

Assessing the economic cost of urban pollution: A case study of landfill waste in Kulonprogo, Indonesia

Dyah Puji Lestari¹, Endah Saptutyningsih^{2,*}

^{1,2}Economics Department, Faculty of Economics and Business, Yogyakarta Muhammadiyah University, 55183 Yogyakarta, Indonesia

Abstract. Introduction – Rapid urbanization in developing countries dramatically increases solid waste production, negatively impacting the socio-economy and ecology. Solid waste management is essential to minimize the associated risks, especially in health and the environment. **Objective** – This study assesses the economic cost of pollution from the disposal of household waste at the Banyuroto landfill, Kulonprogo, Indonesia. **Methodology/Approach** – This study uses the sickness and reimbursement cost approach. The subjects in this study were 100 households in Banyuroto, Kulonprogo, Indonesia, selected using cluster random sampling. **Findings** – The results show that the landfill has a negative impact on the community's life because it causes air pollution (unpleasant odors), water pollution, and waste-related diseases, such as diarrhea, respiratory problems, flu, cough, cold, and itchy rash. The economic cost of pollution emerging from the landfill is IDR 2,355,000 per year. Meanwhile, using the replacement cost method, the estimated cost of environmental quality degradation is IDR 12,144,000 per year. For 1,230 households, the cost is IDR 125,941,304 per year, so the average economic cost due to environmental degradation is IDR 912,104,414 per year. **Originality/Value/Implications** – This study contributes to the literature by highlighting the environmental and health risks from the pollution caused by landfill waste in urban areas.

1 Introduction

Global urbanization has increased rapidly over the past century, which will likely continue in the 21st century. The World Economic Forum notes, “Humanity faces the daunting task of adding more than two billion people to the urban population by 2050, equivalent to creating a city the size of London every month for the next two decades” [1]. Rapid urbanization in developing countries increases solid waste production, negatively impacting the socioeconomic and environmental systems [2-4]. Meanwhile, the infrastructure and land use regulations remain poor, leading to poor waste collection and disposal systems. In addition, the management of municipal waste is inadequate, causing environmental and health problems, especially around the disposal site.

Waste management is a complex problem that occurs in many cities. Smart technologies are considered a solution to many urban problems nowadays. A smart city implements breakthrough technologies to solve various problems to improve the city's performance [5]. It optimizes information and digital technology to improve people's welfare and happiness and reduce costs, time, and energy in government services. The ultimate goal is to make its

* Corresponding author: endahsaptuty@umy.ac.id

citizens happy [6]. A critical aspect of a smart city is to create a healthy and livable environment. However, the implementation often encounters difficulties, including the existing environmental problems in urban areas. For example, rivers are polluted because many residents dispose of waste there. Such pollution not only makes the environment uncomfortable to live in but also contributes to natural disasters, such as floods. The waste in urban areas is not only from households. Industrial production and trade continue to grow in many countries worldwide and have contributed to the rapid increase in municipal and industrial waste production [2-4].

Poor residents in urban slums are the most vulnerable and severely affected by waste disposal [4]. Waste management must be conducted properly to mitigate the risk and impact of a disaster, especially among vulnerable groups. The process must begin with waste collection. However, in developing countries, limited resources and the ever-increasing volume of solid waste pose a challenge to proper processing and disposal [7]. Traditional landfills do not separate waste from the layers of soil or rock beneath it, and the pit extends downward from the surface of the groundwater, so the waste is discharged directly into the groundwater [8]. Meanwhile, sanitary landfills are engineered structures consisting of an underlayer, a leachate collection and disposal system, and a final cover. It is designed to store and treat waste. Therefore, the potential risks of landfill outcomes can be minimized.

Municipalities in affluent countries often use door-to-door collection systems, but those in underdeveloped countries only offer this service to a small proportion of the population due to budgetary and administrative constraints [9]. As a result, waste is disposed of in open dumps, which poses health and environmental risks to those living nearby [10]. The inadequate municipal waste management systems cause urban areas in developing countries to suffer considerable environmental damage and health problems [11]. Research has looked at the impact of waste disposal on human health and the environment [12; 13; 14; 15; 16; 17; 18; 19], especially the environmental pollution [20]. However, relatively few studies [21-23] examine how solid waste impacts the environment and the health of those living near landfills. Examining these impacts is crucial because waste discharged into the environment keeps increasing along with the rising production and consumption, posing a greater threat to human health than ever before [24]. Landfills near urban areas in poor countries are filled with mosquitoes, flies, and rats, which pose a health risk to the residents nearby, especially children [25].

