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The Environmental Impacts of Post-Disaster Rehabilitation and Reconstruction Facilities in Garut Regency-Indonesia

Ida Munfarida[1], Vera Arida[2]
[1]Environmental Engineering Study Program, Faculty of Science and Technology, UIN Sunan Ampel Surabaya, Jl. Ahmad Yani No. 117, Surabaya, East Java, Indonesia
[2]Department of Islamic Community Development, Faculty of Dakwah and Communication, UIN Sunan Ampel Surabaya, Jl. Ahmad Yani No. 117, Surabaya, East Java, Indonesia

ABSTRACT: Garut Regency is referred to as a miniature natural disaster in Indonesia. This is because Garut Regency is surrounded by active mountains with topographic characteristics of the northern part consisting of plateaus and mountains, while the southern part of the surface has a steep steepness and in some areas is unstable. Garut Regency, which is geographically prone to disasters, is the duty of the District Government and the community to protect Garut Regency and the community from disasters. As part of the overall disaster management, the implementation of rehabilitation and reconstruction stages becomes an important stage. Analysis of environmental impacts of post-disaster rehabilitation and reconstruction facilities is an activity needed to assess the impacts that arise on post-disaster rehabilitation and reconstruction facilities in Garut Regency. The research objective was to analyze the environmental impact of post-disaster rehabilitation and reconstruction facilities in Garut Regency on domestic solid waste generation and runoff. The results showed that the activities in post-disaster rehabilitation and reconstruction amenities in Garut Regency will change the land use, generate the solid waste of 1,07 m^3/day and runoff of 2,73 m^3/day. Land use changes can be maintaining by providing the green open space according to the regulation standard, moreover, the possible treatment for solid waste management is through TPS 3R (reduce, reuse, recycle at temporary waste collection site (TPS)) meanwhile runoff management can be managed by providing the proper drainage and infiltration wells.

KEYWORDS: environmental, impact, post-disaster, rehabilitation, reconstruction.

I. INTRODUCTION

Geographically, Indonesia is located between three world plates; including the Indo-Australian Plate, Eurasian Plate, and Pacific Plate which causes various potential disasters in Indonesia. Because of its location on the three world plates, Indonesia is part of a well-known volcanic zone called the "Ring of Fire" and is prone to natural disasters such as volcanic eruptions, earthquake floods, tsunamis and landslides (land movement) (Kaban et.al, 2019).

According to Law No. 24/2007 on Disaster Management, a disaster is an event or series of events that threatens and disrupts people's lives and livelihoods caused by natural and/or non-natural factors and human factors resulting in human casualties, environmental damage, property losses, and psychological impacts. Disasters in Indonesia have been proven to cause various damages to the environment (Dartanto, 2022), economic losses and casualties (Prasojo et.al, 2021) and psychological impacts (Wardiono et.al, 2021).

A disaster is an event or series of events that threatens and disrupts the lives and livelihoods of caused, either by natural factors and/or non-natural factors and human factors that resulting in human casualties, damage to the environment, property loss, and psychological impact (Law No 24/2007). Similarly, in cases of disasters in various countries, humans are a contributing factor. Poorly implemented risk management in local communities contributed to landslides in Uganda (Nakileza & Nedala, 2020). In industrial areas in Ecuador, disasters are generally caused by the behavior and skills of workers and the interaction between workers and the environment (Longo et.al, 2017).

The regency in West Java Province that has a high level of natural disaster risk is Garut Regency, which is referred to as a miniature of Indonesia's natural disasters (Buchari, 2021). This is because Garut Regency, which has an area of 3,074.07 km^2 from 42 sub-districts, is at an altitude of 758.92 m DPL (BPS, 2021). Garut Regency is surrounded by Mount Karacak (1,838 m), Mount Cikuray (2,821 m), Mount Papandayan (2,622 m), and Mount Guntur (2,249 m). The topographic characteristics of the northern part consist of plateaus and mountains, while the southern part of the surface has a steep level of steepness and in some areas is unstable (Buchari, 2021).

