

From Reservoir Weeds to Economic Value: Utilizing Water Hyacinth as a Growing Medium for Straw Mushroom Cultivation in a Circular Economy Program of PT PLN Indonesia Power UBP Saguling

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Abstract

The Saguling Gerbang Lestari is a program initiated by PT PLN Indonesia Power UBP (Power Generation Business Unit) Saguling in 2024 to utilize water hyacinth from the Saguling Reservoir as raw material for a growing medium or baglog used in straw mushroom cultivation. This program aims to reduce the population of the invasive water hyacinth while increasing the value of waste through productive economic activities carried out by the community. Program implementation involved mentoring one community group responsible for managing 16 mushroom cultivation houses. Based on satellite imagery, the Saguling Gerbang Lestari Program significantly reduced the area of water hyacinth coverage in the Saguling Reservoir between 2024 and 2026, from 435 ha in 2024 to 428.5 ha in 2025, down to 282 ha in 2026. As a result, the amount of water hyacinth successfully processed into baglogs reached 144,000 kg in 2024, 230,000 kg in 2025, and 208,000 kg by mid-2026. The use of these baglogs yielded straw mushroom production of 5,586 kg with a net profit of Rp143,580,000 in 2024, rising to 13,328 kg and Rp375,840,000 in 2025, and reaching 11,056 kg with a profit of Rp315,680,000 by mid-2026. These results indicate that the use of water hyacinth as a straw mushroom growing medium can serve as one approach to controlling invasive plants while also providing economic benefits to the community. The Saguling Gerbang Lestari program has the potential to support the implementation of a circular economy by transforming waste into products that are both useful and possess economic value.

Keywords: *Water Hyacinth, Baglog, Straw Mushrooms, Saguling Reservoir.*



A. INTRODUCTION

The Saguling Reservoir, located in the Citarum Watershed (DAS) in West Bandung Regency, West Java, is one of the nation's strategic infrastructures because it serves as the primary energy source for the Saguling Hydroelectric Power Plant (PLTA) managed by PT PLN Indonesia Power UBP Saguling. The continued functionality of this reservoir is threatened by the growth of water hyacinth (*Eichhornia crassipes*), an invasive species that grows very rapidly and is difficult to control if not managed on an ongoing basis (Dewantara et al., 2021).

From an ecological perspective, the presence of water hyacinth in large quantities contributes to an increase in the rate of evapotranspiration and sedimentation at the bottom of reservoirs, which ultimately reduces their water storage capacity and shortens the period during which the reservoirs can be utilized as hydroelectric power plant infrastructure (Salsabila et al., 2023; Utami et al., 2024). A similar condition was observed at the Jatiluhur Reservoir, which shares similar hydrological characteristics as part of the Citarum River cascade reservoir system. There, uncontrolled water hyacinth growth covered more than 10% of the reservoir's surface and disrupted the operation of hydroelectric power plants in the area (Dewantara et al., 2021).

PT PLN Indonesia Power UBP Saguling has carried out self-initiated cleanup using mechanical methods, removing water hyacinth using heavy equipment and labor. This method incurs high operational costs and must be repeated on a regular basis. On the other hand, removing large volumes of water hyacinth can itself create new environmental problems if not properly managed, specifically the buildup of organic waste around the reservoir area (Poernama et al., 2023). This aligns with Utami et al. (2024), who found that without a strategy for further utilization, removing aquatic weeds merely shifts the problem from water to land, without addressing the root causes of sedimentation and the recurring annual operational costs.

Around the same time, the straw mushroom cultivation sector, one of the community's economic enterprises, was grappling with its own challenge, in which the supply of sawdust as raw material for growing media (baglogs) grew increasingly limited. Meanwhile, the steadily rising demand for straw mushrooms as an affordable source of plant-based protein has also contributed to both rising prices and a shortage of sawdust in various regions, as reported by mushroom cultivation partners in Tangerang Regency (Parhusip et al., 2025). These conditions have driven cultivators and researchers to seek substitute materials derived from agricultural waste or other biomass that could serve as an alternative to baglog substrates.

Drawing on these two seemingly separate yet complementary issues, the idea arose to use water hyacinth as a substitute growing medium for straw mushrooms. This scheme offers a double benefit: (i) reducing cultivators' dependence on sawdust, which is increasingly expensive and difficult to obtain; and (ii) reducing the volume of water hyacinth that pollutes and threatens the operational sustainability of Saguling Reservoir (Astuti, n.d.; Indriyani et al., 2021). This approach aligns with the principles of the circular economy, which views waste as a resource with economic value rather than merely a burden to be disposed of (MacArthur, 2013; Yuninda Nova et al., 2020). A similar practice has been implemented at the Jatiluhur Reservoir by processing water hyacinth into compost, which has proven effective in reducing the rate of sedimentation while increasing the income of the local farmer groups (Poernama et al., 2023).

PT PLN Indonesia Power UBP Saguling, through the Bumi Pasundan Innovation Program, has been developing the use of water hyacinth as a growing medium for straw mushrooms since 2024 in collaboration with a foster community

group called Saboer Padjadjaran. A similar program developed by PT PLN Indonesia Power UBP Saguling, which involves processing water hyacinth into livestock feed, was shown to reduce reservoir sediment by up to 829,875 kg and lower the sedimentation rate by 0.09% (Salsabila et al. 2023). However, the achievements of this water hyacinth utilization program as a growing medium have yet to be systematically examined within an academic framework that integrates environmental aspects (weed control and reservoir sedimentation), economic aspects (community empowerment and income generation), and agronomic aspects (quality and composition of growing medium).

Based on the discussion above, the present study aims to comprehensively examine the effectiveness of using water hyacinth as a substrate for straw mushroom baglogs, as implemented by PT PLN Indonesia Power UBP Saguling, in providing dual benefits: reducing environmental pressure while simultaneously generating economic value and empowering the surrounding community, within a circular economy framework. The novelty of this article lies in its approach, which not only highlights the agronomic aspects of water hyacinth utilization, as extensively examined in previous studies (Astuti, n.d.; Indriyani et al., 2021), but also evaluates its relationship with program scale, community participation, and the year-to-year dynamics of water hyacinth coverage in Saguling Reservoir.

B. LITERATURE REVIEW

1. Baglog

A baglog is a cylindrical growing medium wrapped in polypropylene plastic that serves as a growth substrate for the mycelium of straw mushrooms (*Volvariella volvacea*), from which fruiting bodies develop and become ready for harvest. Conventionally, the main components of a baglog consist of wood sawdust as a source of cellulose and lignin, supplemented with materials such as rice bran as a source of carbon and nitrogen nutrients, as well as lime (CaCO_3) to stabilize the medium's pH (Machfudi et al., 2021). The production process involves mixing the materials, packaging, sterilization at high temperatures to kill contaminant microorganisms, cooling, spawn inoculation, and an incubation period until the mycelium has colonized the entire medium before entering the production phase (Pratiwi et al., 2025). The growing demand for straw mushrooms as a nutritious and affordable food source has driven a continuous increase in the need for baglog raw materials, while the supply of sawdust has become increasingly limited and expensive due to the declining timber production (Parhusip et al., 2025).

