# 2023 IJASEIT Water resources

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**Submission date:** 15-Mar-2023 09:01AM (UTC+0700)
**Submission ID:** 2037441660
**File name:** 2023._IJASEIT_WAter_resources.pdf (1.4M)
**Word count:** 6047
**Character count:** 34452

International Journal on
Advanced Science
Engineering
Information Technology

Vol.13 (2023) No. 1
ISSN: 2088-5334

# Potential Economic Value of Water Resource Sustainability for Sustainable Environment: A Case Study in South Sumatra, Indonesia

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***Abstract*—Erosion in coal mining land causes water quantity and quality depletion and inadequate drinking water resources for surrounding communities, making water resources unsustainable. Meanwhile, reclamation reduces erosion but cannot restore water depletion optimally; thus, these resources remain unsustainable. These resources remain unsustainable. The objectives of this study were to develop a water resource sustainability concept for a sustainable environment by analyzing the potential economic value and, secondly, to calculate the water resource value due to erosion, reclamation, and domestic and economic importance, of recycling efforts. The method used in this study was the Expanded NPV. Furthermore, the total potential economic value of water resources loss resulting in unsustainability was IDR 1,137,621,671,375 or IDR 1.14 trillion. In contrast, the potential economic value of depleted water utilization for drinking was IDR 2,298,339,797,000 or IDR 2.3 trillion. Therefore, this utilization provides a potential economic value worth IDR 1.16 trillion for the resources' sustainability in the TAL area of PTBA. The study found and recommended depleted water utilization for drinking as a suitable method to replace water resources lost due to erosion and community drinking water resource loss and to discover a sustainable environment's sustainability concept. In addition, the study formulates environmental economics as a new mining science related to natural resource economics and mining for sustainable water resources and the mining environment.***

***Keywords*—Water resource sustainability; extended cost-benefit analysis; erosion value; domestic and raw water value.**

*Manuscript received 4 Sep. 2021; revised 9 Apr. 2022; accepted 18 Sep. 2022. Date of publication 28 Feb. 2022.*
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## I. INTRODUCTION

Sustainability appears as the most important consideration of natural resource management policy in mining and forms the basic principle of environmental science. Therefore, sustainability is needed to preserve this water resource sustainability for a balanced environment [1]. Also, there is no denying that the mining of natural supplies tends to enhance economic development substantially, generate extensive foreign exchange [2]–[4], create jobs, increase income, and serve as a potential income source for communities [5], [6]. The mining industry is a major contributor to the Australian economy [7]. However, the sector is one of the major contributors to environmental degradation [2], [8] and, therefore, results in insufficient water resources and ecosystems.

Forest clearing is responsible for erosion, river sedimentation, silting, and turbidity [9], with a significant impact on surface and groundwater supplies [10], [11]. This activity also influences downstream regions, resulting in a decreased marine quality and, in addition, eliminates water resource ecosystem services for mining communities [12]. The limited freshwater availability implies less consumption [13]. Water resources are very important in sustaining economic development [14]. This situation illustrates the importance of water for the overall survival of humans and living organisms [15].

Furthermore, mining impact potentially instigates deficient hydrological function of the forest as a catchment area, leading to a significant loss of water resource economic value [9]. Therefore, a collaborative approach is required between hydrologists and economists to optimize the water value instruments [12]. Post-mining closure must adapt to local community expectations [16].

Consequently, reclamation potentially repairs environmental damage [2], [3]. This process can also reduce erosion and protect against soil degradation [17]. However, the possible occurrence is greatly decreased by cultivating legume cover crops (LCC) in early vegetation stages [18]–

[21]. Based on this study, mine reclamation demonstrated the robust capacity to restore environmental degradation but could not completely reform the depleted water resources. Therefore, recycling appears as a crucial necessity and also aids the improvement of water efficiency [22].