Recent natural disasters that often hit the Garut Regency area of West Java Province have caused various

physical, socioeconomic and psychological impacts. Landslides are one of the natural disasters that generally occur in mountainous areas, especially during the rainy season, which can cause property losses and casualties and can cause damage to facilities and infrastructure such as housing, industry, and agricultural land as well as plantations and others which have an impact on the social conditions of the community so as to reduce the economy in certain areas (Subhan et.al, 2019).

Garut Regency, which is geographically prone to disasters, is the duty of the Regency Government and the community to protect Garut Regency and the community from disasters. As part of the overall disaster management, the implementation of rehabilitation and reconstruction stages is important. Activities in the rehabilitation stage are related to the pre-disaster and emergency response stages and also related to the reconstruction stage. The relationship between these stages determines the effectiveness and efficiency of disaster management. This is to achieve the overall efficiency and effectiveness of disaster management.

Post-disaster repair of public infrastructure and facilities is an activity to improve public infrastructure and facilities to meet transportation needs, smooth economic activities, and the socio-cultural life of the community as part of overall disaster management. To anticipate and reduce the negative impacts arising from development activities, an environmental impact analysis study is needed in the area of the planned activity. Analysis of the environmental impact of post-disaster rehabilitation and reconstruction facilities is an activity needed to assess the impacts that arise both positive and negative, including the impact on physical waters, air conditions, land flora and fauna.

II. RESEARCH METHODS

Research on Environmental Impact Analysis of Disaster Post-Disaster Rehabilitation and Reconstruction in Garut Regency is a descriptive quantitative research. This research aims to analyze the existing conditions of disaster risk in disaster-prone areas of Garut Regency and analyze the environmental impact of post-disaster rehabilitation and reconstruction facilities in Garut Regency.

The following is the research framework:

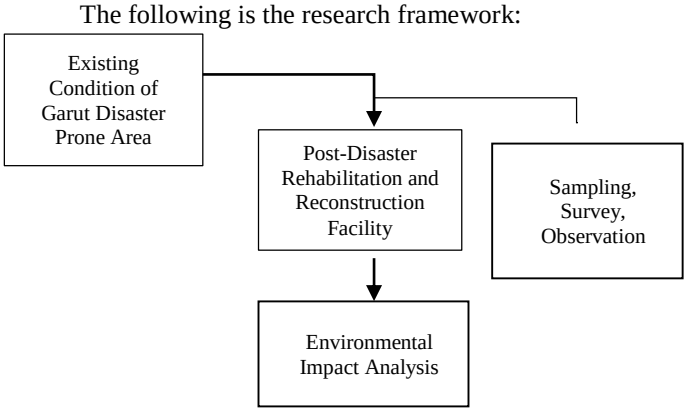

Figure 1. Research Framework

A. Description of the Study Area

The research was conducted at Garut Regency-Indonesia from July to August 2023, starting from area observation and an environmental assessment.

Garut Regency is one of the regencies in West Java Province which is located at coordinates 6°56'49" - 7°45'00" South Latitude and 107°25'8" - 108°7'30" East Longitude. Garut Regency has an area of 3,074.07 km^2 (307,407 ha). The Garut Regency Administrative Area consists of 42 sub-districts, 421 villages, and 21 sub-districts, with the capital city of Garut Regency being in Garut Kota District. The administrative area of Garut Regency is bordered by other areas and is limited by physical boundaries, along with the administrative area boundaries of Garut Regency, that are: to the North, bordering Bandung Regency and Sumedang Regency; East side, bordering with Tasikmalaya Regency; To the south, bordering the Indonesian Ocean; and to the west, it is bordered by Bandung Regency and Cianjur Regency.