These conditions have encouraged the development of alternative substrates based on agricultural waste or other biomass sources, such as straw, rice husks, coconut coir, tofu dregs, durian leaves, palm fronds, and even water hyacinth as a partial or complete substitute for sawdust (Pratiwi et al., 2025). Beyond the technical-ergonomic aspects, baglog production also serves as a household- or group-scale economic enterprise that is relatively easy to run without requiring large plots of land or high mobility (Machfudi et al., 2021). It is these characteristics that have led to the

widespread adoption of baglog businesses in community economic empowerment programs, including by vulnerable groups such as homemakers and the unemployed in areas surrounding strategic infrastructure such as hydroelectric power plant reservoirs, as observed in community-based programs at several reservoirs in West Java (J Bakti Negeri, 2025). Thus, innovation in baglog raw materials is not only relevant in terms of ensuring a stable supply of production but also serves as a gateway to economic empowerment strategies based on local potential.

2. Water Hyacinth

Water hyacinth (*Eichhornia crassipes*) is known as an invasive aquatic weed that grows and reproduces rapidly; if left uncontrolled, it can cover the surface of water bodies and disrupt ecosystem functions, including in artificial water bodies such as reservoirs (Dewantara et al., 2021). This characteristic is driven by its high rate of vegetative reproduction and its tolerance for eutrophic waters, making this plant abundant in reservoirs that receive domestic and industrial wastewater from upstream. A recent study of several lakes and reservoirs in Indonesia confirms that the distribution of water hyacinth is strongly influenced by the season and pollution levels; thus, its management requires continuous monitoring (Muna et al., 2025).

Water hyacinth, which has long been regarded as a weed, has a lignocellulose-based chemical composition that has the potential to be utilized as an alternative raw material. Several characterization studies reported that water hyacinth contained 18–73% cellulose, 8–43% hemicellulose, and 7–26% lignin, with a fairly wide range of values depending on the plant part and the testing method employed (Kusumawati & Haryadi, 2021). These chemical characteristics have been studied in the use of water hyacinth as an alternative growing medium for oyster mushrooms and straw mushrooms. In that particular study, the addition of water hyacinth powder to the baglog media was shown to improve various growth parameters of white straw mushrooms, such as cap diameter, wet weight of the fruiting body, and the biological efficiency ratio, compared to media from pure sawdust (Astuti and Indriyani et al., 2021). These findings reinforce the scientific basis that water hyacinth is not merely weed waste, but rather a biomass resource that can be utilized as a partial or complete substitute in straw mushroom baglog formulations.

3. Circular Economy

The circular economy is a development approach that offers a solution to the limitations of natural resources and the increasing volume of waste resulting from the application of the linear economic model of ‘take-make-dispose’ (Taufik, 2026). The circular economy emphasizes three key principles: eliminating waste and pollution from the design stage, circulating products and materials at their highest value, and regenerating natural systems (MacArthur, 2013). In the context of reservoir areas, the implementation of the circular economy can be understood as a closed-loop system: water hyacinth collected from the water body is processed into productive raw materials such as mushroom growing media, organic fertilizer, or handicrafts, and the

value of these products is returned to the surrounding community in the form of income, while weed pressure on the reservoir is reduced (Yuninda Nova et al., 2020; Poernama et al., 2023). Figure 1 illustrates how PT PLN Indonesia Power UBP Saguling applied the circular economy as a closed-loop model in processing water hyacinth into baglog materials for mushroom cultivation.

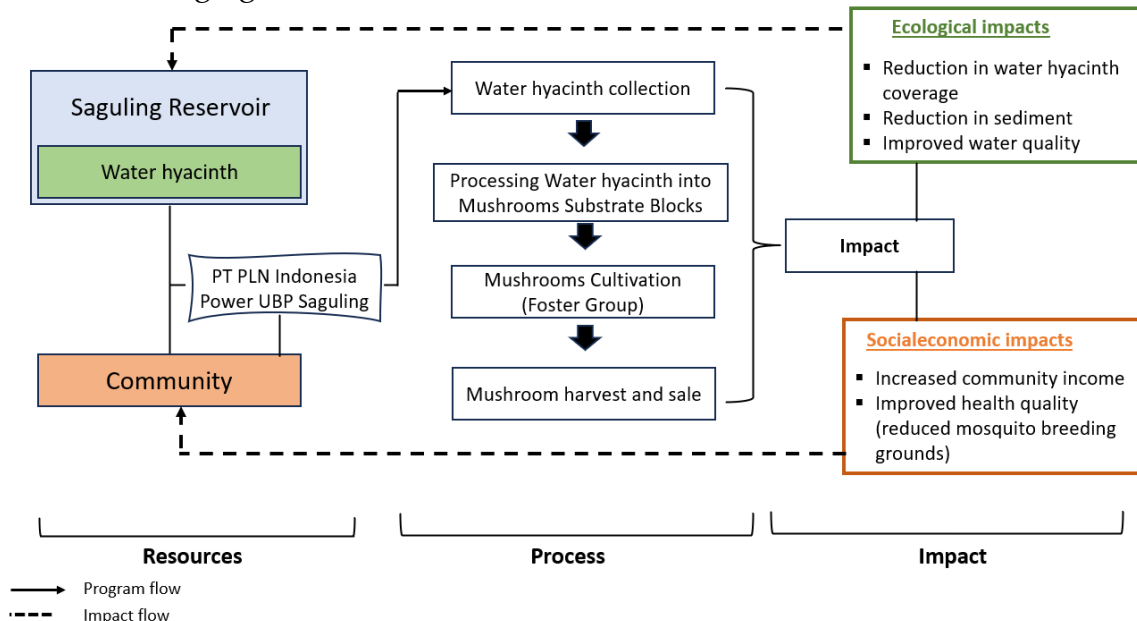


Figure 1. Circular Economy Model for Processing Water Hyacinth into Baglog Materials for Mushroom Cultivation by PT PLN Indonesia Power UBP Saguling

Empirical evidence of this model's application can be seen in several hydroelectric reservoir-based CSR programs in West Java, particularly at PT PLN Indonesia Power UBP Saguling, specifically the Bumi Pasundan Program at Saguling Reservoir. The results of the previous year's circular economy revealed a decrease in reservoir sedimentation, which coincided with an increase in income for community groups managing water hyacinth (Salsabila et al., 2023; Utami et al., 2024). These findings indicate that the principles of the circular economy are not merely a theoretical framework. They have been proven to be effectively implemented on the scale of reservoir areas in Indonesia.