Furthermore, economic valuation is highly demanded as natural resources and the environment continue to diminish in monetary value [23]–[25]. In addition, cost-benefit analysis (BCA) serves as a comprehensive approach to assess the net impact on social, economic, and environmental aspects, as well as an effort to protect natural resources and communities. Also, BCA is used to engage water resource assessments for domestic purposes [26]–[28]. However, by evaluating the potential economic value, sustainability is easily analyzed, and with these provisions, environmental continuity and potable water supplies are adequately conserved. This circumstance agrees with the natural resource management policy, where natural mining resources are conducted while maintaining sustainability and environmental balance [1].

This study aims to develop a sustainable water resource concept for a sustainable environment by analyzing the potential economic value of lost and recovered water supplies in mining areas, surrounding communities, and possible domestic use. In addition, the potential is evaluated by the Expanded NPV. Therefore, the water resources and coal mining environment are expected to remain potable and sustainable.

## II. MATERIALS AND METHOD

### A. *Study Area*

This study was directly carried out in the coal mining of Tambang Air Laya (TAL) at PT Bukit Asam Persero Tbk, Muara Enim Regency, South Sumatra Province (Fig. 1).

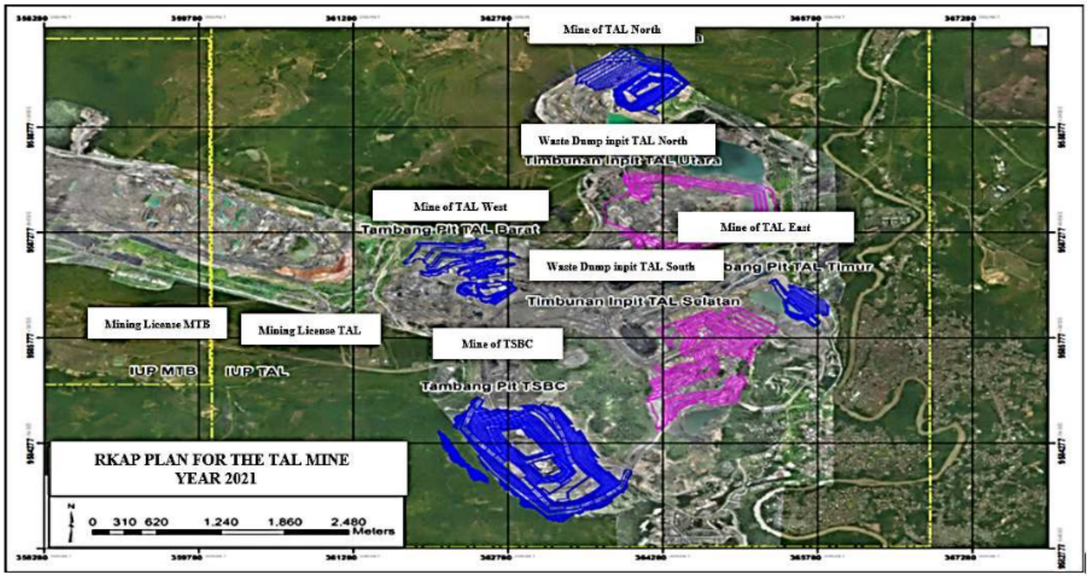

Fig. 1 Research Location

### B. *Cleared and Reclaimed Land and Depleted Water Volume*

The cleared and reclaimed land and depleted water volume was 3,106.59 ha, 1,374.5 ha, and 48,738,366 m$^3$, respectively.

### C. *Methods*

This exploratory research employed the Expanded Net Present Value (NPV) development model. The approach is useful in conducting economic valuation to determine the economic value of water resource sustainability in coal mining. Quantitative techniques were applied to calculate the NPV of benefits and external costs of open coal mining on the value of water resources and ecosystem services by these assessments.