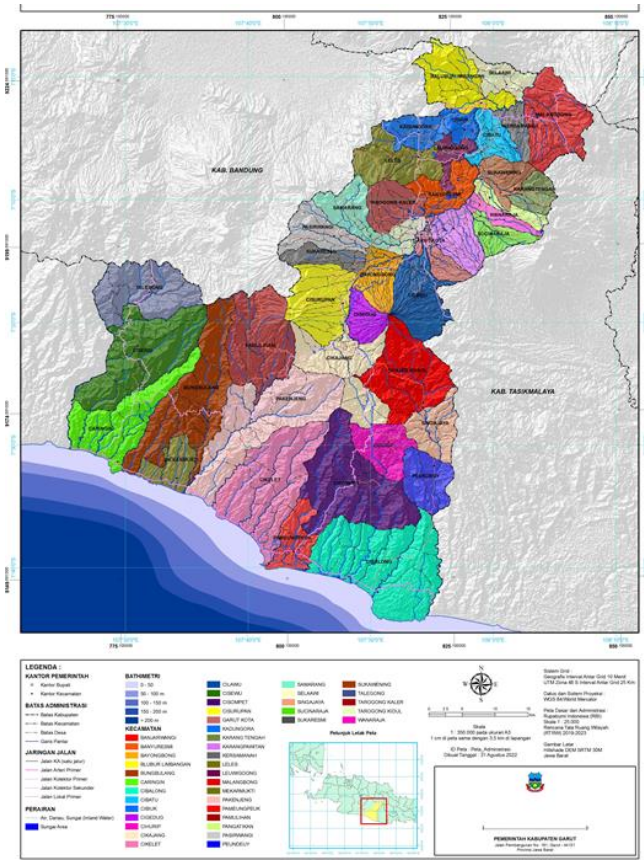

Figure 2. Garut Regency-Indonesia

The area of Garut Regency is 3,074.07 km^2. Area size is one of the bases in disaster risk assessment in terms of determining the potential for disaster exposure. This potential is known based on the condition of the vulnerable areas in each administrative area in Garut Regency. The wider an area exposed to disasters, the greater the potential for the area to be at risk of a disaster in Garut Regency.

B. Environmental Assessment

Operational activities in Post-Disaster Rehabilitation and Reconstruction of Public Facilities will cause impacts on environmental components arising from activities at the site. To determine the affected environmental components, we calculated the environmental components on run off and solid waste generation. Solid waste generation calculation based on Indonesia National Standar (SNI, 2008) as describe in this following table.

Table 1. Amount of Waste Generation

Category	Unit	Standard
Permanent House	Person/day	2,5 L
Semi-permanent house	Person/day	2,25 L
Non-permanent Houses	Person/day	2,0 L
Office	Employee/day	0,5 – 0,75 L
Store	Employee/day	2,5 – 3,0 L
School	Student/day	0,15 L

Source: *SNI, 2008*

The government was planning to build the permanent structure for the post disaster facility in Garut Regency, therefore, the standard for the solid waste generation is 2,5 L/person/day. Meanwhile for run off calculation, based on Indonesia National Standar (SNI, 2016) with the following equation:

$Q_p = 0{,}00278\ C.I.A$

Where:

Q_p is the peak flood discharge (m^3/s);

C is the runoff coefficient;

I is the rain intensity during the concentration time (mm/hour);

A is the flow area (Ha).

The runoff coefficient for urban drainage is strongly influenced by impervious areas and is formulated as follows:

$C = 0{,}9\ I_m\ (1\ I_m)C_p$

Where:

C_p is the runoff coefficient for impervious area;

I_m is the imperviousness ratio.

$$I = \frac{\text{Aimperviousness}}{\text{Total}}$$

The runoff coefficient and impervious ratio can be seen in Table 2 below.

Table 2. Runoff Coefficient and Impermeability Percentage

Land Use	Characteristics	C	I_m
shopping centers and stores	-	0,90	100
Industry	Full building	0,80	80
Settlements (medium-high density)	20 houses/Ha 30 houses/Ha 40 houses/Ha 60 houses/Ha	0,48 0,55 0,65 0,75	30 40 60 75
Settlements (low density)	10 houses/Ha	0,40	< 20
Park	Flat area	0,30	0
Rural area	Sandy soil Heavy soil Irrigation area	0 0 0	

Source: *SNI, 2008*

Since the facility which are going to be build are settlement with high density with the characteristic 60 houses/Ha, therefore, we use C of 0,75 and I_m of 75.

C. Data Analysis

The analysis results were analyzed using descriptive analysis. Descriptive analysis aims to explain the results of the analysis of the potential impact of post disaster facility in Garut Regency. On descriptive analysis, the analysis results were compared with previous researches that have been conducted by another researcher.