4. The Community Empowerment Theory

Community empowerment is defined as an effort to strengthen community institutions, allowing them to achieve progress, self-reliance, and sustainable well-being (Sumaryadi, 2005). The empowerment process generally proceeds through three stages: awareness-raising (fostering community awareness of their potential and rights), capacity-building (providing training and guidance to help community members acquire skills), and empowerment (providing opportunities to participate actively and independently in economic and social activities) (Wrihatnolo & Dwidjowijoto, 2007). With reference to community-based development indicators, the formation of community groups and the creation of jobs are considered early signs of a program's success in mobilizing social capital of the local communities (Sunaryo,

2013). A study on the Bumi Pasundan Program at the Saguling Reservoir, initiated by PT PLN Indonesia Power UBP Saguling, also previously demonstrated this indicator in concrete terms. The program successfully established five community-based business groups with 118 members in 2023, including approximately 31 individuals who were previously unemployed and subsequently secured permanent jobs (Utami et al., 2024).

Furthermore, the success of empowerment efforts must be reflected in the increased production capacity and income for the communities involved. In the Bumi Pasundan Program, the average additional income for group members was recorded at Rp2,000,000 per month per person (Utami et al., 2024). Meanwhile, under the SIMAGMUR Program at Cirata Reservoir, the increase in individual income ranged from Rp1,000,000 to Rp1,500,000 per month, with the group's collective revenue reaching hundreds of millions of rupiah per year (J Bakti Negeri, 2025). These two findings confirm that quantitative indicators, such as the number of groups formed, the production capacity achieved, and the magnitude of income growth, are relevant and replicable benchmarks for assessing the success of empowerment programs based on biomass waste utilization in reservoir areas, including the case of processing water hyacinth into straw mushroom baglogs at Saguling Reservoir.

C. METHOD

1. Location and Time of Research

This study was conducted in the Saguling Reservoir area, West Bandung Regency, which falls within the operational area of PT PLN Indonesia Power UBP Saguling. The study was conducted from 2024 through July 2026. The present study focused on villages participating in the program, including:

- a. Cihampelas Village, Cihampelas District, West Bandung Regency, West Java Province
- b. Mekarmukti Village, Cihampelas District, Bandung Regency, West Java Province

2. Types and Sources of Data

The type of data required in this study was primary data, consisting of the outputs from utilizing water hyacinth as mushroom baglogs and the revenue earned from mushroom sales. Those data were obtained through surveys of the four mushroom cultivation houses and PT PLN Indonesia Power UBP Saguling.

3. Method and Sample Collection

This study employed both primary and secondary data. The primary data were obtained from interviews with community members and relevant agencies. Sample collection was performed using purposive sampling, in which the sample was selected based on specific objectives or characteristics relevant to the study. Interviews were conducted with community members directly involved in the management of

mushroom cultivation houses. The secondary data consisted of Sentinel-2 satellite imagery obtained from Google Earth Engine (GEE).

4. Data Analysis Method

Sentinel-2 MSI Level-2A satellite imagery (10-meter resolution) provided by ESA Copernicus was employed as the primary data source. All stages of data processing and analysis, from cloud filtering using Cloud Score+ to spectral index calculation using NDVI, were carried out entirely through the Google Earth Engine (GEE) cloud computing platform. To identify reservoir areas, the data were analyzed using a Random Forest algorithm (300 decision trees) that classified the area into five land cover classes: Water Hyacinth, Terrestrial Vegetation, Built-up Areas, Water Bodies, and Rice Fields. The results of this method include land cover classification maps from 2023 to 2026, data on the calculated area of each class in hectares, and a graph showing the trend of area change.

In addition, the magnitude of environmental and economic impacts resulting from water hyacinth management is analyzed using the formula proposed by Soemarwoto (2003):

$$\Delta Q = Q_{dp} - Q_{tp}$$

Notes:

ΔQ = Magnitude of Impact

Q_{dp} = Environmental Condition at time t "with the activity"

Q_{tp} = Projected Environmental Condition at time t "without the activity".

D. RESULT AND DISCUSSION

1. Program Scale and Community Participation

The Saguling Gerbang Lestari Program, implemented by PT. PLN Indonesia Power UBP Saguling, is designed to protect the environment while empowering the local communities. The program focuses on transporting water hyacinths from the Saguling Reservoir and then processing them into baglogs in the local community's cultivation houses since 2024. In its implementation, PT. PLN Indonesia Power UBP Saguling provided a mentoring program to community groups to process water hyacinth into baglogs as a growing medium for mushrooms. Furthermore, the Saguling Gerbang Lestari Program is the first program in West Bandung Regency to utilize water hyacinth as a growing medium for mushrooms. This initiative aims to help address various environmental issues around the Saguling Reservoir while supporting the sustainability of the Citarum River ecosystem.

The company's internal data recorded that the volume of water hyacinth processed into a mushroom growing medium increased from 63,000 kg in 2024 to 100,0625 kg in 2025, even though 91,000 kg had been recorded by mid-2026 (Summary Data from PT PLN Indonesia Power UBP Saguling, 2026). In line with this, the number of cultivation houses (is called 'kumbung') in the Saboer Padjadjaran group also increased from 6 (2024) to 16 (July 2026). However, in August 2026, PT. PLN Indonesia Power UBP Saguling planned to add two mushroom cultivation houses managed by

two community groups: one by the Batulayang Group and one by the Karang Tanjung Group (Table 1).

Table 1. Number of Community Groups per Year

Year	Name of Group	Number of Cultivation Houses	Total
2024	Saboer Padjadjaran	6	6
2025	Saboer Padjadjaran	14	14
2026	Saboer Padjadjaran	16	18
	Batulayang	1*	
	Karang Tanjung	1*	

* In the development plan

The year-over-year increase in the number of cultivation houses can serve as an indicator of the success of the community empowerment program implemented by PT PLN Indonesia Power UBP Saguling through the Saguling Gerbang Lestari Program. Participation rates and the expansion of community engagement are key indicators frequently used in evaluating community empowerment programs (Dushkova and Ivlieva, 2024). In addition, it can illustrate community initiatives to adopt and replicate activities among new groups (Syamsiyah et al., 2025).

