



Revitalization of Rawa Pening lake, Indonesia

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ARTICLE INFO	ABSTRACT
<p>Received : 31 July 2022 Revised : 19 September 2022 Accepted : 29 October 2022</p> <p>Available online: 09 March 2023</p> <p>Key Words: Eutrophication Land tenure Sedimentation Tidal rice field Water hyacinth</p>	<p>Rawa Pening Lake has been in critical condition, caused by high sedimentation levels, declining water quality, damage to the watershed, and excessive riparian occupation. Therefore, this study aims to identify the main problems of the revitalization of Rawa Pening lake. Data and information collection were carried out through direct observation and interviews. The results showed that the main problems of the lake were the removal of the water weeds/water hyacinths, tidal rice fields, and buildings on the lake and riparian areas. The solution to the three main problems is lake revitalization. The revitalization concept that can be proposed regarding the control of water hyacinth is by mechanical means (using water hyacinth lifting equipment, boats, and cutting water hyacinth) and by biological methods, namely the cultivation of koan fish that will eat water hyacinth. At the tidal rice fields, it is necessary to determine the water level limit wisely. The areas with elevation of 462.30 m³-463.25 m³ (covering an area of 812 Ha) can be planted twice a year. The areas with a height of 462.05 m³-462.30 m³ (covering an area of 200 Ha) can be planted once in the rainy season. The areas with elevation of 462.05 m³ cannot be planted because it is in a state of flooding. Incommensurate areas and lakes, there is a lot of land and buildings consisting of settlements, tourism destinations, places of worship, and restaurants. Then the proposed alternative solution is the land acquisition compensation of land and buildings in commensurate areas.</p>

Introduction

Indonesia has many lakes which are naturally and artificially formed. The exact number of lakes and their areas has not been known yet, but it is estimated that there are more than 1,575 lakes, consisting of 840 large and 735 small lakes (Kementerian Negara Lingkungan Hidup, 2007). In general, most lakes are facing environmental problems such as eutrophication, sedimentation (Soeprbowati, 2015; Sulastri *et al.*, 2016), the decline in surface area, degradation problems caused by land conversion in the watershed, high soil erosion, and water pollution from the agriculture and households (Trisakti *et al.*, 2014). Revitalization efforts on lake management were agreed during the Indonesian Lake National Conference held in Bali in 2009 which stipulated that 15 lakes are to be saved from damage, one of which was Rawa Pening Lake in Semarang Regency, Central Java. The current problems of

Rawa Pening Lake are eutrophication and sedimentation (Soeprbowati, 2012). Eutrophication is a process in which human activities contribute to the increasing amount of nutrition in the water ecosystem and result in undesirable changes in the quality of the surface water which is influenced by biogeochemical carbon, nitrogen, and phosphorus caused by agricultural fertilizers, fisheries, and household waste (Ekdahl *et al.*, 2004; Scholten *et al.*, 2005; Ayele and Atlabachew, 2021). Meanwhile, sedimentation is mainly caused by land erosion and the decomposition of water hyacinth (Sanjoto *et al.*, 2020). In 1991 sedimentation caused by land erosion reached 4,084,484.59 tons, in 2011 the sedimentation rate of the lake decreased to 3,688,480.45 tons due to the decrease in rainfall, and the sedimentation rate of water hyacinth 2011 to continuously increased from 153,745.30 tons in

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171,349.90 tons in 2011 (Apriliyana, 2015).

Rawa Pening Lake has many strategic functions including economic functions as a power plant, freshwater fishery, irrigation, source of drinking water, and tourist attraction air (Budihardjo & Huboyo, 2007; Dwisapta & Sri, 2013; Samudra *et al.*, 2013; Schmieder, 2004). As for socio-cultural function, the lake usually became a source of inspiration for the birth of cultural and religious traditions of the people around the lake. Meanwhile, to support ecosystem functions, the lake supports the availability of biodiversity, the sources and places of protein formation, toxicity control in water bodies, dampening flood fluctuations in rivers, and microclimate control (Dewan Sumber Daya Air Nasional, 2020). In addition, the agricultural sector increases its production because of this lake. In Semarang Regency, the agricultural sector played the most significant role in supporting the economy, used as rice fields, farms, embankments, ponds/dams, plantations, and forests. Meanwhile, the rest are used as yards and buildings, grassland, swamps, and vacant land for business.

