IMPACTS OF AGRICULTURAL PRACTICES ON THE SUSTAINABILITY OF VOLCANIC LAKES IN DIENG PLATEAU, CENTRAL JAVA

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Volcanic lakes in the Dieng Plateau offer some unique phenomena which are interested for tourists to visit and scientists to study. They also have some specific ecosystem which differs to other lakes. However as land use changes in the surrounding area the lakes is now facing to environmental degradation. The land use in the surrounding area is for intensive agricultural which main crops are vegetable, especially potato (Solanum tuberosum L) This research aims to study the impacts of the agricultural practices to the environmental degradation of lakes which could be give farther impact to the sustainability of the lakes. One among lakes in Dieng Plateau was selected in this research, it was Merdada Lake . The field survey was conducted to collect some data on lakes characteristics (morphometry of lake, water quality, sediments) and agricultural activities. Some interviews to local people were also conducted. Some secondary data from previous study was also collected. Data analysis was conducted based on qualitative and quantitative techniques. The study found that agricultural practices of potato plantation uses water from lake to irrigate the plant by pumping out the water using water pump and distribute the water over the plantation area. The volume of water pumped out of the lake was so high that gradually decrease the water level of the lake, especially during dry season. Agricultural practices lead to soil erosion, which contribute sediment to the lake brought by surface runoff. The use of fertilizer in the agricultural practice contribute nutrient into the lake brought by surface runoff, leading to the eutrophication of the lake, due to the excess used of fertilizer. The study concludes that agricultural practices have some adverse affects on volcanic lakes. Quantitatively the volume of lakes is gradually decreasing due to rapid sedimentation; water level of the lake has been lowering due to high rate of pumping. Water quality of lakes is getting worse, leading to eutrophication. In the long terms the sustainability of the lake is threatened,

Keywords: Volcanic lakes, agricultural practices, erosion, sedimentation, eutrophication.

INTRODUCTION

Lots of research have been conducted on natural and artificial lakes. Most studies have revealed about degradation on Lake Environment as a result of human activity, among which are agriculture and tourism activity. Sudarmadji (2004) reveals the importance of the ecosystem of the lake as it changed due to environmental degradation of the catchment area. Kowenje and Agunya, (2014) studied the Lake Victoria related to chemical contamination, Nomosatryo, and Lukman, (2012) studied Toba Lake to see trophic status, associated with human activities. Piranti, (2012) examined the tropic status Sudirman Reservoir and Wantasen (2009) studied the Tondano Tondano which both showed a decrease in water quality as a result of human activities. Most studies are more interested in the large lake. Only some studies were conducted in small lakes, while small lakes mostly used by locals community for various use. Study on volcanic lakes are still limited. One study of small volcanic lakes because of its uniqueness was conducted by Setiawan et al., (2014) which examined Tolire Lake on the island of Ternate. Research on small lakes is also interesting because of the interaction between community and the lake in managing the lake are usually consider local wisdom. Community involvement in managing water resources has been expressed by Sudarmadji et al., 2010 and Sudarmadji et al., (2013). In fact, Partomo et al., (2011) has revealed the role of the community in the management of the Rawa Pening Lake.

This study was conducted in Merdada Lake and the surrounding area which are expected to affect conditions Merdada lake. Merdada Lake is located in the village of Karangtengah, Batur sub-District, the District of Banjarnegara. It covers an area of about 25 hectares. This lake is surrounded by two hills, namely Bukit Bukit Semurup Pangonan and who actually named Summer Up this hill because the soil is red and frequently suffering frm fires. The extent of this lake is the reason given name "Merdada". "Merdada" refers to the "chest", which implies a field or area. Merdada Lake is the largest lake in Dieng Plateau. Although the lake is the largest lake, it does not have any springs as water supply into the lake. Most of the water comming into the lake is rainwater, only some part is comming from seepage from the surrounding area. As most of the water comming from the rain, during the dry season, this lake will be dry up rapidly. Water in the middle part of the lake looks very clear, but it does not mean that the water qualitatively good for domestic, agricultural or even fishery uses. This lake has a thick mud layer, that it makes dangerous to traverse.

In the periods of 1950 to 1998, the area around the lake was used by PT Dieng Jaya as a mushroom breeding. But then, during the

economic crisis, the nursery was closed. Water of the lake is so important water source for nearby farmers. Potato (*Solanum tuberosum* L.) plantation that is widely found around the lake is very dependent on the availability water in this lake (http://www.indonesiakaya.com/kanal /detail/telaga-merdada-telaga-terluas-di-dieng) date accessed August 1, 2015).

