Utilization of greenbelt zone around the dam Study case: Logung Dam, Kudus Regency, Central Java

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Abstract : Dams have an important role, especially in Indonesia, not only as a water source, agriculture also plays a role in controlling floods and hydropower. Many dams have been built and some are under construction. In line with its existence and function, the existence of dams also faces several problems, one of them is erosion problem which threatens the sustainability of the dam function. Land conversion in upstream and around areas contributes to erosion. Natural landscape around the dam must certainly be maintained into the Greenbelt zone. On the one hand its existence must remain part of the natural landscape but on the other hand it will still function as part of the settlement area. The study is intended to map the greenbelt area that must remain natural and which areas can be utilized. Research begins by identifying physical conditions along the edge of the dam, then analyzing it and combining it with existing land use data, resulting in a map of utilization along the edge of the dam (greenbelt).

Keywords : greenbelt, landuse, erosion, sustainable landscape

1. Introduction

Indonesia has many dams where its existence is very important. It plays various roles, not only as a water resource but also important for agriculture and hydropower. However, the sustainability of this dam is often threatened by several factors, one of which is due to erosion.

The dam, which was originally built in a rural area (far from urban areas), gradually experienced pressure due to the construction of new settlements that is always followed by land clearing. As a result, it changes natural landscape conditions become built areas and not only increase the risk of erosion but also threaten the sustainability of dam functions.

Refer to Saha (2003), erosion is a natural geomorphic process occurring continually over the earth's surface. The process is modified by biophysical environment comprising soil, climate, terrain and ground cover and interactions between them. Soil erosion occurs when Soil particles are loosened, washed down the slope of the land and either end up in the valley or are washed away out to sea by streams and river (Department Agriculture Republic of South Africa, 2008). It can be seen clearly that clearing land could increase erosion. An example of this situation is at Saguling dam located in western of Bandung, West Java that facing sedimentation problem not only due to increase erosion from Citarum river that flow into the dam but also due to clearing land that already touch an area around the edge of the dam.

Figure 1. A new housing area build near waterbody of Saguling dam that increase erosion risk to waterbody (image source : http://triindonesia.blogspot.com/ 2011/08/tanggung-jawab-penataan-kawasan.html)

Sedimentation occurs from two entries, first is coming from the river that empties into the lake and second is coming from runoff (source: the area around the dam) that flow directly into the waterbody. Looking at the second cause, the existence of vegetation around the edge of dam which acts as a greenbelt is very important, especially to hold runoff. This paper shows how the greenbelt must be utilized, based on its physical condition and its relation with land use when the area is in contact with residential areas. Should it be 100 percent full vegetation area or can it be used as cultivated land or a combination of both. The arrangement of greenbelt is intended as an effort to maintain the sustainability of natural landscape including the presence of Waterbody there.

This study took a case study at Logung Dam located in Kudus Regency, Central Java. When this research was carried out (2017), actually Logung Dam was still in construction stage, even the flooding process had not been carried out. The research was carried out early so that it became a guideline in plan of the landscape around the dam, so the sustainability of natural conditions and reservoirs could be maintained.

In general, a reservoir or dam have a large body of water, creating a beautiful view. It have a potential to become a tourist destination. That is why this study is needed as a guideline to arrange the area along the edge of the water, especially the greenbelt zone to deal with the possibility of building tourism facilities around the reservoir.

2. Methodology

Green belt, here is defined as a strip of vegetation. In this study case, the area is stretches 15 km along the edge of the dam. To determine what function is suit along this greenbelt, there are 3 main steps :

a. Identify physical condition
b. Analysis to determine kind of 'green' function along the greenbelt
c. Determine Zone plan along the greenbelt

Physical conditions are important factors that should be identified, such as contour and landcover/landuse. Contour data is acquired by direct measurement along the edge of the dam, however due to time limitation this measurement was focus only on elevation range +92,85 to +95 (elevation +92 is maximum water level). To identify landcover/landuse, was acquired by site observation. In some cases, the google earth application is also used to assist in interpreting land use, followed by direct observation to the area. This method to save time due to large area of observation (around the dam). Other data use only secondary information such as rain and soil type.