Saving the lake from damage has become a national issue. Various approaches to the study related to Rawa Pening lake have been carried out. Sulastri *et al.* (2016) mention that Rawa Pening lake is a eutrophic lake, where phosphorus plays a role in causing eutrophication and the growth of more water hyacinth. Hidayati *et al.* (2018) show that the presence of water hyacinth has been a concern for many years. Water hyacinth control failed and even tended to increase during the period 2012 to 2016. Then Sittadewi (2008) examined tidal land and stated that the land formed due to processes of the rising and falling water levels of Rawa Pening lake occur the fluctuations between the dry season and the rainy season. The use of tidal land is for rice fields. Some of the studies above present interesting issues to look at the problem of Lake Rawa Pening. However, this research is different from previous research. In general, it discusses the problem of water hyacinth and tidal land, but the substance and data presented are different. No research specifically examines the revitalization of Rawa Pening lake. This study aims to analyze the main problems of Rawa Pening which is currently experiencing damage. Efforts are needed to save the lake from damage and maintain the function of the lake based

on the principle of ecosystem balance and supporting the carrying capacity of the environment.

Material and Methods

This study was conducted in the area around Lake Rawa Pening, located in four sub-districts, namely the sub-districts of Bawen, Ambarawa, Tuntang, and Banyubiru, Semarang Regency, Central Java province. Geographically, it is located at coordinates 7° 4' 00" South Latitude – 7° 30' 00" and 110° 24' 46" East Longitude – 110° 49' 06" East Longitude and is at an altitude between 455-465 meters above sea level (dpl). The location of this lake is strategic because it is on the edge of the Semarang-Solo and Semarang-Yogyakarta National highways, and is on the road between Ambarawa-Salatiga City (Kementerian Lingkungan Hidup, 2011). Data were obtained during pre-research and research implementation stages. The pre-research was conducted in April 2022, in the pre-research or preliminary study aimed at mapping concepts and mapping problems. Then the research will be carried out starting from May 23 to May 31, 2022, although the research was conducted for nine days, this research does not reduce the quality of research data and information because in the field it only takes field data, because previously there was a preliminary/pre-research study. The research method used a combination of interviews and direct observation of the subjects and objects of research. Interviews were conducted with in-depth interviews with a face-to-face interview process. Field observations and interviews with lake managers, the National Land Agency, village heads, and local communities to obtain data related to the revitalization of Rawa Pening lake are presented descriptively.

Results and Discussion

Water weeds removal

Water hyacinth is a dangerous weed due to its rapid spread and dense growth (Malik, 2007; Safauldeen *et al.*, 2019), consuming nutrients and oxygen from the water bodies that affect other plants and animals' growth (Sindhu *et al.*, 2017), which is influenced by temperature, wind water nutrients, water currents, waves, and seasons (Higgins & Richardson, 1996; Wilson *et al.*, 2005). Many efforts have been made

to eliminate these weeds either by chemical or biological methods, but the maximum result has not been achieved. On the other hand, water hyacinth has the potential to be used as phytoremediation, paper, organic fertilizer, biogas production, human food, fiber, livestock feed, as an ornamental plant and even its biomass has the potential to be a source of renewable energy (Jafari, 2010; Rezania *et al.*, 2015).

The same thing happened to Rawa Pening Lake with the hyacinth growth rate ranging from 6.40-7.26%/day (Prasetyo *et al.*, 2022), which can trigger the lake siltation because the root system of hyacinth allows high sediment trapping. The measurements of sedimentation and water quality of Rawa Pening Lake conducted in 2015 revealed that the lake underwent shrinking and siltation which resulted in the effective area of the lake becoming 1,850 ha with a reservoir volume of 48.15 million m³ (elevation +463). The surface of the lake was covered by water hyacinth with an elevation of +463m ± 755 ha or about 47.7% of the total surface area, while the sedimentation rate was 1.77mm/ha/year (Balai Besar Wilayah Sungai Pemali Juana, 2015). Water hyacinth removal was necessarily needed because its rapid growth produced a lot of unutilized water hyacinth. In 2015, the water hyacinth area was ± 755 ha or about 47.7%, in 2017 the water hyacinth area reduced to 400 ha or about 25.27% and in 2018 it reduced again to 300 ha or about 20% (Balai Besar Wilayah Sungai Pemali Juana, 2018). In 2020, 550 ha area of water hyacinth was removed (Balai Besar Wilayah Sungai Pemali Juana, 2020). Receding water was the obstacle to the water hyacinth removal process since the equipment could not be operated at the disposal site, while the nearest disposal site is in the Bukit Cinta area. However, another disposal is still required due to the rapid growth of water hyacinth.