As can be seen from Figure 2, the 16 mushroom cultivation houses (are called 'kumbung') used for straw mushroom production were distributed around Saguling Reservoirs, comprising 12 in Cihampelas and 4 in Mekarmukti. Meanwhile, 2 new cultivation houses were built in Batulayang and Karang Tanjung in August. The distribution of the 18 cultivation houses across four locations indicates that the program has not only grown in terms of the number of production units but has also expanded geographically. This spatial expansion reflects the diffusion of innovation and the strengthening of community participation, whereby the knowledge and skills already applied by the initial group are progressively adopted and replicated by other groups. The community's ability to initiate and adopt activities is a key element in building self-reliance and ensuring the sustainability of programs (Dushkova and Ivlieva, 2024).

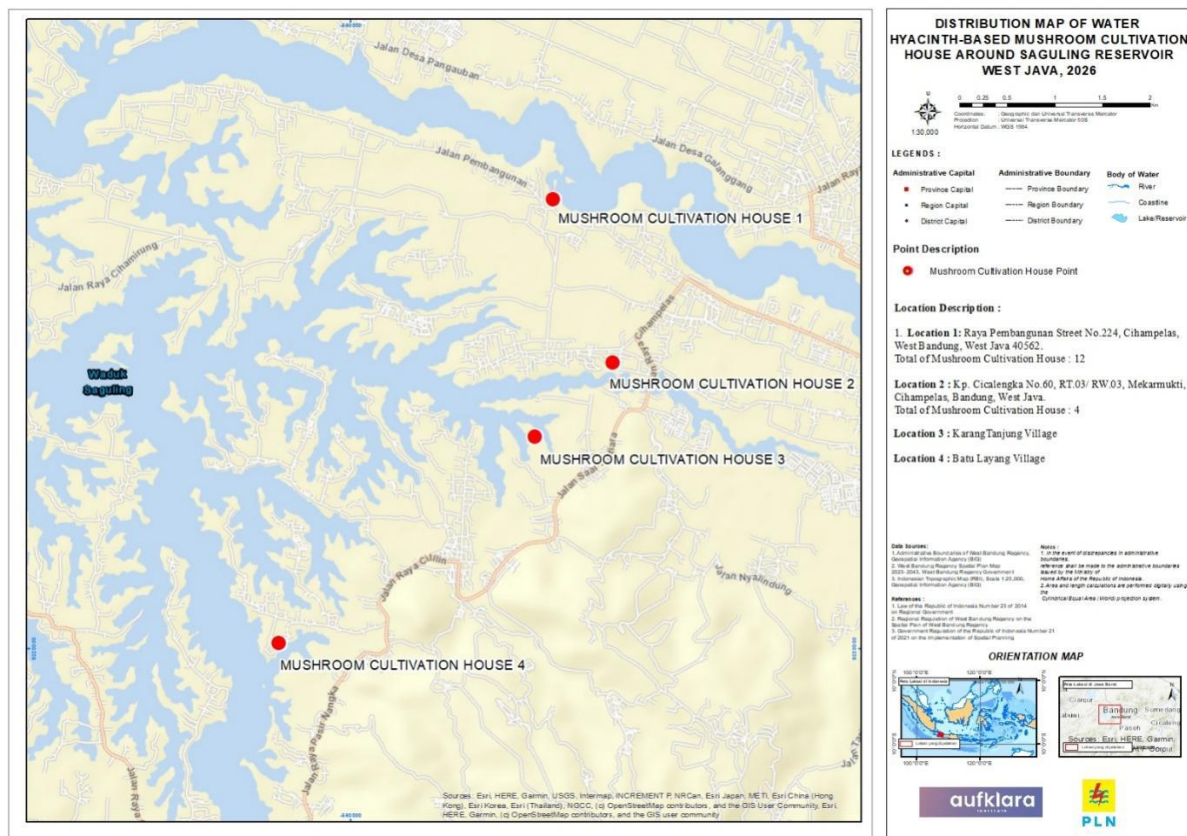


Figure 2. Distribution Map of Straw Mushroom Cultivation Houses

2. The Process of Converting Water Hyacinth into Cultivation Media for Straw Mushrooms

PT PLN Indonesia Power UBP Saguling has developed an innovation to mitigate the impact of water hyacinth by using it as straw mushroom cultivation media. Water hyacinth is used as the main component of the cultivation media, accounting for 50% of its composition. Water hyacinth harvested from reservoirs must undergo a series of processing steps to ensure the material is of sufficient quality to support mycelium growth and fruit body production. The processing stages carried out include fermentation using EM4 and molasses, mixing with other materials, preparation and pasteurization of the cultivation house, inoculation (spawn spreading), incubation and watering, and maintenance until harvest (Figure 3)

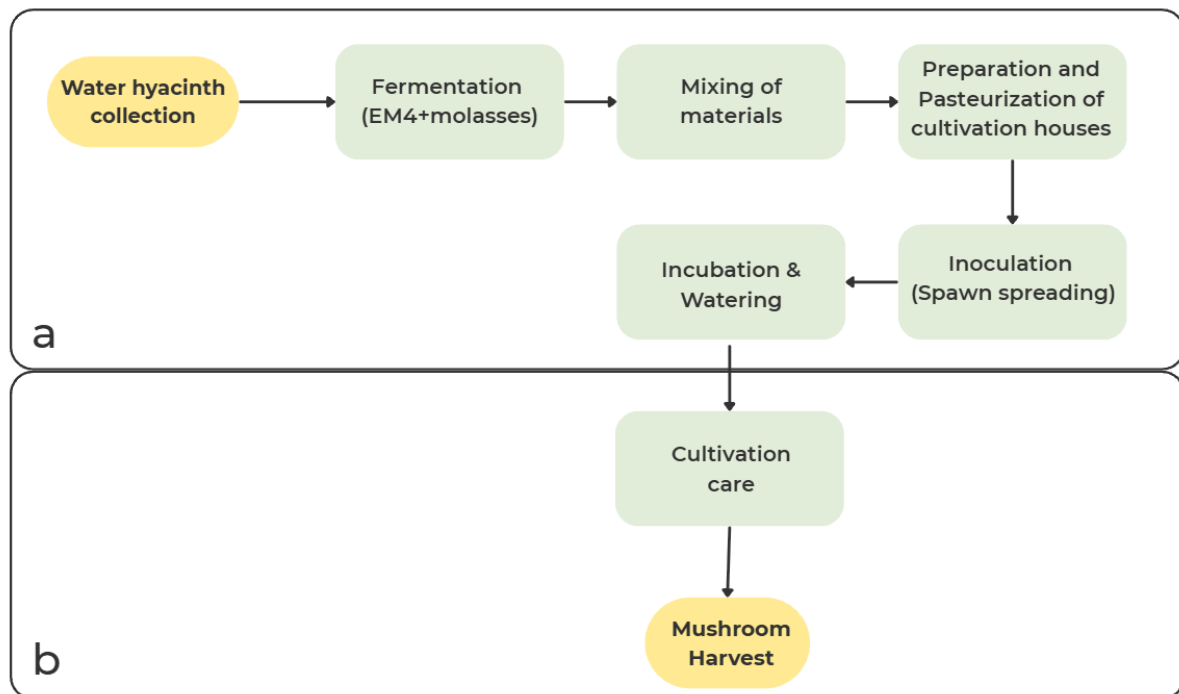


Figure 3. Stages of Converting Water Hyacinth into a Mushroom Cultivation Medium (a) and the One-Cycle Production Process for Straw Mushroom (*Volvariella volvacea*) (a+b)