The data then was analysed, its steepness was categorised to extreme, moderate and gentle. Landcover and landuse is categorised based on its function. These data then are combined to get area which has potential risk from its erosion aspect. Basically, there are 3 proposed landuse can be implemented in greenbelt zone, there are : forest, cropland and recreation.

3. Discussion

3.1 General description of Logung Dam

Logung dam is located about 15 km at north east of Kudus Regency, Central Jawa. Refer to Taufiq and et al, 2017) the dam/reservoir would covers the area : 144 ha, covers area of Tanjungrejo and Kandangmas village.

There are some facts about the reservoir :

a. The reservoir is actually a meeting point of Gajah river and Logung river and others creek. Long of Logung river is about 20,125 km begin from Mount Argojembangan (elevation : +1,300 m) to hills of Patiayam (+350m) that is located near the location of reservoir.
b. The water catchment area that support this reservoir covers an area of approximately 43.81 km^2.
c. From geology aspect, the location of reservoir lies on stable geology structure.
d. From the topography aspect, the reservoir is located on undulating land. The existence of the river makes this area has a form of slope 'V' that is quite steep. In fact, this condition is the reason why the area around the reservoir is potentially eroded. Most of the steepness in the greenbelt area is between 20% - 45%.
e. Specification of dam :
    - Type : Embankment Dam
    - Purpose : Hydroelectric, Irrigation, Watersupply
    - Elevation of a normal water surface : +88,50
    - Elevation of Maximum water surface : +92,85
    - Storage Capacity (water elevation normal) : 20,150,000 m^3
    - Area of Inundation : approx 144 ha

Figure 2. Location of Logung Dam near Kudus City.

3.2 Erosion risk along the edge area of dam

Erosion is the process of sweeping solid materials by flow of water or runoff, it is tranported away to other locations. It occurs when a raindrop hits soil surface which is less covered by vegetation, and there are no roots to bind the soil. Then soil particles are, washed down the slope, either end up in the valley or are washed away out to waterbody by stream or river.

Hardiyatmo (2012), states that erosion process by raindrop can be classified as follow :

- Splash erosion
- Sheet erosion
- Rill erosion

- Gully erosion
- Stream/channel erosion

Moreover, Hardiyatmo also states that splash occurs when raindrops hit soil surface. The impact breaks up soil that individual soil particles are 'splash' onto the soil surface. Rill erosion occurs when surface water concentrates in depressions or low points through paddocks and erodes the soil. This kind of erosion is common in bare agricultural land and can be reduced by reducing the volume and speed of surface water with grassed waterways and filter strips, ripped mulch lines, and contour drains. While Gully erosion occur when smaller water flows concentrate and cut a channel through the soil.

Refer to Saha (2003), the erosion is actually a natural process, but is often intensified by human activity. Land clearing is one cause why erosion occur. In agriculture activity, inappropriate farming techniques also cause erosion such as poughing land 2 or 3 times/year to produce annual crops or planting crops down the contour instead of along it.

From field observations to the area around Logung Dam, the landuse is still dominated by vegetation such as natural forests, forests and cultivated fields. this condition will certainly help in preventing erosion that may occur, but there are also traces of Gully erosion in some locations which shows the risk of erosion due to runoff, which potentially brings runoff with all the particles entering the water body.

Soil erodibility is determined by several factors, ie slope, soil texture & structure, terrain unit, organic material and vegetation cover.

- Slope, if slope getting more steep, the erosion risk will increase as a result of the increased velocity of water runoff.
- Soil Texture, there are three main particles of soil : sand, silt and clay. The more sandy a soil then the more easy it will erode.
- Soil Structure, if soil lose its structure and cohesion, it will erodes more easily. Soil structure means the grouping or arrangement of soil structure.
- Organic Material, it binds the soil particles and plays an important part to prevent soil erosion. If soil has many organic matters both plant and animal, it will increase infiltration capacity and in the other hand it will decrease water runoff.
- Vegetation cover, less vegetation on soil surface makes soil vulnerable to being swept away, either by wind or water. Dept Agriculture of Rep South Africa states that plants provide protective cover on the land and prevent soil erosion for the following reasons : (1) plants slow down water as it flows over the land and this allow much of the rain to soak into the ground; (2) plants roots hold the soil in position and prevent it from being blown or washed away; (3) plants break the impact of a raindrop before it hits the soil, reducing the soil's ability to erode; (4) plants in wetlands and on the banks of rivers are important as they slow down the flow of the water and their roots bind the soil, preventing erosion.