In a previous study [26], field and laboratory tests were conducted for groundwater quality around the Banyuroto landfill. The results showed that the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) parameters exceeded the quality standards of two groundwater samples: the BOD levels of 5.58 mg/L and 11.52 mg/L. The results of the COD parameter test were 7.24 mg/L and 12.38 mg/L. In contrast, the results of research on the quality of leachate obtained BOD levels of 591.2 mg/L and COD levels of 3092.05 mg/L. Thus, the study shows that the Banyuroto landfill waste at Progo has a negative impact on the quality of the surrounding groundwater. Due to the negative impact of a landfill, as illustrated above, the local community has to incur additional costs to replace or treat the polluted water sources and health costs to improve the declining quality of health.

Table 1. Previous studies on the costs of sickness and water source replacement

Variable	Reference
Sick Expenses (Health Expenses)	Gravitiani and Juwita [27], Utami et al. [28], Butt and Khair [29], Sandjoyo [30], Malik et al. [31], Ahyar et al. [32], Folefack [33], Alberini and Krupnick [34], Verma and Srivastava [35]
Replacement Cost	Gravitiani and Juwita [27], Sari and Lucyana [36], Irawanti, et al. [37], Utami et al. [38], López-Morales and Mesa-Jurado [39], Astuti [40], Sandjoyo [30], Ahyar et al. [32], Dharmasena and Bhat [41]

2 Methodology

2.1 Study Site

This research was conducted in Banyuroto Village, Kulonprogo Regency, Indonesia, which has a Banyuroto landfill. The data were collected from December 2020 to January 2021. The research subjects are the respondents, which consist of village residents who live approximately three kilometers from the landfill.

2.2 Study Design and Administration

We surveyed households in the study locations to discover the medical expenses. First, medical expenses are incurred to treat illnesses caused by environmental degradation. These expenses include (a) doctor's medical or consultation costs for treating patients, whose range is determined by the health facility where the doctor practices; (b) medicine costs for purchasing drugs, both at health facilities and outside health facilities, such as food stalls or grocery stores; (c) healthcare cost (hospitalization) if the patient is hospitalized or requires further treatment. Second, replacement costs are paid to replace or purchase clean water, such as bottled drinking water or water from the regional drinking water companies (PDAM). The sampling technique used in this study was cluster random sampling, which is a part of probability sampling [42] and is also known as the regional sampling technique or conditional sampling. This technique is suitable if the population in the study is spread across several regions, provinces, districts, sub-districts, and so on [43]. This study uses cluster random sampling because the population was large, covering a village and its sub-districts. The number of samples to be used in this study is 100. The sample in this study was the head of a household that lived around the Banyuroto landfill. The data were collected through direct interviews and questionnaires.

2.3 Data Analysis

The economic value of environmental degradation around the Banyuroto landfill was obtained from the sickness cost and replacement cost based on the interviews with respondents.

2.3.1 Cost of Illness Approach

Calculations using the cost of illness approach (health costs) aim to estimate the negative externalities borne by the community for treating illnesses caused by air and water pollution and other sources of disease originating from the landfill. The total costs only include direct costs, e.g., the cost of drug purchases, medical or doctor consultation fees, and treatment costs during the recovery period. The total health costs incurred by the community are calculated using the following formula [44]:

where MC = medical cost/year; MCHH = medical cost/household/year; intensity = disease intensity/year; TMC = total cost of treatment/year.

Then, to obtain the average health costs incurred by the community, the total medical expenses are divided by the number of respondents who paid the expenses. The average health costs incurred by the community to treat their illnesses are calculated as follows [30]: where, AMC = average medical cost; MC_i = the medical expenses of respondent *i*; *n* = the number of respondents, *i* = respondent *i* (1,2,3,4 ...*n*).

2.3.2 Replacement Cost Approach

Calculations using the replacement cost approach in this study aim to estimate the negative impact of water pollution caused by the Banyuroto landfill leachate. The total costs calculated are related to the costs incurred by the community to buy drinking water every month. The cost of replacing or purchasing clean water is calculated using the following formula [45]:

where TCW is the total cost of purchasing clean water per year, and CWHH is the cost of clean water per household per year.