### D. *Economic Valuation Using the Expanded NPV Method.*

*1) Erosion value (potential economic value of water resources lost due to erosion):* The erosion value was possibly calculated using the extended cost-benefit analysis (Expanded NPV) developed by [27].

$$Extended\ NPV_{ne} = \sum_{t=0}^{n} \frac{B_{npe} - C_{npe}}{(1+r)^t}$$

$NPV_{ne}$ = Net Present Value
= The erosion value is derived from the erosion recovery value and the erosion resisting value (IDR)
$B_{npe}$ = The erosion recovery value is an external benefit of ex-mining land revegetation (IDR).
$C_{npe}$ = The erosion-resisting value is an external cost of the mining clearing impact (IDR)
n = Mine life (production and post-production
r = Discount rate = 1, 2,….n
t = Interest rate

*2) The domestic water value (the potential economic value for the loss of drinking water resources for the community):* Domestic water value was also evaluated using the Expanded NPV method. The above equation was derived from the extended benefit and cost mathematical analysis model by [27].

$$Extended\ NPV_{cad,T} = \sum_{t=0}^{n} \frac{C_{adr,T} - M_{pa}}{(1+r)^{t}}$$

$NPV_{cad}$ = Net Present Value
= Domestic water cost value of the community (IDR)
$C_{adr}$ = Average domestic water cost per respondent (IDR)
$M_{pa}$ = The number of people buying water around TAL PTBA
n = Mine life (production and post-mining)
r = 1,2, …. n
t = Interest rate
T = Research year

*3) The raw water value (potential economic value of water resources from utilizing (recycling) depleted water) :* The raw water value was determined using the developed method by a previous study [27].

$$Extended\ NPV_{nab} = \sum_{t=0}^{n} \frac{B_{ab} - C_{ab}}{(1+r)^{t}}$$

$NPV_{nab}$ = Net Present Value
= The raw water value originates from the benefit and cost estimates (IDR)
$B_{ab}$ = The raw water benefit from recycling (IDR)
$C_{ab}$ = The raw water cost from recycling (IDR)
n = Mine life (production and post-mining)
r = 1,2, …. n
t = Interest rate

## III. RESULTS AND DISCUSSION

### *A. Impact of mining on water resources and community*

Figure 2 represents the occurrence of soil erosion and water depletion due to mining.

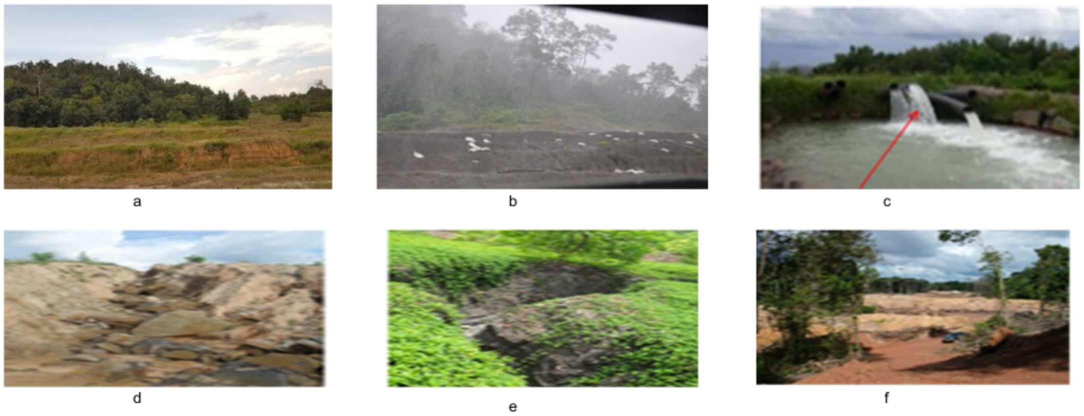

Fig. 2 Land erosion and water depletion

The above illustration showed the erosion occurrence on the ground/open land in Indonesian coal mining (a, b) and water depletion(c) due to the pumped outlet at TAL PT Bukit Asam Persero Tbk, Kutai site (d), Suriname Artisanal Gold Mining (e).