For the purpose of analyzing the edge of dam, the area is divided into 4 zones : East zone, Centre, North and West zone.

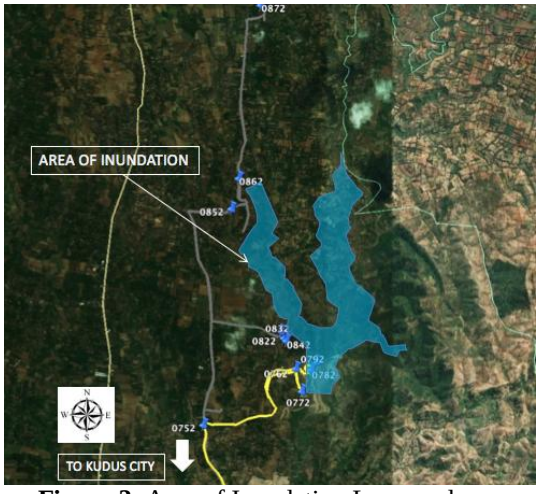

Figure 3. Area of Inundation Logung dam

There are some facts resulted from site observation (especially on elevation +92 to +95) which focus on 2 physical aspects that influence its erosion risk : slope and landcover/landuse.

Table 1. Physical condition in each zone

	East Zone	Centre Zone (East strip & West strip)	West Zone	North Zone
Slope	• About 60% area along this east zone/strip (green belt zone) categorised as extreme slope (> 40%) • some spot areas have potential risk of land slide • in area behind the green belt zone, dominated by undulating landscape with gentle/moderate slope.	• Centre zone (east strip) categorised as strong to extreme slope (slope : 15% - 45%) • Centre zone (west strip) categorised as strong to extreme slope (15% - 45%)	• This zone is categorised as Strong to very strong slope (15% - 40%, • Area behind green belt zone is undulating with moderate slope	• This zone categorised to moderate slope (5-15%)
Landcover/ landuse	• Area along east zone (green belt) is dominated by evergreen forest land which most trees remain green throughout the year. • Area behind green belt have mix landuse, dominated by crop land (especially on moderate slope) and forest.	• Area along east & west strip (green belt) dominated by evergreen forest land. Whereas, area behind green belt zone is dominated by cropland	• Area along west zone (green belt) is dominated by cropland, but some spot area is still as evergreen forest land. • Whereas, area behind green belt zone is dominated by cropland as well	• Area in north zone is dominated by cropland. It is because there is a village near this zone.

Refer to Muhajir (2016), land with slope 15-30% is categorized as critical, whereas landcover that only covered by 26-50% vegetation is categorised as critical and if covered below <25% is categorised very critical related to its erosion risk.

Figure 4. Cropland in east zone (behind green belt zone) on steep slope.

Figure 5. Forest mix with cropland in greenbelt zone along west zone (slope classification : moderate).

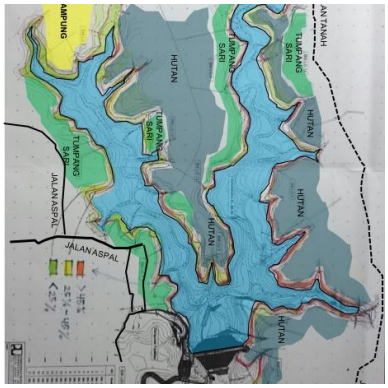

Figure 6. Landuse around the dam

Based on the physical condition, there are some points regard to its potential erosion risk in each zone. These points also consider critical level :

Table 2. Erosion risk in each zone

Centre Zone

	East Zone	(East strip & West strip)	West Zone	North Zone
Erosion risk	• Moderate • Some spots have potential risk of land slide	• Moderate - High	• High	• Moderate
Concept	• Erosion control is supported by vegetation • Keep vegetation existing, it will play a role to reduce runoff speed, increase erosion resistance and increase the bond strength between soil particles • Apply terrace land model especially on cropland			