Then, the average cost of clean water purchased by the community is obtained from the total cost of purchasing clean water divided by the number of respondents paying the cost of purchasing clean water. The average cost of clean water incurred by the community is calculated as follows [30]:

where ARCW = average replacement cost for water; RCW_i = water replacement cost for respondent *i*; *n* = number of respondents; *i* = respondent *i* (1,2,3,4.... *n*)

Finally, the average cost of environmental quality degradation is obtained from the summation of the average health cost and the average replacement with the following equation [30]:

where ADEQ = average decrease in environmental quality; AMC = average health cost; ARCW = average replacement cost for water.

3 Results and Discussion

One of the negative impacts of the Banyuroto landfill is the decreased environmental quality suffered directly by the community. The following is a table of changes or degradations in environmental quality based on public perceptions.

The results of the study show that the most negative impact perceived by the community is air pollution or repulsive odors, with 78% of respondents believing to have been impacted. The air quality around the landfill is deteriorating due to piles of garbage that are not appropriately managed. Furthermore, 27% of respondents felt the water was polluted, and 24% felt that their health was deteriorating. The percentages were more than 100% because some respondents felt a decrease in environmental quality in more than one way. Some respondents also believed to have been impacted by water pollution and a repulsive smell at

the same time. Others believed they experienced the water pollution, the repulsive smell, and the air pollution. These public perceptions show that the negative environmental impact of the Banyuroto landfill is high, as it has caused noticeable discomfort.

Table 2. Decline in Environmental Quality Based on Community Perceptions

No.	Environmental Quality Decline	Public perception*
1.	Water pollution	27%
2.	Air pollution or repulsive smell	78%
3.	Health decline	24%

*The perception of the same sample can be more than one environmental impact

3.1 Estimation of the Economic Value of Decreasing Environmental Quality Due to the Operation of the Banyuroto Landfill

The environment has an important role in human life and will affect the health of humans in it. Decreasing the quality of the environment, such as through pollution, will cause inconvenience. This decline in environmental quality can be caused by activities that cause negative externalities, such as environmental pollution that will cause a decrease in environmental quality, which can increase the cost of living.

As mentioned previously, the cost of environmental degradation near the Banyuroto landfill is estimated using two methods: health costs and replacement costs. The replacement costs incurred by the community are used to buy clean water from public companies and bottled water because the water source near the landfill is unsuitable for consumption (dirty and smelly). Meanwhile, health costs are incurred by the community to treat illnesses caused by a decrease in the quality of the environment around the landfill.

3.1.1 Estimation of Health Cost (*Cost of Illness*)

Garbage can be a direct or indirect source of disease [46]. Aside from being directly responsible for the proliferation of parasites, bacteria, and pathogens, garbage also becomes a nest of disease carriers such as rats, flies, cockroaches, and mosquitoes. Diseases from improper waste management include diarrhea, dysentery, malaria, dengue fever, and respiratory problems. The decreasing environmental quality will pose a health risk for the community near the landfill. Declining health means people must spend money on healthcare and treatment, hence health costs.

These costs are calculated per household head, estimated from the fees paid for the doctor's or medical personnel's services and medicine purchases. In this study, the diseases the respondents and their families suffered from were considered not too severe so that they could continue their activities or work. The results of interviews showed that 24 respondents claimed that their families were affected by a disease suspected to be related to the decreasing environmental quality.

Of the 24 respondents affected by the disease, two suffered from more than one disease in the past month. Therefore, the total number of cases was 26. Of the 26 cases, only 25 cases, or 23 respondents, paid for the health care. One respondent or one case received free health services using a health card. Table 3 summarizes the diseases the respondents or their family members contracted.

The table shows that 26%, or as many as 26 cases, were found among the respondents, which comprise diarrhea, respiratory problems, flu, cough, cold, and itchy rash. The rash was the most prevalent at 11%, or 11 cases, followed by flu, cough, and cold, which amounted to 8%,

or 8 cases. Meanwhile, the percentage of respiratory problems was 5% (5 cases), and diarrhea was 2% (2 cases).

