential to develop. Many small rivers have much energy to exploit by hydropower electrification, from pico-hydro to micro-hydro scale, particularly in Indonesia. Erinofiardi et al., (2017) concluded that the micro-hydropower plant has the lowest minimum payback period of other resources and suggested that the Indonesian government push micro-hydropower development more than any other renewable energy source in Indonesia. Rahajoeningroem and Utama (2020) implemented HSAP in the early stage of the micro-hydropower plant project in Perjaya Dam, South Sulawesi.

Bendung Perjaya (Perjaya Dam) was built in 1996 and later in the late 2010s was planned to be expanded as a hydropower project. It is located in the Musi watershed in South Sumatra (JICA, 2019). An earlier study conducted by JICA (2003) mentioned a report on the case of drought faced by communities living near the Komering river (Perjaya). Some assumed that this was due to the dam's presence, but the actual reason is that there was accumulated sediment at the bottom of the river. According to the study by Lestari (2014), the water flowing through the Perjaya Dam has the potential to be converted into energy of about 31,576 Gigawatt hours (GWh) per year. This study shows the results of physical and mathematical models of the existing situation in the Perjaya Dam. The Austrian government funds the hydropower project under the "Perjaya Low Head Utilisation Pilot Project" as reported by the Ministry of Public Works (2018). Like the Pelosika project, an early-stage sustainability assessment using HSAP was implemented recently in the Perjaya project to understand the project's risks and provide information on opportunities and challenges in developing micro-hydropower in the proposed location.

Rahajoeningroem and Utama (2020) conducted a study on the potential of planning micro-hydropower plants by utilizing irrigation networks to provide suggestions on national water resources policies, particularly on policies to increase water, food, and energy security. There was no published report mentioning who initiated the assessment or the assessment funding sources. The steps included in the assessment were preparation, data collection, data analysis, assessment using HSAP, presentation of the results, and focus group discussion. Nine topics were assessed including, demonstrated need, options assessments, policies and plans, political risks, institutional capacity, technical issues and risks, social issues and risks, environmental issues and risks, and economic and financial issues and risks.

One prominent result of this assessment is that there is no information regarding the project's environmental impact assessment (Rahajoeningroem & Utama, 2020). The environmental impact is an essential component as it builds the concept of sustainability infrastructure. However, one study discusses the biodiversity aspect of the Perjaya Dam, i.e., fish migration (Nizar et al., 2014). Perjaya Dam is equipped with a fish ladder, one among four fish ladders present in Indonesia (Maryono, 2008; Nizar et al., 2014). The study conducted in 2013 concludes that the fish ladder works effectively for fish migration during the wet season.

RESEARCH ANALYSIS

From the reports discussed in this paper, we can say that HSAP is applicable to be employed in Indonesia, even though only two out of three present results of the hydropower sustainability assessment using HSAP. Gama (2016) stated that HSAP has compliance with relevant regulatory/law government requirements at the national and local levels. It can also be applied as a sustainability improvement tool for Indonesia's projects' preparation and implementation stages.

The report of the Ir. H. Juanda project is the most comprehensive among all. The use of HSAP is relatively new in Indonesia. The government used it first in 2017 for the Pelosika project. Gama (2016) mentioned that the sustainability assessment using HSAP is somewhat subjective, and thus it could provide bias in the judgment of the accessors. Specific training is also required to become an accredited assessor. Some drawbacks of using HSAP are: that the implementation requires a long duration of the assessment and therefore is cost-intensive. Hydropower projects possess three key challenges 1) hydropower project is influenced by policies and incentives from the government, 2) it is sensitive to climate change due to their dependency on the run-off, and 3) the impacts of extreme weather could affect water quantity and quality as well as damaging plant infrastructures (Tahseen & Karney, 2017). Therefore, assessing a hydropower project's sustainability for the long term and under climate change circumstances is highly recommended.

The last section shown in Table 2, named Climate Change Mitigation and Resilience, addresses the estimation and management of the project's greenhouse gas (GHG) emissions, analysis and management of the risks of climate change for the project, and the project's role in climate change adaptation. The intent is that the project's GHG emissions are consistent with low carbon power generation, the project is resilient to the effects of climate change, and the project contributes to broader adaptation to climate change. Unfortunately, the climate change-related section is not available in the early-stage assessment of the project. It only can be assessed in the preparation, implementation, and operation stage.

Indonesia has a high hydropower potential, and the performance of the existing power plants could also be optimized. For instance, Saguling (est. 1981) and Cirata (est. 1982) reservoirs in the Citarum watershed were built particularly for hydropower plants and managed by state-owned electricity enterprises, i.e., PT. Indonesia Power and PT. PJB (Bappenas, 2014). Therefore, it might be useful if the sustainability assessment is applied in these projects for the operational stage.

Another large capacity hydropower project currently under construction in Indonesia is the Upper Cisokan pumped-storage hydropower project (1,040 MW) in West Java. In a report by the World Bank (2011), a risk assessment result of the Upper Cisokan project is presented. The Operation Risk Assessment Framework (ORAF) of the project resulted in the high-risk category for the preparation and implementation stages. Risks assessed were project stakeholder risks, implementing agency risks, and project risks (e.g., social and environmental risks). The risks assessed were only a small part of the topics covered in HSAP (see Table 2). Although the ORAF is beneficial for the project, a more comprehensive assessment is highly recommended for this project as it belongs to the large hydropower projects in Indonesia.

Many studies discuss only a few aspects of hydropower sustainability, e.g., water corrosivity in Cirata dam (Sunardi et al., 2020), and sustainable micro-hydropower operations in Ciptagelar village (Sato & Ide, 2021). The national environmental impact assessment is insufficient to be used as a proxy for the hydropower sustainability assessment as it covers only limited topics.

CONCLUSIONS

The hydropower sustainability assessment using HSAP is relatively new in Indonesia. Nevertheless, it has been implemented in at least three hydropower projects: Pelosika in Southeast Sulawesi (2017), Perjaya in South Sumatra (2020), and Ir. H. Juanda in West Java (2016). Two of the projects are at the early stage of development (Pelosika and Perjaya). One project is at the operation stage (Ir. H. Juanda). There are also limited published reports or studies discussing sustainability assessment results using HSAP. Some of the common challenges related to the use of HSAP is that the assessment is subjective and therefore recommended to use independent assessors, which requires specific training to become an accredited assessor, and the assessment activity is also time-consuming and cost-intensive.

Alternative sustainability tool options (e.g., Low Impact Hydropower Certification) are available, but the use of such tools in Indonesia is unknown. The form of hydropower sustainability assessment can come in various forms. The implementation often needs to adapt to the local context. It is necessary to have the same understanding of the concept of sustainable infrastructure within the hydropower project. The national Environmental Impact Assessment is insufficient to fully assess a hydropower project's condition at multi-stages (early stage, preparation, implementation, and operation stages), as it does not cover some topics assessed using HSAP.

With this mini-review, the current state of HSAP implementation in Indonesia has been figured out. There are still many things to improve in the future. HSAP has its advantages and disadvantages, as more effort is needed to develop sustainable hydropower plants in Indonesia. There should be a real step to solve some obstacles, so this most beneficial renewable energy power plan can be realized, and the government plan to get a higher percentage of renewable energy sources in Indonesia's energy mix can be achieved. HSAP is there to help the decision-maker assess a project, even before the project has started to be a sustainable infrastructure.

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