First, water hyacinth collected from the reservoir was cleaned of dirt, mud, and other foreign materials. It was then fermented using EM4 and molasses to break down the plant fibers and improve the material's quality. EM4 is a mixture of effective microorganisms that consists of various types of bacteria and fungi, such as decomposing bacteria, which serve to accelerate the fermentation process (Suriadikusumah, 2024). Molasses is a sugar-rich liquid commonly used as an energy source for decomposing microorganisms (Sari, 2018), thereby accelerating the fermentation or decomposition of fiber.

Subsequently, the fermented water hyacinth was mixed with other ingredients according to the growing medium formulation (50% water hyacinth, 25% wood flour, 15% rice bran, and 10% lime) until the mixture was homogeneous. The selection of the right materials for preparing mushroom growing media significantly affects straw mushroom production. Water hyacinth is the primary source of lignocellulose in this composition. Cellulose, hemicellulose, and lignin are the main substrates required by *Pleurotus spp.* for growth (Muswati et al. 2021; Ejigu et al. 2022). Meanwhile, sawdust was utilized as a substrate because its texture is suitable for storing the mycelium and providing space for it to spread (Safitri et al., 2021). The addition of rice bran serves as a source of nutrients, and lime is used to maintain the pH of the growing medium at a neutral or slightly alkaline level, thereby supporting optimal fungal growth. In a study by Safitri et al. (2021), a mushroom cultivation medium with a composition of 50% sawdust and 50% bamboo powder yielded the best results for mycelial growth. Meanwhile, Nurjasmi et al. (2024) found that a growing medium composed of 85% sawdust, 10% rice bran, and 5% lime yielded optimal mycelial growth.

The homogenized mixed media was transferred to a cultivation house for pasteurization, the process of circulating hot air to sterilize the media or remove contaminants. Once the substrate was ready, Straw Mushroom spawn was added (inoculation) and incubated for 15 days. During the incubation process, the growing chamber must not be opened to prevent contamination and maintain relative humidity. Following incubation, the medium was watered periodically to maintain humidity. The temperature inside the greenhouse was also kept stable at around 28°C. Temperature and humidity are environmental factors that significantly influence the growth of straw mushrooms. Fluctuations in these two parameters can affect both the yield and the quality of the mushrooms produced. The optimal temperature for straw mushroom mycelial growth ranged from 22-28°C, while the ideal humidity ranged from 80-90% (Sulistiaawaty et al., 2025).

After the incubation and watering stages, the maintenance stage is also an important phase to pay attention to. Temperature and humidity levels, as well as pests and disease infestations in straw mushrooms, must also be monitored regularly. Mushroom growth took place over approximately 25 days following the incubation stage, so the entire straw mushroom production process took about 40 days per harvest cycle.

3. Water Hyacinth Removal at Saguling Reservoir

From 2024 through July 2026, efforts to control the spread of water hyacinth on the surface of Saguling Reservoir were carried out through cleanup campaigns and routine monthly removal activities. Water hyacinth removal was carried out either mechanically using an excavator or manually by hand (Figure 4). Cleanup efforts were performed in conjunction with events organized by the government, the private sector, and the community. Meanwhile, routine removal was conducted by PT PLN Indonesia Power UBP Saguling in collaboration with the community and its foster groups. Over the past three years (2024-2026), 12 cleanup activities were carried out (Table 2).

Table 2. Events and Activities as Part of the Cleanup Campaign from 2024 to 2026

Year	Activities	Water Hyacinth Removed (Kg)	Participants (People)
2024	HPSN 2024 – Tackling Plastic Waste Productively	1,380	156
	Green Employee Involvement – World Environment Day	1,740	321
	Employee Volunteering – Zero Waste Warrior	1,140	95
Total in 2024		4,260 (4.26 metric tons)	572
2025	HPSN 2025 – Bewara: Collaborative Action for Waste Management and Cleanup	960	302
	Employee Volunteering – Zero Waste Warrior	500	95
Total in 2025		1,560 (1.56 metric tons)	397

2026	HPSN 2026 BEWARA – Rancapanggung Village	1,200	250
	Joint Action with Foster Groups – Water Hyacinth Cleanup	115	50
	Water Hyacinth Cleanup – Karang Tanjung Village	394,087.5	50
	Water Hyacinth Cleanup – Cililin Village	394,070	50
	Water Hyacinth Cleanup – Batulayang Village	1,824.67	70
	Water Hyacinth Cleanup – Rongga Village	1,824.66	65
	Water Hyacinth Cleanup – Rancapanggung Village with the Regent	5,614,768	500
Total in 2026		6,407,889.83 (6,407.9 metric tons)	1,035

The number of cleanup activities increased significantly in 2026. This indicates that the community is becoming increasingly aware of the importance of removing water hyacinth from the Saguling Reservoir. A relatively rapid growth of water hyacinth populations over a wide area may cause various problems, such as increased sedimentation, a decline in the quality of aquatic ecosystems, and the potential for the plants to serve as breeding grounds for mosquitoes and various disease-carrying organisms, thereby posing a threat to public health. Honlah et al. (2019) noted that water hyacinth infestations can slow the flow of water, making them an ideal breeding ground for mosquitoes. In addition, excessive water hyacinth can lead to anoxic conditions harmful to aquatic life due to the activity of decomposer bacteria (Auchterlonie et al., 2021). Without proper management through routine removal, aquatic ecosystems may become increasingly disrupted, leading to various environmental and health problems.



Figure 4. Removal of Water Hyacinth At Saguling Reservoir Using an Excavator (a) and Manually (b)

4. Water Hyacinth Coverage Area

The extent of water hyacinth coverage in the Saguling Reservoir can be determined from satellite imagery data available on Google Earth Engine. The data were processed using Sentinel-2 imagery with a resolution of 10 meters. The imagery was analyzed using the Random Forest algorithm to classify image pixels into specific object categories.