Deforestation also instigated certain changes in water consumption, resulting in erosion, where the loss of hydrological function in the forest, as a catchment area, possibly occurred. This event contributed to the unsustainable outcome of water resources in terms of quantity, quality, and loss of plant economic value [9]. The situation also eliminated water ecosystem services as a resource provider [14], allowed sufficient space for environmental degradation, and initiated chemical, physical, biological, and environmental changes [8]. Furthermore, erosion is known to decrease surface water level, remove the land cover, increase the deforestation rate[11], [27], and lower the water level, e.g., in the Baganuur mine, Mongolia, the decline in soil fertility, as well as trigger surface and groundwater pollution [3]. In addition, increased surface water runoff and sedimentation decreased water quality, and disrupted land and river transportation was observed [29]. However, erosion of mine waste disposal, contamination of surface water, groundwater, and soil by released chemicals from the mining process, and extinction of certain species [10]. Soil erosion also occurred in the open land of mining areas and river sediments [9], causing significant damage to flora, fauna, hydrological relationships, and soil. Previous studies have reported the incident as a major challenge in coal mining. Also, sedimentation results in river silting and turbidity [30]. However, turbidity is probably responsible for declining water quality and poses a major environmental problem. This condition is triggered by suspended particles, specifically sediment and soil particles from various erosion processes, due to human activities, e.g., mining [31]. These distributions require utmost priority in measuring the trade-offs between economic water benefits in mining and usage [12]. Therefore, water resources necessitate protection to enable proper and general utilization as a natural resource for society and living organisms. Furthermore, limited freshwater and groundwater by barely 3 and 30%, respectively, causes less consumption [13].

The above points showed the importance of water to humans and entire living organisms [15]. Therefore, a collaborative approach between hydrologists and economists appears as a great necessity in optimizing the value of water instruments [12].

The above illustration showed the erosion occurrence on the ground/open land in Indonesian coal mining (a, b) and water depletion(c) due to the pumped outlet at TAL PT Bukit Asam Persero Tbk, Kutai site (d), Suriname Artisanal Gold Mining (e).

Deforestation also instigated certain changes in water consumption, resulting in erosion, where the loss of hydrological function in the forest, as a catchment area, possibly occurred. This event contributed to the unsustainable outcome of water resources in terms of quantity, quality, and loss of plant economic value [9]. Reclamation in the coal mining area of TAL PT Bukit Asam Persero Tbk is figured out as follows.


a

b

Fig. 3 Reclamation of TAL PTBA

The conversion of land to forest by reverting to a tree-covered landscape or establishing a commercial forestry program is a major mine reclamation alternative (Figure 3). A typical example is the recovery of entire former Appalachian mines to become one of the most beautiful forests in the world. This process is highly needed to restore the forest structure and function [29] as an erosion barrier [8], [9]. Therefore, reclamation is believed to reduce erosion, prevent soil degradation, decline runoff rates, and increase porosity, permeability, and infiltration [17]. Moreover, erosion is possibly minimized by planting legume cover crops in the early vegetation stages. Figure 4 represents the LCC cultivation in the TAL PTBA reclamation zone.


a

b

Fig. 4 Planting of legume cover crops at PTBA Tambang Air Laya

Furthermore, the introduction of LCC tends to prevent and control soil erosion, enrich and protect soil, increase water availability, and serve as an environment preservation technique. The soil's physical, chemical, and biological properties are improved by increasing aggregate stability and reducing erosion. This provides various benefits for the agroecosystem, including erosion and weed control, as well as nutrient management [20]. Consequently, the improvement also prevents soil erosion and nutrient leakage. It provides ecosystem services, including erosion control, water quality regulation, soil moisture retention, soil organic matter, and microbial biomass accumulation, weed and pest control, and subsequent commercial crop yields. In addition, there is a possibility to regulate climate, soil, and water as well as control erosion, clean water, and weed [32]. However, mitigating soil degradation functions as a shield from raindrops and surface runoff and increases the organic matter.