Merdada Lake formerly has high impression because of the dense surrounding forests with clear water, calm and deep water. This situation atrracts a lot of tourists to visite to seek the coolness and tranquility. But at this moment the condition is much more different from the conditions in the past. Merdada Lake impression as nature tourism obyect that offering natural beauty, fertile land and abundant water resources is almost nothing left. Merdada Lake that used to have very interesting conditions, today has been affected by many changes, so it is no longer interesting from the aspect of tourism (Rusiah et al., 2005). Furthermore, water in the Merdada Lake has been exploited for agriculture pupose, mainly for irrigation uses in potato plantation. Third that with agricultural activities by the surrounding community, Merdada Lake has experienced negative effects such as silting and deterioration of water quality, thus threatening the existence of the Merdada Lake in the future.

Actually, in this area lives style of the community is one the fenomena which is interesting to learn, due to local knowledge in preserving the environment. The local cultural of the communities for generations have some way to manage the natural resources and environment. However, the facts show that the situation has been changed significantly. Merdada Lake is now highly exploited, by taking so much water out of the lake for irrigation, though this lake is also used for fishing cultivitation.

Merdada Lake can actually be developed in accordance with the potential of its prospects to improve the welfare of society. However, Merdada Lake has changed due to the negative impact of agricultural practices. Agricultural practices in the surrounding area and its catchment area is so intensive. The area having steep slopes that should not allowed to be used for agriculture has been cultivated with agricultural crops, especially potato. This is very worrying because it create high rate of erosion which constribute sediment that goes into Merdada Lake; in turn it can lead to rapid silting of the lake. The use of fertilizers and pesticides also has the potential to pollute the lake water Merdada. Based in those evident, therefore, studies on the impact of agricultural activities on the Merdada Lake is needed to analyse the sustainability of Merdada Lake. The question can arise as follows. a). How Merdada Lake support the activities of the surrounding communities in terms of ecological balance; b). In what extend the agricultural activities has benefit to the local

community and how far those activities resulting negative impacts to Merdada Lake and c).What kind of negative impact has happened and likely to continue if there is no effort to stop, which will threate the existence of Merdada Lake in the future.

With the formulation of the issues raised in the previous section, the purpose of this research is: a). Understanding the potency of Merdada Lake to support agriculture uses; b). Analysing the benefits of agricultural activites to the local community in term of economic aspects, c). Analyzing the environmental impacts of agriculture practices, to the environment of Merdada Lake, especially those on the sedimentation and water quality of the lake.

Methods

This research basically use the secondary and primary data. The secondary data used derived from previous study which has been conducted in the Merdada Lake. The primary data was also collected during the field work. This research needs some instrument to colect data. Map showing the location has been used, such as adminitratic map of Wonosobo District and Banjarnegara District as well as satelite imagery, GPS was also used to determine the exact location when collecting data and collecting samples. To collect some information the quesioner was also used. Beside that deep interview with the local leader was also conducted. During the field study some documentation using digital camera was also performed.

The location where samples was collected was than plotted into the map based on GPS result. The observation of the environmental conditions of the lake were organized in such a way that make possible to analyse, using tables. The data on on socio-economic conditions of the people of the community leaders and the information office in the village and sub-district records related to the local customs of local communities related to the management of the lake. Interviewing residents and community leaders to find out how the community conducted the management of the lake. The interview was conducted to the farmers who use the land around the lake on agricultural practices, who taking water from the lake, using fertilizers and pesticides.

All the data collected were then processed to and analyze the results of interviews, in order to obtain how the management of the lake, and how much people earn income from agriculture. The whole analysis is pincipally used descriptive analysis.

RESULT AND DISCUSSION

Merdada Lake with an area of 25 hectares and an average depth of about 2 meters is potential as a source of irrigation water in the surrounding area. However, due to the input of Merdada Lake only in come from of rain, meaning that its catchment area is actually not too large, especially inputs from rain only occur when the rainy season only. It means that the Merdada Lake potential as a source of irrigation water is limited (Fig.1). Merdada Lake the source of water from the rain water has a water quality should close to or similar to the quality of rain water. It means that water of this lake does not have excessive substances. The quality of water in the volcanic lakes is often influenced by the volcanic activity in the area (Setiawan et al., 2014). In this regard, the Merdada Lake is potential to be developed for irigation and aquaculture.