Table 3 Diseases the Respondents Contracted during the Study Period

No	Disease	Percentage of Cases	Number of Cases
1.	Diarrhea	2%	2
2.	Respiratory problems	5%	5
3.	Flu, Cough, and Cold	8%	8
4.	Itchy rash	11%	11
Total		26%	26

As mentioned above, out of the 26 cases, two people had more than one disease, so the total number of respondents suffering from the illness or experiencing declining health is 24. It should also be noted that one respondent with a respiratory disease was treated free of charge. Therefore, the total number of cases requiring medical attention or expenses was 25 or 23 respondents.

Table 4 Health Expenses Paid by Respondents

No	Disease	Number of Cases	Medical Expenses (IDR/Year)
1.	Diarrhea	2	IDR 50,000.00
2.	Respiratory problems	4	IDR 1,450,000.00
3.	Flu, Cough, and Cold	8	IDR 315,000.00
4.	Itchy rash	11	IDR 540,000.00
Total		25	IDR 2,355,000.00

In this study, the cost of treating the diseases the respondents contracted was calculated from the cost of doctor visits and drug purchases incurred by one household. The total cost of treatment is cumulative for all families in Banyuroto Village. Table 4 shows the diseases the residents often suffered from. From the data, it can be seen that respiratory problems require higher medical costs compared to other diseases. This is because the drugs to treat colds and coughs may not only be over-the-counter and require a prescription or are only available at pharmacists. Moreover, respiratory problems or shortness of breath often relapse when the sufferers smell repulsive odors from garbage at the landfill. In this case, they often need to see a general practitioner or go to the hospital.

The estimated annual health costs incurred by 24 respondents for the 26 cases, with 23 paying respondents, amounts to IDR 2,355,000.00. However, according to the residents who live near the landfill, it does not cause serious illness because they are used to the situation. Also, they have lived in the village for a long time, with some born and raised there. In addition, the community thinks that their illness is not too serious, so they can treat it with over-the-counter medicine or services from the health center. They consider the costs to be relatively affordable. The cumulative cost of health or medical expenses incurred by the people of the village is calculated as follows.

$$AMC = \frac{\sum MC_i}{n} \times \text{the number of households}$$

$$= \frac{2.355.000}{23} \times 1,230 \text{ households}$$

$$= 102.391 \times 1.230 \text{ households}$$

$$= 125,941,304$$

Based on the calculation above, the village community's cumulative average health cost is IDR 125,941,304.00 per year.

3.1.2 Estimated Replacement Costs

In addition to health costs, the negative impact of a landfill on the community can be estimated using the replacement cost method. The indicator is water pollution, which turns the groundwater unclear and smelly, making it unfit for daily consumption. The following is the cost of replacing clean water sources borne by the people of Banyuroto Village as an impact of the landfill operations.

Table 5 Replacement of Clean Water Sources

No	Clean Water Source	Percentage	Number of people
1.	The public drinking water companies (PDAM/PAM)	16%	16
2.	Water bottle	3%	3
3.	No Effort	8%	8
Total		27%	27

The table shows that 27% or as many as 27 respondents replaced their source of clean water. Sixteen percent (16 people) use PDAM/PAM, and 3% (three people) bought water bottles. However, 8% (eight people) did not try to replace their clean water sources. They believed that the water was safe for consumption as long as they let it sit before use to remove the smell from the water. Table 6 shows the replacement costs for clean water borne by the community.

Table 6 Costs of Replacing Clean Water Sources

No.	Clean Water Source	No. people	Replacement Fee (IDR/person/month)	Replacement Fee (IDR/month)	Replacement Fee (IDR /person/year)	Replacement Fee (IDR/year)
1.	Drinking water company	8	50,000	400,000	600,000	4,800,000
2.	Drinking water company	2	55,000.00	110,000	660,000	1,320,000
3.	Drinking water company	1	60,000	60,000	720,000	720,000
4.	Drinking water company	3	70,000	210,000	840,000	2.520.000

No.	Clean Water Source	No. people	Replacement Fee (IDR/person/month)	Replacement Fee (IDR/month)	Replacement Fee (IDR /person/year)	Replacement Fee (IDR/year)
5.	Drinking water company	2	80,000	160,000	960,000	1,920,000
6.	Bottled water	3	24,000	72,000	288,000	864,000
Total		19	339,000	1,012,000	4,068,000	12,144,000

In this study, the replacement costs incurred by the community were calculated per household, which were then multiplied by the number of families in Banyuroto Village. From Table 6 above, the cost of replacing clean water in the village varies, with respondents paying for piped water at a monthly cost of IDR 50,000.00, IDR 55,000.00, IDR 60,000.00, IDR 70,000.00, and IDR 80,000.00. Meanwhile, those who use bottled water as a source of clean water paid IDR 24,000.00 per month.