The reclamation of the Hanjiawan coal mine region provided certain benefits for ecological development by enhancing soil quality, fertility, and forest cover and reducing soil/water loss while serving an important role in economic and social aspects [11]. Moreover, effective reclamation offers long-term success and high mining profitability for future economic benefits. According to [3], PTBA's coal mining land reclamation was barely for environmental improvement through conservation and protection but also served as an economic investment activity to create harmony and social benefits for local industry, agriculture, forestry, livestock, and eucalyptus plants. Furthermore, PTBA reclamation to mine closure in NPV by 2043 reported a potential economic value of USD 91,295,530 (1 USD = IDR 13,329). Meanwhile, the Appalachia Kentucky instance was estimated at a total ecosystem value of $ 456,428,682 [33].

The results of this study demonstrated the inability of mine reclamation to restore pumped water depletion from the outlets entirely, but it was possible to repair erosion. This circumstance was due to a more effective water absorption and storage in forest land compared to reclaimed regions. Forest land exhibited sufficient porosity and very rapid permeability. The extensive soil porosity prevents surface runoff, resulting in increased water infiltration to a certain capacity before saturation. Moreover, forest land showed a great ability to restrain erosion compared to reclaimed portions. In addition, the excessive infiltration rate was due to higher biodiversity (understory, shrubs, and trees), litter production, porosity, and permeability, and decreased bulk density, preventing erosion. The vegetation diversity (biodiversity) effectively reduces rain energy and inhibits surface runoff velocity.

Consequently, to increase water efficiency, recycling offers a paramount alternative [22]. This approach was adopted in the TAL PTBA mine outlet to restore water resources lost due to depletion and subsequently uphold sustainability in terms of quality and quantity. The provision was in line with natural resource management policies, where using natural coal resources is needed to maintain water resource sustainability for a balanced environment [1].

### B. *Expanded Net Present Value (ENPV)*

The economic valuation of the water resource sustainability for a sustainable environment was analyzed using the Expanded Net Present Value (ENPV). Resources, economy, and environment are interdependent systems for an economic valuation [33]. This process aimed to provide a monetary assessment of natural resource loss and environmental degradation's impact on humans [25]. Economic valuation is very important as natural resources and the environment showed no monetary value. The effort aims to provide environmental protection as the ecosystem is responsible for free natural water resource availability. In addition, the instance for *Spain's Urdaibai Biosphere* reserve in Spain was performed using the conservation and management policies framework to maximize social welfare.

Furthermore, economic valuation was also conducted on the quality of water bodies, agricultural production, native forest protection, biodiversity, and recreation, where the local population was willing to financially support the management plan [26]. Cost-benefit analysis (CBA) serves as a comprehensive economic valuation method for a net impact assessment on social, economic, and environmental aspects [26], [27]. This process was used to provide a potable water resource assessment. Previous studies stated the provisions of benefits and costs directly (financially) and indirectly (externalities) in economic, social, and environmental aspects of open coal mining [3], [12], [33], [34]. Economic valuation in this study was performed on erosion, domestic water, and raw water values of TAL PTBA, using an extended benefit and cost analysis model.

*1) Erosion value:* Based on calculations (Formula 1), the erosion value (Expanded NPVne) between 1997-2023 was specified as IDR 716,328,638,488,- or 716 billion rupiahs, with an erosion-resisting estimate ($C_{npe}$) of IDR 736,436,108,129,- or 738 billion rupiahs, and an erosion recovery ($B_{npe}$) of IDR 20,107,469,641,- or 20 billion. These results indicated that the forest clearing by TAL PTBA coal mining triggered an erosion and, therefore, eliminated the ecosystem service value, leading to an unsustainable supply of 716 billion rupiahs. This shortfall was due to the loss of forest ecosystem services as an erosion barrier, causing unsustainable water resources by 736 billion rupiahs. Furthermore, reclamation tends to reduce erosion and restore forest ecosystem services and sustainable water resources by 20 billion. However, reclamation possibly obtained a water resource sustainability value of 20 billion, but the lost water resources (716 billion rupiahs) were not completely restored. The calculation of erosion-resisting and recovery values employed benefit transfer similar to previous studies, including flood control estimates based on tropical forest types in the Brazilian Amazon, resembling Indonesian forests [27].