Fig. 1. Merdada Lake From Satelite Image (Google Earth aceeced on June, 2015)

Historically, in fact Merdada Lake an interesting tourist attraction, although at this time it can be observed that there is nothing to attract tourists to visit the Merdada Lake. From the satellite images it seems that have significant decreasing of the area of Merdada Lake. On the west side of the lake appears to progress faster than the land area of the east. The original shape of the lake round (circular), but with the development to the westward is faster that make the shape of the Merdada Lake, especially those occupied by water body becomes un-circle any more (Figure 1). It is likely was caused by the use of the area around Merdada Lake for mushroom cultivation (years 1950-1998), which is now over.

Erosion and sedimentation in the surrounding area of the lake has significantly constributed to the development of the shape of the lake. Merdada Lake has no inlet and outlet, cunsequently the reducing water of

the lake is mainly caused more evaporation. However, as Merdada Lake is used as a source for irrigation of the crops on agricultural in the vicinity, a lot of water is extracted from this lake. Merdada Lake can also be used as a conservation area, because the existing condition is very poor. There has some efforts to restore the Merdada Lake conditions, or at least inhibit the rate of destruction of the lake (Figure 2).

Fig. 2. Merdada Lake (left) as Conservation Area (right)

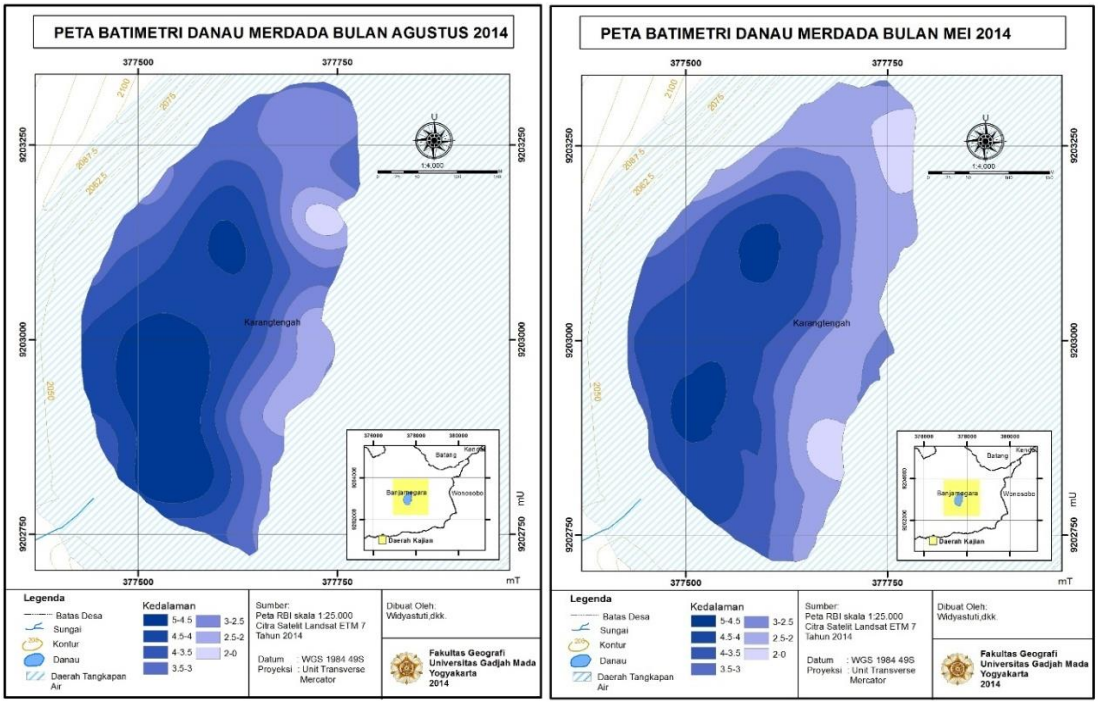

Fig 3. Batimetry of Merdada Lake Meiy 2014 (left) and August 2014 right) after Widyastuti et al., 2014

Benefits of Agricultural Practices

Merdada Lake water has been used by the community for irrigation purposes, not only in the area around Merdada Lake, but it is often extended outside its catchment area. How to take advantage of lake water that is done by pumping water pump is large enough, then the water distributed by PVC pipes (PVC) to where it is needed (Fig. 4).