Various lake cleaning efforts have been initiated from dredging lakes and construction of check dams, controlling water weed by periodically removing the water hyacinth, herbicides spraying, drifting water weed through Tuntang River, relocating water weed to the temporary disposal which later thrown to landfills, and many other methods. Nevertheless, all these efforts did not show significant results. There is a more effective and efficient method that saves energy, costs, and time does not cause traffic

disruption, road damage, environmental pollution, and other impacts that can trigger social conflicts, that is, the creation of embankments delimiting the lake area with citizens' land and the creation of Rawa Pening wildlife conservation island (Interview with the Head of Kesonggo Village, 2022).

Water hyacinth is considered a nuisance weed, so various ways (mechanical and biological) are carried out to overcome it. They are: a) Herbicides. b) Lifting water hyacinth directly from the aquatic environment. c) Predators (animals that eat water hyacinths). The predator is the koan fish. Koan fish disturb the balance of weeds on the water surface. So, their leaves touch the surface of the water. The decomposition occurs and is then eaten by fish. d) Utilizes water hyacinth as a material for making paper, compost, biogas, furniture, and handicrafts, as a growth medium for edible mushrooms.

Tidal rice field ownership

The tidal area was formed due to the tide of the water surface (Sittadewi, 2008), and becomes a part of the wetland ecosystem (Noor, 2015). The tidal area in Rawa Pening Lake is used by the surrounding community for rice farming activities with an area of about 1,030.51 ha. The use of tidal land as rice farms improved the economy of the community, but it might result in environmental degradation that will threaten the sustainability of the lake ecosystem as a whole such as flooding, narrowing the area of the lake, the leakage of nutrients into water caused by agricultural activities, hastening the eutrophication of the lake, and increasing the acidity level of the land due to the decomposing organic materials and various chemicals used in agricultural activities (Cahyaningrum, 2020; Nugroho *et al.*, 2014). Many rice fields were found in Banyubiru Village with the area of 186.90 ha, Kebumen Village 185.13 ha, Pojoksari Village 146.98 ha, Tambakboyo Village 119.49 ha, Asinan Village 93.00 ha, and Candirejo Village 149.771 ha (Balitbang Provinsi Jawa Tengah, 2003). This tidal area is closely related to the determination of elevation. Based on the Decree of the Minister of Public Works and Public Housing Number 365/2020, the elevation limit of 462.7 m is higher than the previously set limit. As a consequence of the regulation, the community could not plant rice for two years because the tidal rice fields managed by the community were waterlogged, such as in Bejalen Village where the

puddle covers 700 meters of the land, whereas in Asinan Village it covered 1 kilometer of the land. Farmers have lost their livelihoods and things are getting more difficult with the COVID-19 pandemic (Interview with the residents of Bejalan Village, 2022). Regarding the elevation limit, the community has demanded it to be lowered since 2020, and it was approved that the elevation limit is lowered to 461.30 m. The lowered elevation enables the community to replant whimsical land at least once a year. Siswanto (2022), sluiceway keeper of Jelok Dam, said that for tidal rice field farmers, the lower the water level, the more the farmers will be benefited because they can harvest twice a year. However, if the elevation is raised, it will have the potential for water to flood the tidal rice fields so that the community will experience loss due to harvest failure or because the tidal rice fields cannot be replanted. On the other hand, lower elevation of the water discharge in Rawa Pening Lake might result in the obstruction of the Hydroelectric Power Plants (PLTA) operation. The decrease in elevation is

carried out gradually by the targets that the community wants to achieve. In fact, the community participated in monitoring the entrance of the Jelok Dam so that they could directly see and supervise the activity through a schedule of farmer pickets made by themselves. However, the elevation might be changed at any time during the rainy season. During the decrease in elevation, the condition of the residents' lands that were flooded gradually receded. There were even those that were not flooded anymore. The following are the data from the community related to the current condition of citizen lands at elevation 461.32 as of June 3, 2022 (Table 1).