3.3 Proposed utilization of greenbelt

3.3.1 East Zone
- Greenbelt lies on steep to extreme slope (range between elevation +92 s / d +95)
- Green belt zone has a length approximately 4.200 meters with an area of about 40 ha.
- The function of green belt dominated for evergreen forest, which also serves to protect the slope from the potential landslides.
- With this extreme slope condition, the appropriate vegetation grown on this zone are : *Acacia villosa*, *Pinus mercusii*, *Swietenia macrophylla*, *Cassia siamea*, *Tectona grandis*, *Aleurites moluccana*, *Agathis alba*, *Dalbergia pinnata*, *Andropogon zizanioides* , *Cinnamomum zaylanicum*, *Eugenia aromatica*, *Myristica fragrans*, *Parkia speciosa*, *Pithecelobium jiringa*, *Gnetum gnemon*, *Persea americana*.

3.3.2 Centre Zone
- Green belt zone (centre-east) has a length approximately 3.500 meters with an area of about 30 ha.
- Green belt zone (centre-west) has a length approximately 3.700 meters with an area of about 34 ha.
- Maintaining the vegetation / hard tree (existing)
- Plant additional vegetation / tree hard for slope stabilization
- Plant a groundcover vegetation
- Cropland located above/behind greenbelt zone is developed into argoforestry (intercropping)

3.3.3 North Zone
- Greenbelt as a bufferzone
- Green belt zone has a length approximately 900 meters with an area of about 12 ha.
- The function of green belt dominated for evergreen forest, which also serves to protect the slope from the potential landslides.
- Landuse behind greenbelt zone is possible to be developed as recreational (camping ground) and cropland.
- Plant a groundcover vegetation

3.3.4 West Zone
- Green belt zone has a length approximately 2.700 meters with an area of about 28 ha.
- Maintaining hard tree vegetation (existing) and possible to be developed as arboretum
- Planting groundcover vegetation (concept of terraces land model)
- Cropland located behind green belt zone is developed become argoforestry (intercropping)
- Some spot area is possible become recreational area such jetty

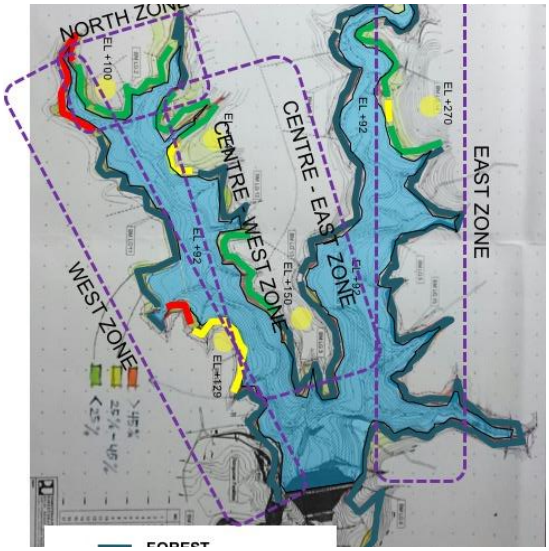

Figure 7. Proposed landuse in greenbelt zone

4. Conclusion

Greenbelt play an important role to minimise erosion risk around the reservoir/dam. Existence of vegetation along this greenbelt should be protected from land conversion and other encroachment such bushfires, felling and / or illegal mining.

The greenbelt zone in the Logung Dam is dominated by extreme contours with a slope range of 25% to more than 45%. Based on these physical conditions, basically there are 2 utilizations of the greenbelt. First is Greenbelt that must be left natural by making it as forest (even enhanced by planting new trees especially at extreme contours). Second, it is a green belt that allows to combine forests with agricultural land, such as agroforestry. This landuse allocation is mainly for areas that come into contact with settlements (for example villages located not far behind). This must be implemented because the land owned by the community cannot be allocated only to forests which cannot be cut down due to risk of erosion. Actually there is a third alternative for the use of the greenbelt, namely for tourist areas, especially in areas that have good views to see the panorama of mountains and reservoirs. When compared with the total area, the allocation for this tourism area is very small compared to the total greenbelt area which still has to be green.

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