*2) Domestic water value:* The sample water emanated from the Enim river in TAL PTBA. Figure 5 shows the river conditions of Enim and Artisanal gold mining sites in Suriname (c).

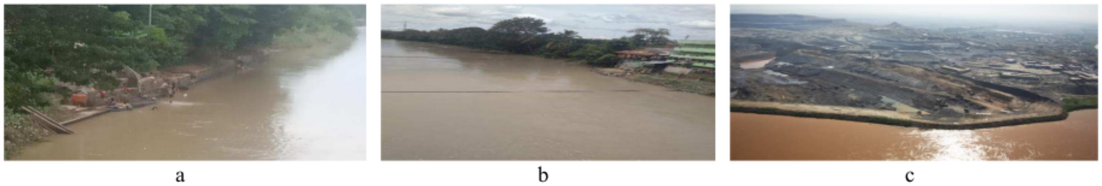

Fig. 5 The condition of PTBA Enim river (a, b) and China's coal industry polluting the Yellow River basin (c) Green Peace, 2014

Based on the above figure, the Enim river was known to be highly turbid and degraded. This condition matched previous reports, where the rivers formed a component of the degradable freshwater ecosystem [35]. The result was also by questionnaire data, where 43.07% of respondents did not utilize Enim water for drinking or cooking, based on bad smell and high turbidity. This showed that the sample had declined in quality. Furthermore, the present study results were supported by the Enim water quality test from Muara Enim Regional Environmental Agency. The unsuitability for bathing and consumption conformed with Minister of Health Regulation on Requirements for Drinking Water Quality and Clean Water. However, both guidelines require a maximum turbidity value of 5 and an odorless state. Meanwhile, the turbidity for Enim River at all monitoring points reflected a value above five but was very stinky.

Erosion instigates the accumulation of sediments containing chemical toxins responsible for groundwater pollution and changes in drinking water taste. The water appears turbid due to dispersed colloidal particles' total dissolved solids (TDS) content. Consequently, turbidity influences watercolor significantly, and the suspended material adversely affects the quality. Excessive TDS increases turbidity and alters the transparency, while high water hardness triggers a bad taste. During mining, runoff sediment quantity increased, and the total suspended solids (TSS) in the form of soil surface layer were removed by rainwater flow. This deposit emanated from the degraded forest land [36]. The TSS, as a pollutant, accesses the hydrosphere and lithosphere through surface runoffs, causing water and soil pollution. Also, the suspended materials adversely impacted water quality as sun penetration reduced. However, water turbidity increased due to decreased photosynthetic processes, where growth disturbances for the producing organisms were observed. Another TSS impact exceeding water quality standards was unable to support fishing activities.

Deforestation due to mining revealed a significant impact on the downstream area through sediment transfer. It instigated water pollution in terms of quality and quantity, inadequate clean water availability, and river silting due to elevated sedimentation responsible for reducing water depth [30]. The impact of coal mining on water resources triggers (1) surface water runoff and changing conditions in the catchment area, 2) destruction of aquifer structure, 3) damaging water circulation and balance conditions, and 4) water resource contamination. Furthermore, Gujiao coal mining activities played an important role in declining river runoff. In contrast, for one-ton coal, a decrease in the river, surface, and base flows, estimated at 2.87, 0.24, and 2.63 $m^{3}$, were observed, respectively. This condition significantly influenced water resource availability as a free ecosystem service [12]. The questionnaire data indicated the elimination of ecosystem services of Enim river as a free portable water source by TAL PTBA coal mining. This impact causes the inability of the community to enjoy free supply and therefore requires payment. The charges are used to purchase water from neighbors in gallons and PAM water, although the costs gradually increase. This study calculated domestic water value using the contingent valuation/willingness to pay approach and a mathematical model developed from a previous study by the reclamation percentage method from a time horizon [27]. Based on equation 2 calculations, the domestic water value of the surrounding community in TAL PTBA between 1997-2023 was IDR 421,293,032,887 or 421.3 billion rupiahs. These findings indicate that TAL PTBA coal mining was responsible for the loss of environmental benefits to the community, devoid of ecosystem services. Consequently, potable water resources were reportedly unsustainable at 421.3 billion rupiahs.