The demand of the community to meet the needs of tidal rice fields affected: a) the non-fulfillment of water needs in rice fields covering an area of 20,067 ha, which is downstream; b) the harvest from rice fields covering an area of 20,067 ha was not optimal to support rice self-sufficiency in Central Java Province; c) users who utilize water from Rawa Pening Lake, such as Hydroelectric

Table 1: Plot at elevation 461.32

SN.	Village/Ward	Description
1.	Bejalan Village	There are still waterlogged
2.	Asinan Village	There are still waterlogged
3.	Tuntang Village	No waterlog found
4.	Tambakoyo Ward	No waterlog found
5.	Banyubiru Village	There are still waterlogged
6.	Rowoboni Village	No waterlog found
7.	Rowosari Village	No waterlog found
8.	Sraten Village	There are still waterlogged
9.	Pojoksari Ward	There are still waterlogged
10.	Candirejo Village	No waterlog found
11.	Kebumen Village	No waterlog found
12.	Lopait Village	No waterlog found
13.	Kesongo Village	No waterlog found
14.	Kebondowo Village	There are still waterlogged

Power Plants, Local Water Supply Utility, do not meet their needs; d) increasing water deficit; e) BERKY harvester equipment cannot work optimally because it requires elevation above +461.90 m in order to work properly (Balai Besar Wilayah Sungai Pemali Juana, 2021). The changing of water elevation level must be carried out wisely because it affects the area around the lake as well as the output of water used as an irrigation source for 2,000 acres of rice fields in the Grobogan and Demak Regencies.

Especially during the rainy season, water discharges clearly increase so that the lands around the lake that are originally dry will potentially be flooded. In this condition, the community wanted the water gate to be opened immediately so that the water immediately recedes to prevent flood in the downstream area, considering the amount of water needed by the Hydropower Plant to optimally supply the electricity. The decrease in water surface elevation has been tested by BBWS (2021) at a

minimum elevation of +461.90 m and minimum elevation of +461.65 m, as follows (Table 2).

Land and building ownership of the Lake and Riparian areas

The effective area of Rawa Pening Lake has shrunk by 820 ha (about 30%) from the initial area of 2,670 ha to 1,850.10 ha (Balai Besar Wilayah Sungai Pemali Juana, 2018). Based on the Decree of the Minister of Public Works and Public Housing Number 365 of 2020 concerning the Determination of Rawa Pening Lake Riparian Borders, the area of this lake is 2507 ha with a water body area of 2387 ha and the riparian area of 120 ha. The riparian area

of the lake is 50 meters from the edge of the highest water table ever with a height of 463.3 m. In the lake and riparian areas, there are 251 buildings, consisting of settlements, tourism spots, places of worship and restaurants. The total area of the entire building located at 50 m from elevation 463.3 is 6.19 ha. The number of rice fields that enter the riparian area of the lake is 65.6 ha in all villages around Rawa Pening Lake. The total length of the road entering the riparian area is 2,519 meters. The number of rice fields in the water body is 386.82 ha. The number of Floating Net Cages is 3223 buah (Balai Besar Wilayah Sungai Pemali Juana, 2020).

Table 2: Alternative lowering the elevation of water level of Jelok Dam

Alternative	Alternative I Min. Elevation +461.90 m	Alternative II Min. Elevation +461.65 m
Volume	The elevation of the Jelok Dam based on the Reservoir Annual Operation Plan September II is +462.11m so the water to be released is ± 3.78 million m3	The elevation of the Jelok Dam based on the Reservoir Annual Operation Plan September II is +462.11 m so the water to be released is ± 8.28 million m3
Fieldwork on the revitalization project of Rawa Pening Lake	The tools were working but it was not effective	Currently, most of the water hyacinth has been brought to the lakeside which caused the tool cannot be operated.
Hydroelectric Power Plant	Electricity production decreased to 7.5 MW (50% of 15 MW)	Electricity production decreased to 4.7 MW (31% of 15 MW)
Raw Water	It can still be served entirely	It can still be served entirely

Table 3: Inventory of certified land parcels within the lake and riparian areas.