III. RESULTS

Based on the Decree of Garut Regency Number 360/Kep.668.BPBD/2018 Dated November 9, 2018 Regarding the Determination of Community Groups Receiving House Construction Cost Assistance for Victims of the Cimanuk River Flash Flood Disaster, the location of Post-Disaster Rehabilitation and Reconstruction of Garut Regency has been determined as follows:

Table 3. Location of Post-Disaster Rehabilitation and Reconstruction in Garut Regency

No	Location		Green Open Space (m^2)	Percentage (%)	Area (m^2)
	Village	Sub district			
1	Sirnajaya Blok Gadog	Tarogong Kaler	3.950	17,95	22.000
2	Lengkong Jaya 1	Karang pawitan	2.238	15,98	14.000
3	Lengkong Jaya 2	Karang pawitan	3.920	20,63	19.000
4	Lengkong Jaya 3	Karang pawitan	1.441	10,54	13.664
5	Cimungcang	Garut Kota	3.538	10,10	35.000
6	Margawati	Garut Kota	1.100	10	11.000
	Total		15.747	13,73	114.664

Source: *Decree of Garut Regency, 2018*

Total area for Post-Disaster Rehabilitation and Reconstruction Facilities in Garut Regency is 114.664 m^2 with the most extensive area is Cimuncang Village- Garut Kota Sub district. Meanwhile the smallest is Margawati Village-Garut Kota Sub district. The existing area of all the development planning for Post-Disaster Rehabilitation and Reconstruction Facilities were flat lands. The Garut Regency Government are planning to convert those lands into building. Therefore, there will be the changes on land use from greenly flat lands into building. Those changes will lead to land deterioration if no management considers. The significant step to apply is providing the green open space in Post-Disaster Rehabilitation and Reconstruction Facilities for replacing the loses of the ecosystem.

In each area, the government is planning to design the green open space at minimum 10%. This is accordance to Regional Spatial Plan of Garut Regency Year 2011 – 2031 (Regional Regulation Garut Regency, 2019). The highest percentage planning for green open space is 20,63% in Lengkong Jaya 2 Village-Karangpawitan Distric. Based on Regulation of the Minister of Agrarian and Spatial Planning Nomor 14 Year 2022, Green Open Space is an elongated area / path and / or grouped which use is more open in nature, where plants grow, both those that grow naturally or deliberately planted, with considering aspects of ecological function, water catchment, economic, socio-cultural, and aesthetic functions.

Green open space existence important for maintaining the biodiversity and ecosystem (Taylor & Hochuli, 2017). In addition, since the green open space consist of particularly tress, it is providing for up taking the air pollutant from atmosphere. Zappitelli et.al (2023) stated that *Celtis australis, Platanus x acerifolia, Ulmus pumila,* and *Quercus rubra* can absord the carbondioxide in highest capacity compared to evergreen needle leaves.

Based on solid waste generation calculations (Table 4), the total volume of solid waste generated is 1,07 m^3/day. With the highest amount is 0,50 m^3/day in Margawati Village. Solid waste generation based on the number of resident that will reside on the post-disaster facility. Therefore, the more the people reside, the more the solid generation.

Table 4. Solid Waste Generation

NO	Land Use	Resident	Solid Waste Generation (m^3/day)
1	Sirnajaya Blok Gadog	100	0,25
2	Lengkong Jaya 1	25	0,06
3	Lengkong Jaya 2	25	0,06
4	Lengkong Jaya 3	25	0,06
5	Cimungcang	51	0,13
6	Margawati	200	0,50
	Total	426	1,07

Source: *Data Analysis, 2023*

Waste is material or substance in solid or semi-solid form that originates from human or animal activities and is discarded because it is no longer needed, reused or desired (Tchobanoglous et.al, 1993). Types of waste can be classified in general into three, namely: (a). Non-organic waste. Non-organic waste is material made from non-organic materials. Some examples of household waste that are classified as an organic waste are cans, plastic bags, and can also be in the form of plastic bottles; (b). Organic waste. Organic waste is material that has been discarded and is deemed unnecessary, but can still be used, managed and utilized if done properly; and (c). B3 Waste (Toxic Hazardous Materials). The definition of "B3 waste" is one type of waste that contains hazardous and toxic substances for living things. This example of waste/garbage is due to indications of the chemical substance mercury, which comes from used paint cans and other dangerous chemicals (Tchobanoglous et.al, 1993). We found that, at the Post-Disaster Rehabilitation and Reconstruction location, the waste generated only consists of organic and an organic waste, there is no B3 waste.