Therefore, the overall loss of water resource economic value in similar mines was estimated at IDR 1,137,621,671,374 - or 1.14 trillion rupiahs. This estimation was derived from the erosion and domestic water values of IDR 716,328,638,488, - or 716 billion and IDR 421,293,032,887, - or 421.3 billion rupiahs, respectively. Based on these results, a significant loss was observed in water resources as an ecosystem service, resulting in unsustainable water resources by 1.14 trillion rupiahs. However, recycling provides a potential solution to rebuilding the actual state.

### C. *The Raw Water Value from Utilizing (Recycling) TAL PTBA Depleted Water for Drinking Water*

One of the basic needs of the mining industry is water [37]. Increasing water efficiency was conducted by adopting new technologies and more efficient processes, combining reuse, recycling, and finding alternative water sources [22]. Recycling discharged water from the mine appears very useful to the native population as a domestic water source, reduces the potential for land subsidence, and conserves valuable water resources for sustainable local environmental management. In Indonesia, PT Adaro Indonesia recycled (utilized) mine water using water treatment plant 300 technology [27], [38]. Subsequently, the processed potable water becomes safe for immediate consumption (Fig. 6).

Fig. 6 The processed mine void wastewater of PT Adaro Indonesia that can be consumed directly

Water from the Eastern Kentucky underground coal mine was supplied for municipal, industrial, agricultural, or household purposes. A similar circumstance was also observed in the former West Virginia coal mine, where recycling meets local water supply needs. Baganuur, Mongolia, mine water served as a community and agricultural and domestic source. Furthermore, the use of Greenwood, Arkansas, coal mine water for drinking purposes generated over twenty million dollars in economic benefits. This utilization provided the benefit values for lost water resources and economics. A previous study showed the use of PT Adaro Indonesia's coal mine void water for drinking provided economic benefits of IDR 4,438,400,888,338 (± USD 369, 866, 740) or 4.4 trillion rupiahs.

This study's raw water value (Expanded NPVav) was obtained by recycling the depleted water in TAL PTBA. This estimate originated from the raw water benefit value (Bav) and raw water cost value ($C_{av}$). Based on equation 3 results, $B_{av}$ and $C_{av}$ were evaluated as IDR 5,458,557,017,875, - or 5.5 trillion rupiahs, and 3,160,217,220,875, - or 3.2 trillion rupiahs, respectively. In addition, the raw water value (Expanded $NPV_{ba}$) from mine water was obtained as IDR 2,298,339,797,000, - or 2.3 trillion rupiahs. These calculations indicate that the recycling approach generated a water resource sustainability value of 2.3 trillion rupiahs. Therefore, the results of this study confirmed that the depleted water in TAL PTBA was used for drinking purposes to provide potential economic value and replace the water resources. Consequently, the utilization provided economic, social, and ecological benefits for the sustainability of water resources for a sustainable environment and the maintenance of potable supplies to the community. Table 1 generally represents the economic valuation results of benefit and cost values for the impact of TAL PTBA coal mining on water resource sustainability for a sustainable environment.

TABLE I
THE ECONOMIC VALUATION RESULTS

| Benefits and costs components | Benefit and cost value | Unit (IDR) | Description |
|---|---|---|---|
| NPVne = Net Present Value (Project time 32 years) | Net erosion value | 716,328,638,488 | The erosion value was derived from the erosion recovery value and the erosion-resisting value |
| Bnpe | Erosion recovery benefit value | 20,107,469,641 | The erosion recovery value is an external benefit of ex-mining revegetation |