The estimated replacement cost paid by each household to meet their clean water needs for one year is IDR 12,144,000.00. Therefore, the replacement costs for purchasing clean water per year are incurred by the community members.

$$\begin{aligned}
 ARCW &= \frac{\sum R CW_i}{n} \times \text{the number of households} \\
 &= \frac{12.144.000}{19} \times 1,230 \text{ households} \\
 &= 639,157 \times 1,230 \text{ households} \\
 &= 786,163,110
 \end{aligned}$$

The calculation shows that the cumulative replacement costs incurred by the people of the village were IDR 786,163,110.00 per year.

Finally, the total cost of environmental decline due to the landfill operation is estimated by adding up all the community's health and water replacement costs in one year. Table 7 shows the estimated total cost based on the cost of illness paid by 23 respondents and the replacement of clean water sources by 19 respondents.

Table 7 Total Cost of Decreasing Environmental Quality Paid by Respondents

Cost Expenses (IDR)	Total IDR/Year
Health/Medicine Cost	IDR2,355,000.00
Replacement Cost	IDR 12,144,000.00
Total Cost (Community Losses)	IDR 14,499,000.00

Source: Primary Data

From the table above, the estimated economic loss of environmental degradation due to a landfill was IDR 14,499,000.00 per year. These results are the sum of the health costs of 26 cases of illness (minus two respondents suffering from two cases of illness, so the total number of patients was 24) paid by 23 respondents (25 cases of paid treatment minus one receiving free treatment) is IDR 2,355,000.00/year. Meanwhile, the cost of replacing the clean water sources by 19 respondents is IDR 12,144,000.00 per year.

Meanwhile, the total cumulative economic loss due to the declining environment resulting from the landfill operation is calculated from the sum of the health costs and the replacement costs in a year, as follows.

$$\begin{aligned}\text{Environmental Degradation Cost} &= \text{Cost of Illness} + \text{Replacement Cost} \\ &= \text{IDR } 125.941.304,00 + \text{IDR } 786.163.110,00 \\ &= \text{IDR } 912.104.414,00/\text{year}\end{aligned}$$

The calculation above shows the total economic loss of the community, which is IDR 912,104,414.00/year. The estimated cost of environmental quality degradation consists of health costs (to treat illnesses) and replacement costs (to procure clean water) borne by all families in the village. The community's losses should be the responsibility of landfill management, but the community pays for themselves.

Thus far, this research has shown that a landfill negatively impacts the people who live nearby. The impact is in the form of decreasing quality of environment, health, and comfort. The findings have given empirical evidence of the economic loss of degraded environmental quality due to the operation of the landfill, consisting of health costs and clean water purchases.

3.2 Perceptions of the Environmental Conditions Near Banyuroto Landfill

3.2.1 Environmental Impact

The field research indicates that, in general, there is no significant environmental damage. The two noticeable environmental impacts are water pollution (unclear and smelly water) and air pollution (repulsive odor). According to data from the Department of Public Works, Housing, and Settlement Areas (DPUPKP) of Kulonprogo Regency, the average volume of waste at the landfill is 9,396,461 kg/year, and the average monthly volume is 783,038 kg/month. The accumulation of waste will produce a liquid known as leachate, resulting from the waste decomposition. This will produce a repulsive odor. Additionally, leachate contains hazardous materials and organic matter that can contaminate groundwater. The higher the volume of garbage, the more leachate is produced, which can affect the condition of the groundwater in the village, making it unfit for consumption (although not all respondents stated that the water was unfit for consumption).

The pollution caused by the landfill makes the water unclear and smelly. The piles of garbage at the landfill are increasing every year, but the waste processing has not been improved. A controlled landfill system contains the leachate produced by the piles of waste. However, leaking pipes can overflow rivers with leachate, seeping into the ground and contaminating the water sources. This has resulted in the degraded quality of water, rendering it unsuitable for daily consumption. A previous study [26] has shown that the results of field and laboratory tests show that the BOD and COD parameters of groundwater and leachate exceed quality standards. The BOD levels of two groundwater samples near the landfill were 5.58 mg/L and 11.52 mg/L. Meanwhile, the leachate has caused the BOD levels to reach 59.2 mg/L and COD of 3092.05 mg/L. This shows that the landfill has a negative impact on the surrounding water quality.