Accumulation of solid waste will create the serious problem both for community and environment. Solid waste generation whether in household temporary or in disposal facility will yield the odor problem (Du et.al, 2023). Insufficient solid waste management (SWM) will lead to the environmental pollution and human health (Vinti et.al, 2023).

The conventional method for solid waste management are collection, transport, processing, recycling, and disposal (Tchobanoglous et.al, 1993). Moreover, the treatment could be improved starting from the community itself. Handling of solid waste generated from activity locations can be through the TPS3R concept (Reduce, Reuse, Recycle at temporary waste collection site (TPS). At TPS3R, waste is sorted. The results of the waste collection that has been sorted will be deposited into the place of making handicrafts from waste or at the garbage collection site. The remaining waste that cannot be processed is then disposed of to the final disposal location in collaboration with the Garut Regency Environmental Service.

Meanwhile, runoff from the activity of Post-Disaster Rehabilitation and Reconstruction amenities can be seen at Table 5.

Table 5. Runoff Generation

No	Location	Area (m^2)	Building	Green Open Space	Open Space	Run off
1	Sirnajaya Blok Gadog	22.000	13.200	3.950	4.850	0,50
2	Lengkong Jaya 1	14.000	8.400	2.238	3.362	0,32
3	Lengkong Jaya 2	19.000	14.080	3.920	3.680	0,42
4	Lengkong Jaya 3	13.664	12.222	1.441	4.024	0,34
5	Cimungcang	35.000	30.462	3.538	10.462	0,87
6	Margawati	11.000	9.840	1.100	3.300	0,27
	Total	114.664	95.916	15.747	30.118	2,72

Source: *Data Analysis, 2023*

Runoff from the activity of Post-Disaster Rehabilitation and Reconstruction location is 2,72 m^3/day. Based on Minister of Environment and Forestry Regulation Number 5 Year 2022, Runoff water discharge is derived from the estimated surface flow discharge from rainfall. It is means that the runoff is the precipitation that does not infiltrate into the soil but instead moves on land surface. Mismanagement of runoff will lead to waterflood in the area this is because ascending the runoff will increase the peak discharge in a watershed (Basri et.al, 2022). Based on Regulation of The Minister of Public Works of The Republic of Indonesia Number 12/PRT/M/2014, run off can be managed by building drainage. Drainage Infrastructure is an arch or channel of water on the surface or under the ground, either naturally formed or created. or under the ground, either naturally formed or made by man, which functions to channel excess water from an area which functions to channel excess water from an area to the receiving water body. The proper drainage will control the run off into the nearest receiving water body so it will not create the flood in the post-disaster facility. In addition to this, the run off can also be managed by another installation. According to Regulation of The Minister of Public Works and Public Housing of The Republic of Indonesia Number 09/PRT/M/2015, utilizing excess surface water can be done through shallow infiltration wells and deep infiltration wells. Based on previous research, besides being used as groundwater recharge, infiltration wells function as runoff controllers (Syahputra et.al, 2023).

IV. CONCLUSIONS

Based on the results of research on the Environmental Impacts of Disaster Rehabilitation and Reconstruction Facilities in Garut Regency, the following conclusions were obtained: there are environmental impacts on post-disaster rehabilitation and reconstruction facilities, including land use changes about 114.664 m^2, waste generation of 1,07 m^3/day and runoff of 2,72 m^3/day. Land use changes can be maintaining by providing the green open space based on the regulation standard. Moreover, the promising treatment for solid waste management is through TPS 3R (reduce, reuse, recycle at temporary waste collection site (TPS)) meanwhile runoff management can be done by providing the proper drainage and infiltration wells.

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