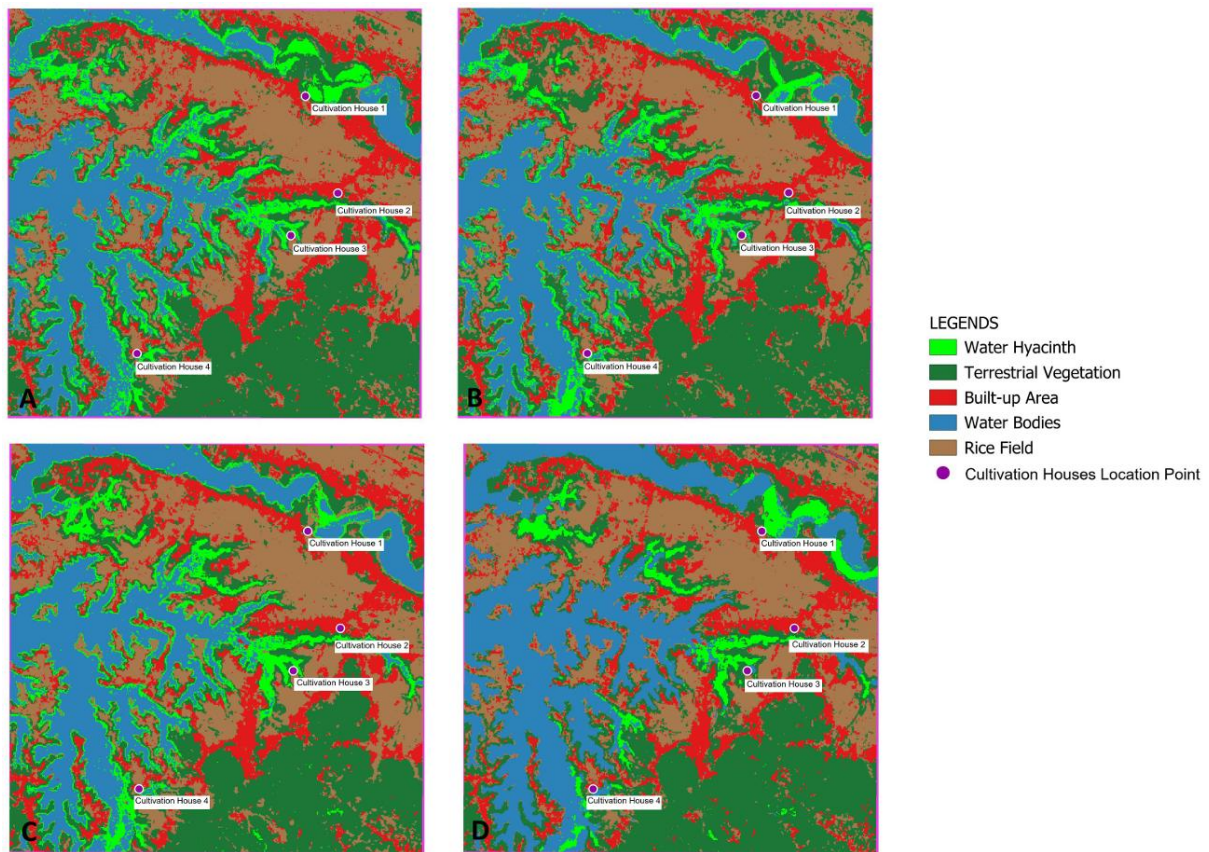


Figure 5. Land Cover at Saguling Reservoir from January-August in 2023 (a), 2024 (b), 2025 (c), and 2026 (d)

Based on the satellite imagery analysis, land use around the Saguling Reservoir is categorized into five types: water hyacinth, water bodies, terrestrial vegetation, built-up areas, and rice fields. Since only January-August data were available for 2026, the analysis was limited to that same period across 2023-2026 to ensure comparability. The distribution of land use around the Saguling Reservoir from 2023 to 2026 is shown in Figure 5. The area of all five types of land use showed fluctuating distribution patterns each year (Table 3 and Figure 5).

Table 3. Land Cover Area by Type for the January-August Period, 2023-2026

Land Use Type	Total Area (Ha)			
	2023	2024	2025	2026
Water bodies	1.094	1.043	1.102,5	1.370,5
Water hyacinth	377,5	435	428,5	282
Terrestrial vegetation	1.486	1.519,5	1.393	1.507
Built-up areas	751,5	810	886	811,5
Rice field	1.479,5	1.382	1.379,5	1.370,5
Total	5.189	5.189	5.189	5.189

The area covered by water hyacinth in Saguling Reservoir from 2023 to 2026 decreased (Table 3 and Figure 6). This was due to water hyacinth removal efforts carried out by PT. PLN Indonesia Power UBP Saguling as part of the Saguling Gerbang Lestari program. Meanwhile, from 2023 through 2024, the area covered by water hyacinth increased. This is believed to be due to development in built-up areas

and rice fields. Rice farming activities may involve the use of fertilizers containing nitrogen and phosphorus. Both of these nutrients can trigger massive water hyacinth growth. Meanwhile, the built-up areas around Saguling Reservoir include residential areas and industrial zones, among other developed land uses. Residential activities around Saguling Reservoir have the potential to contribute domestic wastewater, such as detergents, which can trigger water hyacinth growth. According to Yusal et al. (2025), waste from household activities is one of the largest contributors to eutrophication, particularly detergents, because they contain phosphates. Eutrophication is the enrichment of water bodies caused by the accumulation of excess nutrients, particularly nitrogen and phosphorus, the primary components of agricultural fertilizers (Herlina et al., 2019). Algal blooms and water hyacinth (*Eichhornia crassipes*) proliferation occur as a result of eutrophication (Wulandari et al., 2023).