Meanwhile, air pollution is a repulsive odor arising from the pile of garbage at the landfill. The waste decomposition produces methane (CH₄) and hydrogen (H₂S), which can cause a repulsive smell. This stench invites insects and rats to find food and breed [47]. Most

residents who live near the landfill stated they could smell the odor, but not those who live further away from the landfill. The unpleasant odor from the garbage piles that decompose at the landfill impacts the community within a 1 km to 1.5 km radius. The repulsive smell from the pile of garbage will become even more pungent when the rainy season arrives. The rainwater will mix with the rotting garbage and make the odor worse. In this case, the community admits that the repulsive smell of the garbage is disturbing, but they do not mind it because they are used to it.

Regarding the overall level of comfort living in the area, although the landfill impacts the surrounding environment, the respondents stated that they could endure living around the landfill. The repulsive odor from the pile of garbage at the landfill is disturbing, but this discomfort seems normalized and common. Therefore, the community did not do anything to oppose and prevent this pollution from happening. They think they have lived in the village for a long time since birth, so they feel they are used to the environmental conditions there.

3.2.2 Health Impact

The results of field research show that some people have suffered from diseases such as diarrhea, respiratory problems, flu, cough, cold, and itchy rash. A prior study by [48] has shown that the diseases people often suffer from around the landfill are itching, diarrhea, coughing, and respiratory problems. This happens because of the buildup of waste that can invite disease vectors. In addition, the decline in public health is also caused by environmental degradation, such as unhealthy air and water quality and the non-optimal implementation of clean and healthy living habits. To deal with the health hazards, the community obtains treatments from health facilities and doctor's clinics and purchases medicines from counters or pharmacies. Some people seek treatment at the hospital for respiratory problems and further treatment from a medical doctor. Nonetheless, they think that they have never experienced a severe illness and that the illnesses they suffer from the landfill are minor, such as flu, coughs, and colds.

3.2.2.1 Other Impacts

This study also discovers the community's opinions regarding other disturbances, such as the noise of garbage trucks, garbage falling from the trucks, the pollution of rice fields, and the non-optimal yields of the rice fields near the polluted river. Some farmers whose fields are near the river stated that the leachate flows into the river, which becomes a source of irrigation. The polluted water is red, turbid, and smelly. Aside from the effect on agriculture, the polluted river also affects residents' well-being, especially when the rainy season arrives, and water overflows their settlements.

3.3 Estimation of the Economic Loss of Decreasing Environmental Quality Due to the Existence of a Landfill in Banyuroto

3.3.1 Health Cost

The existence of the Banyuroto landfill has impacted the surrounding community negatively, i.e., air pollution (repulsive smell) and water pollution (unclear and smelly). The piles of garbage attract flies and mosquitoes, which can transmit diseases. The diseases that the people who live around the landfill in Banyuroto Village suffer from include diarrhea, flu, cough, cold, respiratory problems, and itchy rash. As a result, the community has to pay

extra costs for treatment, such as buying medicine or going to the doctor. The estimation of health costs incurred by the community can be seen in Table 4, which is IDR 2,355,000.00 per year. These results were obtained from 26 cases of disease suffered by 24 respondents, with only 23 respondents paying for treatment. Meanwhile, the results of the estimated cumulative health costs for the entire community in the village were IDR 125,941,304.00/year. These results were obtained by multiplying the health cost by the number of all households in the village, which totaled 1,230 households.

Previous research conducted by [7] showed several diseases suffered by the people around the Yaoundé waste disposal site, such as malaria, diarrhea, respiratory diseases, and digestive diseases. Overall, the people who live around the waste disposal site incur medical expenses and consult a doctor in the amount of 142,380 FCFA. Furthermore, [29] conducted research using the same estimation, i.e., the cost of illness. The study results showed that the quality of drinking water in Quetta City was foul-smelling, unpleasant, and discolored, spreading diseases such as diarrhea, cholera, and typhoid. Health costs incurred by the community for transportation costs, doctor fees, diagnostic tests, purchasing drugs, and hospitalization were Rs. 41070, Rs. 65620, Rs. 80200, Rs. 128610, Rs. 257550, and Rs. 67710 per household. [28] conducted research using the same method and concluded that polluted river water posed health hazards, such as diarrhea and itchy rash, so people had to pay for treatment as much as IDR 11,667,500.00/year or IDR 191,270.00/family/year.