| Benefits and costs components | Benefit and cost value | Unit (IDR) | Description |
|---|---|---|---|
| Cnpe | Erosion-resisting cost value | 716,328,638,488 | The erosion-resisting value is an external cost of the impact of forest clearing by mining |
| NPVad = Net Present Value | Net domestic water value | 421,293,032,887 | The communal domestic water cost value was derived from the average domestic water cost value per respondent with the number of people buying water around TAL PTBA |
| Cadr | Average domestic water cost value per respondent | 36,931, | Average domestic water cost per respondent |
| Mpa |  | 1,077,338,068, | The number of people buying water around TAL PTBA |
| NPVnab = Net Present Value | Net raw water value | 2,298,339,797,000 | The net raw water value originated from the raw water benefit value from recycling depleted water for drinking water with the cost of recycling depleted water for drinking water |
| Bab | Raw water benefit value | 5,458,557,017,875 | Raw water benefits from recycling depleted water for drinking water |
| Cab | Raw water cost value | 3,160,217,220,875 | Raw water cost from depleted water recycling for drinking water |

### *D. The Concept of Water Resource Sustainability for a Sustainable Environment in the Mining Sector*

The background in the basic principles of environmental science comprises natural, artificial, and social [39], while sustainability deeply emphasizes the priority elements. Therefore, effective utilization and management of natural resources are greatly focused on environmental and natural resource sustainability. Based on the above principle, this study obtained the concept of water resource sustainability for a sustainable environment in the mining sector (Fig. 7). This view was developed from a previous study [27].

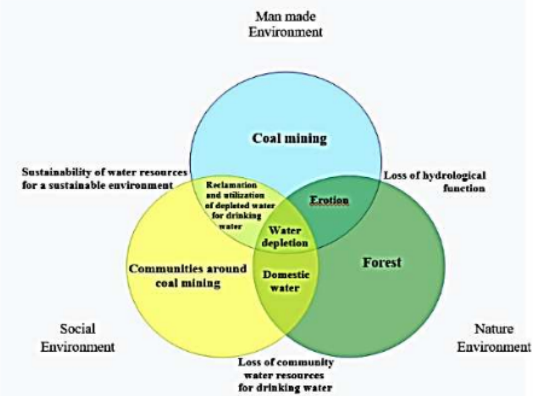

Fig. 7 The concept of water resource sustainability for a sustainable environment in the mining sector

Coal mining, with the ability to clear forests, causes erosion, as the plants tend to lose the hydrological barrier function. Also, erosion is responsible for water depletion, as the forests no longer behave as a catchment area and decline the water quality, resulting in the loss of clean water resources for surrounding communities. However, to restore the hydrological barrier role and lost resources, reclamation and utilization of depleted water for domestic use are possibly employed. This process provides economic benefits for water resource sustainability for a balanced environment. Based on the above concept, the analysis of potential economic value showed water depletion was instigated by erosion. Also, the loss of drinking water resources for the proximate communities in TAL PTBA mining generated unsustainable water resources of 1.14 trillion rupiahs. Utilization (recycling) of mine water provided water resource sustainability by 2.3 trillion rupiahs, and this utilization generated sustainability benefits of 1.16 trillion rupiahs.

Furthermore, recycling depleted water due to TAL PTBA coal mining obtained a potential economic value for water resource sustainability of 1.16 trillion rupiahs (see Figure 7). Therefore, the water resources in the TAL PTBA and the environment tends to remain sustainable, as well as the surrounding communities.

## IV. CONCLUSIONS

The coal mining of Tambang Air Laya (TAL) PT Bukit Asam Tbk, South Sumatra province, Indonesia, instigated an environmental impact, with the loss of forest area's function as an erosion barrier. In addition, a significant loss of Enim river's role as a clean water source for the surrounding communities was also reported. These circumstances resulted in unsustainable water resources at the sample location. However, mine reclamation could reduce erosion but could not restore lost water resources completely. The recycling or utilization of depleted water for drinking purposes was barely able to initiate a certain degree of replacement but also obtained potential economic value for the water resource sustainability in the site area by 1.2 trillion rupiahs. Therefore, water resources remained sustainable, and the sustainability of the environment and clean water resources for surrounding TAL PTBA communities appeared effectively maintained.

## ACKNOWLEDGMENT

The authors are grateful to Sriwijaya University and PT Bukit Asam Persero Tbk for supporting this research.

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