SN	Village/Ward	District	Number of Plots	Total Area Per Plot (M2)
1	Asinan Village	Ambarawa	175	310.600
2	Bejalen Village		121	221,418
3	Kupang Ward		46	94.084
4	Candirejo Village		191	411.872
5	Kebondowo Village	Banyubiru	28	105.225
6	Banyubiru Village		71	205.877
7	Rowoboni Village		0	0
8	Lopait Village	Tuntang	34	61.928
9	Rowoboni Village		130	229.572
10	Rowosari Village		152	283.499
11	Tambakboyo Ward		10	113.409
12	Tuntang Village		424	397.778
Total Number			1382	2435262

The riparian area can only be used for: a) water resources infrastructure buildings; b) road access, bridges, and docks; c) gas and drinking water pipelines; d) electricity and telecommunication cable stretches; e) tourism, sports, religious, research, and development science infrastructure; f) sanitation infrastructure and facilities, and g)

electricity development. Buildings entering the riparian area are declared as a status quo, meaning that it is not allowed to change, add, and improve the area because they will gradually be ordered to restore the function of the riparian area. Practically, since 1967 there have been buildings and ownership rights to land in the form of property rights that are

on the lake boundary. The forms of land ownership around Rawa Pening Lake are as follows: first, the Letter C document, is a land register book that exists in the village for generations and is stored in the respective village office. Meanwhile, residents who own the lands are only given the excerpts of Letter C. Before the land registration activity, Letter C was a basis for the withdrawal of land tax and strong evidence that explained that the land was a customary property right and the name listed in Letter C was the taxpayer so that the registration was through conversion. Letter C is the basis for the issuance of land title certificates (Figure 1).



Daringan Culinary Park, Blue peg on the community house, Blue peg on resident's rice field

Figure 2: Blue pegs on the boundary of the lake area.



Yellow peg in front of the community houses, Yellow peg on community rice fields, Yellow peg on the community land

Figure 1: Yellow pegs on the riparian area

Second. Village Treasury Land, is land controlled or owned by the village government as one of the original sources of village income for social benefit. Provision of Village Treasury Land: a) it is used for the sake of village development and community service; b) position land which is the provision to village officials as additional income for their service while serving as village officials; c) as a tribute to officials who have completed their duties; b) lands that have general functions and social functions such as fields, cemeteries, village halls, and so on. Kesongo Village located in Tuntang District is one that has village treasury land that is used for public interest to increase the village's original income and carry out social functions. Village treasury land is used for rice fields that are managed by the community, parking lots by fishermen and fish cage owners, and culinary tourism (Figure 2).

Yellow and blue pegs mark the corresponding lake and riparian areas which aim to protect the lake area and restore the lake's function as it supposed to be. However, in its implementation, it causes anxiety in the community because the pegs that have been installed are in buildings and land owned by the community that has been certified and is still in the form of letter C, which has the potential to cause conflicts between citizens and state officials. On the other hand, it has an economic impact in the form of decreasing income and shifting livelihoods because people lose land rights. The following is an inventory of certified land parcels downloaded from the Semarang Regency Land Office in 2022 (Table 3). Land ownership status within the lake or riparian areas is as follows: 1) If the lake boundary land is used for city facilities, buildings, roads, or public facilities, it will remain unaltered, maintained as long as no reason is found that is more important than its current benefits; 2) If the lake boundary land is owned by the community, its original purpose must be returned as a riparian, as long as the ownership rights to the land are validly recognized, but the landowner must comply with the designation of the land as a riparian area; 3) Buildings that have already been established on the riparian area are declared in the status quo, i.e., cannot be changed, added, and repaired and new construction permits will no longer be issued; 4) Community land acquisition with a comprehensive land procurement mechanism both in lake bodies and riparian areas

Conclusion

The revitalization of the Rawa Pening Lake was carried out by *first*, removal of the water

weeds/water hyacinth that caused the silting. Once the water hyacinth is removed, it sinks and dispositions. This deposition will cause sedimentation and a decrease in the capacity of the water reservoir. In 2020, 550 ha area of water hyacinth has been removed. The cleaning of water hyacinth is difficult because of its rapid growth. Various efforts have been made such as dredging the lake, building dam checks, cleaning by spraying with herbicides, drifting weeds through the Tuntang River, and pulling and holding weeds to final disposal, but the results are not significant. *Second*, tidal rice fields are closely related to elevation. The determination of the elevation limit by the government is 462.7 m, causing tidal rice fields cannot be planted by the community, then on the demand of the community, the elevation is lowered

to 461.30 m, but the decrease in elevation hinders the operation of the Hydroelectric Power Plant. *Third*, ownership of land and buildings in the lake and riparian areas. Ownership of land and buildings can only be done for land acquisition (compensation) to the land owner. The revitalization of the riparian areas was carried out at the highest elevation of the lake water body of 463.3 m which was then pulled out along 50 m. This riparian area will later be made an embankment that can function as a jogging track and also a public space.

Conflict of interest

The authors declare that they have no conflict of interest.

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