3.3.2 Replacement Cost

Another estimation of the negative impact of the landfill is using the replacement cost method. The water pollution has made it unclear and smelly, making it unsuitable for daily needs. As a result, the community has to incur additional costs to replace the polluted water sources. The estimated cost of replacing clean water sources that the community has to pay can be seen in Table 5, which is IDR 12,144,000.00/year. This is the cost of replacing clean water sources paid by 19 respondents whose water source is polluted and becomes unsuitable for consumption. Meanwhile, the cumulative estimated cost of replacing clean water sources is IDR 786,163,110.00/year. This amount is needed to replace clean water for the entire community, as many as 1,230 households.

The results of previous research conducted by [1] show that the cost of replacing clean water consumption at the Piyungan landfill is IDR 33,637,995,000.00 per year, and the cost of electricity used by residents to breathe fresh air was IDR 19,697,925,000.00 per year. Meanwhile, the total replacement cost for clean water sources incurred by Mojosongo Village residents due to the pollution by the Putri Cempo landfill was IDR 88,291,620,000.00 per year, and the cost of clean air was IDR 51,702,300,000.00 per year. Furthermore, [13] conducted a study using the replacement cost method and discovered that groundwater extraction costs US\$ 25 billion at present value (between US\$ 0.6 million and US\$ 3 million over 26 years). Meanwhile, reducing water leakage in Mexico City costs between US\$1.9 million and US\$8.4 million. Likewise, [2] conducted research using the substitute method and revealed that the replacement cost of clean water borne by the community as a result of the existence of a CPO factory was IDR 134,526,933.00/year or IDR 625,707.00/household/year.

The economic loss due to the declining environmental quality caused by the Banyuroto landfill was estimated using the health cost and replacement cost methods. The result was IDR 14,499,000.00/year, obtained from the total medical costs of 26 cases (paid by 23 respondents) and the replacement of clean water sources by 19 respondents. The cumulative estimate of the economic loss of the degraded environmental quality was IDR 912,104,414.00/year, borne by 1,230 households.

The economic value of the degraded environmental quality around the landfill is largely due to the operations, so the management of the landfill should be responsible for the health hazards the community suffers from. However, the costs are borne by the community. The management should handle this problem by repairing leaking leachate pipes and optimizing waste management at the landfill to minimize the negative impact of landfill pollution. The main waste management problem is that waste does not undergo processing, and landfill management is inadequate despite being the most popular way of handling final waste. Destroying or reducing the amount of waste produced by human activities is challenging, especially with the rapid population growth. Considering the environmental impacts, the management of landfills needs to be improved continuously, one of which is by recycling waste [49].

In addition, efforts are needed to deal with the decline in public health around the landfill. Collaboration between the community and the government is needed to deal with the problems originating from the landfill. One way to avoid health problems for the people who live nearby is to promote health behaviors through marketing, disseminating, and introducing health messages to the community, which include maintaining personal hygiene and carrying out clean and healthy behaviors (*perilaku hidup bersih dan sehat/PHBS*) with self-awareness [48]. In this case, the government is expected to provide facilities and infrastructure to deal with health problems in the environment around the landfill, such as adequate and accessible medical facilities for the community and landfill workers. As such, the declining health can be mitigated, the economic losses can be reduced, and people's welfare can be improved.

4 Conclusion

This study estimates the cost of environmental degradation due to the Banyuroto landfill using the costs of illness and replacement. The cost of degraded environmental quality using the health cost involves 24 respondents (23 paying respondents) with 26 cases of illness. The result was IDR 2,355,000.00 per year. Meanwhile, the estimate of loss due to degraded environmental quality reduction from replacing clean water (involving 19 respondents) was IDR 12,144,000.00 per year. The total value of the environmental degradation was IDR 14,499,000.00 per year. The average value of environmental quality degradation for 1,230 households in Banyuroto Village was IDR 125,941,304.00 per year, which is a cumulative health cost. Meanwhile, the estimated value of environmental quality degradation using the clean water replacement cost was IDR 786,163,110.00 per year. The total average economic value of environmental quality degradation for all the people in the village was IDR 912,104,414.00 per year. This value is the economic losses faced by all the people of the village in the past year.

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