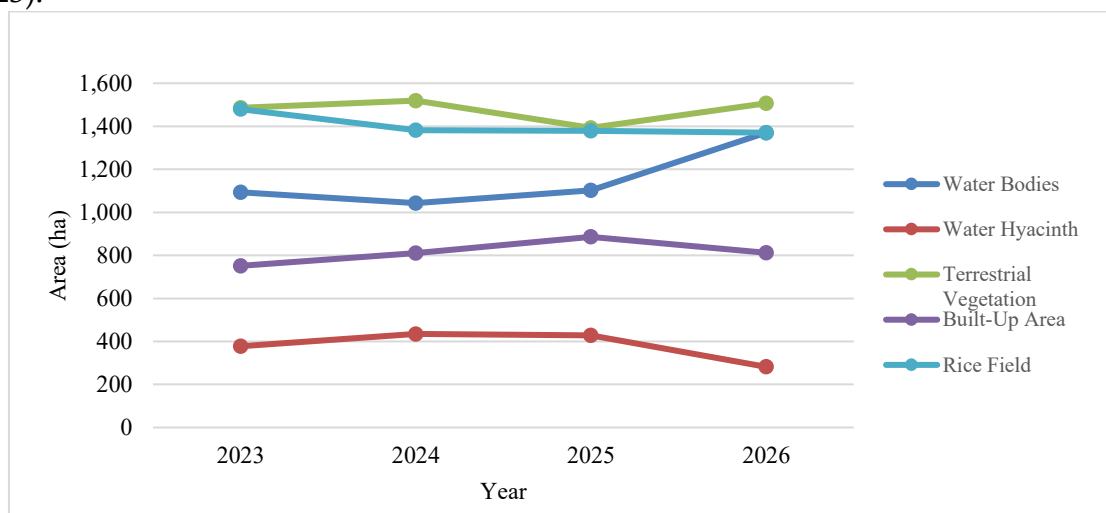


Figure 6. Graph of Land Cover Area, January – August 2023-2026

Floating net cage (KJA) activities carried out by the community at Saguling Reservoir may also be one of the factors contributing to the massive growth of water hyacinth. Unused leftover fish feed from those net cages can serve as a source of nutrients for water hyacinth, triggering it to grow even more rapidly. Chuzaimah et al. (2025) revealed that the distribution and coverage area of water hyacinth in Saguling Reservoir are influenced by nutrient inputs from floating net cages as well as runoff.

The downward trend in the area covered by water hyacinth in Saguling Reservoir by 2026, from 428.5 ha to 282 ha, is in line with the efforts undertaken by PT PLN Indonesia Power UBP Saguling through the Saguling Gerbang Lestari program. Some of the activities carried out as part of the Saguling Gerbang Lestari program include the removal of water hyacinth (through routine operations and cleanup campaigns) and the processing of water hyacinth into marketable products (animal feed, handicrafts, fertilizer, and baglog material for mushroom cultivation). One of the initiatives that has successfully reduced the area covered by water hyacinth significantly through routine removal and large-scale cleanup efforts, carried out with the support of both the private sector and the government. In 2026, the removal of

water hyacinth from the reservoir through cleanup efforts increased sharply by 6,407.9 metric tons compared to 1.56 metric tons in 2025 (Table 2).

5. Utilization of Water Hyacinth as a Cultivation Medium for Straw Mushroom

Water hyacinth harvested from the reservoir is utilized and processed into various products, particularly (i) straw mushroom cultivation media, (ii) livestock feed, (iii) liquid fertilizer, and (iv) handicrafts. The quantity of water hyacinth collected from Saguling Reservoir and utilized as mushroom cultivation media during the 2023-2026 period is presented in Table 4.

Table 4. Water Hyacinth Collected by Foster Partner

Year	Water Hyacinth Collected (Kg)	Water Hyacinth Utilized as Mushroom Cultivation Media (Kg)	Percentage of Water Hyacinth Utilized as a Mushroom Cultivation Medium (%)
2023	44,000	0	0%
2024	335,150	144,000	42.96%
2025	499,795	230,000	46%
2026	314,890	208,000	66.05%
Total	1,193,835	582,000	

The total amount of water hyacinth collected rose each year. Since the 2026 figures cover only January through August, the annual total will be higher once full-year data through December is available. The total amount of water hyacinth collected from 2023 through mid-2026 was 1,193,835 kg or 1,193.83 metric tons. Meanwhile, the total amount of water hyacinth utilized for baglog production from 2024 to mid-2026 was 582,000 kg or 582 metric tons. The percentage of water hyacinth converted into baglogs increased steadily each year, reaching its highest level of 66.05% in 2026.

The utilization of water hyacinth as a medium for mushroom cultivation, or “baglog,” began in 2024. The utilization percentage rose significantly to 42.96% in the first year, then increased slightly to 46% in 2025. On the other hand, the volume of waste transported grew by nearly 67.06% (from 335,150 kg to 499,795 kg). The consistent increase in the utilization rate (2024 and 2025) indicates that the absorption capacity of the foster groups utilizing water hyacinth is proportionally following the upward trend in raw material supply. Ebrahimi et al. (2025) revealed that balance in the biomass supply chain refers to the alignment between the upstream (supply) and downstream (conversion capacity) sides, which is one of the main challenges to the sustainability of business models based on waste biomass. In the business context, the use of water hyacinth as media for straw mushroom cultivation involves a balanced supply chain, characterized by an increase in the supply of water hyacinth transported from reservoirs (upstream) followed by a corresponding increase in the utilization of water hyacinth (downstream) at a stable rate.

The increase in the use of water hyacinth in baglogs is due to the growing number of mushroom cultivation facilities under the Saguling Gerbang Lestari Program, led by PT PLN Indonesia Power UBP Saguling. In 2024, Saboer Padjajaran, a mushroom baglog processing group, operated six cultivation houses; by 2025, it had

expanded to 14. In 2026, this group added 2 cultivation houses through the BOSS program, bringing its total to 16 (Table 5). This growth from 2024 to 2026 suggests that the community empowerment program implemented by PT PLN Indonesia Power UBP Saguling has been successful.

Table 5. Utilization of Water Hyacinth as a Cultivation Medium for Straw Mushroom in 2024-2026

Month	The number of cultivation houses			Water hyacinth demand per cultivation house (kg/month)	Water hyacinth utilized as a mushroom cultivation medium (kg)		
	2024	2025	2026		2024	2025	2026
January	6	8	14	2,000	12,000	16,000	28,000
February	6	8	14	2,000	12,000	16,000	28,000
March	6	8	14	2,000	12,000	16,000	28,000
April	6	8	14	2,000	12,000	16,000	28,000
May	6	8	16	2,000	12,000	16,000	32,000
June	6	8	16	2,000	12,000	16,000	32,000
July	6	9	16	2,000	12,000	18,000	32,000
August	6	10	n.a	2,000	12,000	20,000	n.a
September	6	10	n.a	2,000	12,000	20,000	n.a
October	6	10	n.a	2,000	12,000	20,000	n.a
November	6	14	n.a	2,000	12,000	28,000	n.a
December	6	14	n.a	2,000	12,000	28,000	n.a
Total					144,000	230,000	208,000

Notes: n.a (not available): data not yet collected

Institutional capacity is one of the key elements in the development of natural resource-based businesses based on the concept of community empowerment. Massiri et al. (2024) identified three levels of institutional capacity that influence program success: the micro level (the capacity of individual group members), the meso level (the capacity of the organization or group management), and the macro level (support from larger institutions or those with power). In this regard, the facilitating role of PT PLN Indonesia Power UBP Saguling at the macro level can develop simultaneously and in an integrated manner with the micro level (individual members) and the meso level (foster groups), thereby ensuring consistent annual growth in the number of cultivation houses.