Fig 4. Pumping out Water from the Lake for Irrigation

Merdada Lake used also for aquaculture, by breeding fish into it. However, aquaculture in such a way has not been successful. It can be seen from the observation that does not look to have a lot of fish in the lake. Even some of those anglers in Merdada Lake did not have enough fish in such inducement. It means that the population of fish in the lake is limited. Using water from Merdada Lake has been significantly increasing economic benefit from agricultural sector. The evidenced of the spread of potato plants in the vicinity (almost 90%) give some indication of these phenomena. If no benefit, then the potato crop land will not grow as wide as it is now (Figure 5).

Fig 5. Agricultural Land Planted with Potato

Environmental impact

Merdada lake water utilization as irrigation water of agricultural crops such as potato plants give a huge impact on the economy of local communities. This is evident from the extent of agricultural land in the surrounding potato. Land that is originally used as forest has been

converted into agricultural land.The used of water for irrigatian is very high, it is done by pumping out water from the lake. Study conducted by Widyastuti et al., 2014 shows that pumping water was conducted in May to September, while in October-April farmers use rain to irrigate agricultural land. Pumping for irrigation is unbelievably varied in terms of time and number of pumps. There were more than 100 pumps were used to pump water out of the lake. It was estimated during dry season with pumping time of 12 hours / day and each water pump discharge aboput 20 L/sec, the volume of water is 7.2 m^3/h.

The negative impact on the environment due to agricultural practices is very clear. Land being used for potato plantation is the main source of soil erosion. Soils erosion is followed by sedimentation in Merdada Lake. This evident can be observed from the decreasing of volume and shape of Merdada Lake as seen from satellite imagery (Figure 1). When the rain falls, the land having relatively steep slope will be easily eroded, and provide sediments which is brought by runoff into the lake. Therefore, environmental impacts such as siltation of lakes have been starting from the edge of the lake. This can be proved by analysis of grain size of the sediment. Coastal area of the lake that gradually becoming flat land is utilized by farmers for agricultural land. This will gradually change the condition of the lake, which will decreasing the lake depth, getting narrow and narrow (Fig. 6). The erosion and sedimentation prosesses will be clearly observed during rainy season as the agent of erosion come from rainfall. Runoff comming from the lake surrounding area constributes sediment into Merdada Lake. In this season the erosion and sedimentation processes silmutaneously take place.

Fig. 6. Change of Coast of Merdada into Agricultural Land

Fig 7. Sedimentation of Merdada Lake, Reducing the Volume

Use of fertilizers, both organic and chemical is unavoidable in potato farming. The use of pesticides to control pests in agriculture is also unavoidable in growing potato. The rest of the fertilizers that are not absorbed by the plants can be carried into the lake through the flow system (runoff). Furthermore, it lead to the enrichment of the lake water conditions, so that the water plant will thrive in the waters of the lake. It will also speed up the silting and narrowing of the lake. On the other hand the possibility of pesticides used will also have an impact on the condition of the lake. The low growing rate of fish is likely due to the influence of pesticides into the lake.

Fig. 8. Aquatic Vegetation in the Merdada Lake

The negative impact of farming potato to the environment, directly or indirectly affecting the condition of Merdada Lake. Silting caused by sedimentation of material derived from agricultural land has reduced the capacity of the lake, it can even change the shape of the lake. The color of the water becomes more turbid, the water level of the lake has been much covered by aquatic vegetation, so that the function and use of the lake for irrigation will decline. Study by Widyastuti (2014)

indicate that water quality in the Merdada Lake is suitable for agricultural. However, it evident that the use of water pump which are placed close to the water body subject to spoiling out some oil. It give the posibility of water to be contaminated (Fig. 9). During the dry season when water level is decreasing it is clear that the color of water in some part of the lake has changed to be come darker. It should be further investigated.

Fig 9. Spoilling Oil from Water Pumps

The ecosystem of the lake will subyect to significant change, although it has been some effort for conservation. The effort however will not work properly if the conservation is only focused on the the lake itself, as the lake waters are also influenced by the conditions of its catchment area. Therefore, the comprehensive effort in conservation, should be done in order to keep the existence of the Merdada Lake.

CONCLUSION

1. The negative impact of farming potato to the environment, directly or indirectly affecting the condition of Merdada Lake. Silting caused by sedimentation of material derived from agricultural land has reduced the capacity of the lake, it can even change the shape of the lake.
2. Lowering of water lavel in the Merdada Lake will always happen due to high rate of pumping water out of the lake.
3. Water quality will also change due to the contribution of fertiliser which not taken by vegetation, and furthermore by spoiling oil from water pumps.

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