The growth in the number of straw mushroom cultivation houses has led to an increase in the amount of water hyacinth harvested from the reservoir and put to use. Each cultivation house required 12,000 kg of water hyacinth per month as the primary component of the mushroom cultivation medium. The amount of water hyacinth used in baglog production for mushroom cultivation increased from 144 metric tons in 2024 to 230 metric tons in 2025. By July 2026, the usage had already reached 208 metric tons. This indicates that mushroom cultivation using water hyacinth as a growing medium, an initiative launched by PT PLN Indonesia Power UBP Saguling through the groups it mentors, has seen a significant increase. In addition, this reflects the acceptance of technological innovations involving water hyacinth as an alternative substrate, while also serving as an economical and environmentally friendly solution for the utilization of aquatic weeds.

The use of water hyacinth as a mushroom cultivation substrate reflects a paradigm shift in its management, from eradication to valorization, in which the

biomass is converted into value-added, economically valuable products. This is in line with the concept of the circular economy model, which emphasizes three key principles: (i) eliminating waste and pollution from the design stage onward, (ii) circulating products and materials at their highest value, and (iii) regenerating natural systems (MacArthur, 2013). Harun et al. (2021) also proposed a similar concept regarding the circular economy of water hyacinth, which is processed into various products, whether fresh, processed, or fermented into biogas.

6. The Program's Impact on the Local Economy

The Saguling Gerbang Lestari Program, run by PT PLN Indonesia Power UBP Saguling, utilizes water hyacinth as a growing medium for mushrooms in the form of baglogs. This provides economic opportunities for residents living near Saguling Reservoir who work as mushroom farmers. In 2026, there was one mushroom baglog management group operating a total of 16 mushroom cultivation houses in the Saguling Reservoir area.

In 2024, 144,000 kg of water hyacinth was used as raw material for mushroom baglog production (Table 4), resulting in a mushroom harvest of 5,586 kg and a net profit of Rp143,580,000. Then, in 2025, the water hyacinth use rose to 230,000 kg, yielding 13,328 kg of mushrooms and a net profit of Rp 375,840,000. Meanwhile, by July 2026, 208,000 kg of water hyacinth had been used as substrate for mushroom baglogs, yielding 11,056 kg of mushrooms and a net profit of Rp 315,680,000. Table 6 presents the mushroom production and the net profit earned from mushroom sales.

Table 6. Straw Mushroom Production and Sales Profit in 2024-2026

Month	Total Mushroom Production per Month (kg)			Net Profit from Mushroom Sales per Month (Rp)		
	2024	2025	2026	2024	2025	2026
January	390	952	976	9.700.000	26.560.000	27.280.000
February	432	980	1.680	10.960.000	27.400.000	48.400.000
March	408	980	1.216	10.240.000	27.400.000	34.480.000
April	600	1.400	1.328	16.000.000	40.000.000	37.840.000
May	450	1.092	1.200	11.500.000	30.760.000	34.000.000
June	492	1.190	1.728	12.760.000	33.700.000	49.840.000
July	384	1.008	1.120	9.520.000	28.240.000	31.600.000
August	600	1.400	1.808	16.000.000	40.000.000	52.240.000
September	420	1.064	<i>n.a.</i>	10.600.000	29.920.000	<i>n.a.</i>
October	372	910	<i>n.a.</i>	9.160.000	25.300.000	<i>n.a.</i>
November	570	1.330	<i>n.a.</i>	15.100.000	37.900.000	<i>n.a.</i>
December	468	1.022	<i>n.a.</i>	12.040.000	28.660.000	<i>n.a.</i>
Total	5.586	13.328	11.056	143.580.000	375.840.000	315.680.000

Notes:

n.a (not available): data not yet collected

The use of water hyacinth as a medium for mushroom cultivation is one example of the circular economy in action. The water hyacinth biomass removed from Saguling Reservoir does not end up as waste but is used as a raw material for straw mushroom cultivation medium. This process reflects a “waste-to-value” approach,

transforming materials once considered an environmental problem into resources with practical and economic value. Water hyacinth, when processed into various products such as handicrafts (Wardiah et al. 2019), liquid compost (Kusrinah et al. 2016), and compost (Nihahayati et al. 2023; Hasibuan et al. 2026), can boost the local economy. This approach demonstrates that efforts to control water hyacinth can be integrated with the community's productive activities, thereby yielding both environmental and economic benefits.

7. Ecological Impacts of Water Hyacinth Utilization

Water hyacinth is known as an invasive plant that dominates bodies of water such as lakes, reservoirs, and rivers due to its high rate of vegetative reproduction and tolerance to eutrophic conditions (Harun et al. 2021). The increasing spread of water hyacinth in Saguling Reservoir, which serves to support the operations of the hydroelectric power plant, poses a distinct challenge for managers. It has the potential to disrupt hydrological functions, accelerate sedimentation and reservoir siltation, thereby reducing the operational lifespan of the reservoir. In addition, the invasive growth of water hyacinth on surface water bodies can block sunlight from entering the water. This blockage disrupts the photosynthesis process carried out by phytoplankton, which in turn lowers dissolved oxygen (DO) in the water. A decrease in DO levels can threaten the survival of aquatic life. When oxygen levels drop too low, aquatic organisms can die off (Sudana, 2011; Auchterlonie et al., 2021). Through the Saguling Gerbang Lestari Program implemented by PT PLN Indonesia Power UBP Saguling, the removal of water hyacinth also benefits aquatic life.

E. CONCLUSION

The Saguling Gerbang Lestari Program, initiated by PT PLN Indonesia Power UBP Saguling in 2024, is an effort to utilize water hyacinth waste from the Saguling Reservoir as a growing medium in baglogs for straw mushroom cultivation. This program involved one community group, supported by 16 mushroom cultivation facilities. The utilization of water hyacinth helps control the population of this invasive plant while also creating economic value for the surrounding community.

Spatial analysis using satellite imagery showed a downward trend in water hyacinth coverage at Saguling Reservoir, which shrank from 435 hectares in 2024 to 282 hectares in 2026 as the program was implemented. The reduction in area shown on the map is a direct result of the massive effort to remove water hyacinth from the reservoir; of the total 1,086.81 metric tons of weeds removed from 2023 through mid-2026, 254.62 metric tons were used as raw material for straw mushroom baglogs.

In 2024, 144,000 kg of water hyacinth were successfully processed into baglogs; this figure increased to 230,000 kg in 2025 and reached 208,000 kg by mid-2026. The utilization of these baglogs resulted in a straw mushroom harvest of 5,586 kg, generating a net profit of Rp143,580,000 in 2024, rising to 13,328 kg with a profit of Rp375,840,000 in 2025, and reaching 11,056 kg with a profit of Rp315,680,000 by mid-2026. These results imply that the water hyacinth usage through the Saguling Gerbang

Lestari program not only supports waste management and the control of invasive species but also has the potential to sustainably increase productivity and provide economic benefits to the community.

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