Environmental Mitigation Cost for Mining Road Construction in Indonesia According to IFC Standard Compliances

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ABSTRACT

Project and its environment are connected each other, including for mining activities that require land clearing for support facilities area such as access road. For minimizing negative impact from project activities to the environment, it is required regulation from government and financial institution that obligate integration between planning mitigation for environment which refers to available standard compliances with project plan. In this paper the Author described the application of environmental compliance standard published by IFC using project case study for mining road in Indonesia. Cost associated for environment mitigation based on IFC standard compliance presented in estimation process following GAO steps process for order of magnitude comparison with available database.

Keywords: environmental, IFC standard compliances, mining road construction project, dust control, noise control, land use and erosion control, waste water impact and sediment control, GAO cost estimation process, environmental mitigation cost

INTRODUCTION

In many countries, mining activities would affect the environment conditions in their vicinity from exploration to exploitation stage such as land clearing activity for roads, camps, processing plant and other facilities. This impact will have greater influence for forest environment and can't be avoided since mining industry will take places mostly on this area. Road construction as one of mining key elements, damaging the forest since their location will lies over in length of forest footprint following the design requirements. Good road design will take into account this matter through the design process including additional cost for mitigation as the consequences, in order to have a minimum impact for forest destruction and the habitats[1]. Generally the cost for environmental mitigation is not anticipated in common cost estimation process and put this cost as risk reserve. Therefore, it is very difficult to find environment cost record whereas cost for road directly connected with the environment[2]. For Indonesia as the third rank of tropical forest in the World, mining activities either regulated or not regulated is one of operation industries that contribute to the forest destruction[3] and required immediate action to prevent it from getting worst. One of significant action identified for prevention, is regulating mining activities by rules as mandatory condition, either by government (in this case the Indonesian Government) or by financial institution such as the World Bank. The term from the Indonesian Government will give any mining companies permit for land access and operation, while the World Bank through their International Finance Corporation (IFC) standard requirements for the access to investment capital. By using both strategies will encourage any mining companies apply environmental standards in their project investment process.

In this paper, the Author main target is giving brief description of IFC application in project cost limited for mining road during construction stage, as small contribution to all effort for problem solutions concerning mining and environmental problems. With project case study, the Author will provide answers for two specific research questions as follows:

- What are the IFC standard compliances for mining road construction project
- How to calculate the cost of environmental mitigation for mining road construction project following IFC standard compliances.

IFC Standard Compliances for Mining Road Project

Brief Description of IFC Standard Compliances

IFC is a member organization of the World Bank members that focuses on the private sector for developing countries[4]. IFC was founded in 1956 and currently has 184 member states including Indonesia with one main vision to ensure environmental sustainability.

IFC provides Environmental, Health and Safety (EHS) guidelines that can be easily accessed on their website. There are general and specific EHS guidelines for several industries including mining which contains EHS elements with performance indicators and monitoring actions. Depending on the project conditions, local standards sometimes also used as reference for consideration because generally IFC requirements are always higher than these standards, which will affect the project cost (in this case standards published by the Ministry of Environment Indonesia).

In order to establish mitigation actions, should be required the interpretation of some relevant guidelines due to the limitation of specific document scope. For instance, scope of IFC mining guideline only apply for specific mining works: underground mining, open pit mining, alluvial mining and marine dredging except for quarry material extraction (IFC provides specific document for quarry material extraction). This guideline does not apply for ore processing plant facility or any other facilities required in the mining industry such as mining road. Therefore the interpretation for mining road should be done with the combination of IFC General EHS, Mining EHS and Toll Road EHS documents[5].

IFC Standard Compliances for Mining Road Construction

Inside IFC Mining EHS document there are several environmental elements and sub elements topic listed with their recommended practices, which also covered by General and Toll Road EHS documents present in Table 1:

Potential Environmental Elements Related with Mining			
No	**Elements**	**Sub Elements**	
1	Water Use and Quality	1.1	Water Use
		1.2	Water Quality
		1.3	Stormwater
		1.4	Acid Rock Drainage and Metals Leaching
		1.5	Groundwater Resource Protection
2	Wastes	2.1	Waste Rock Dumps
		2.2	Tailings
		2.3	Waste Geochemical Characterization
		2.4	General Non Hazardous Waste
		2.5	Hazardous Waste
3	Hazardous Materials	3.1	Cyanide
4	Land Use and Biodiversity	3.2	Terrestrial Habitats
		4.2	Aquatic Habitats
		4.3	Marine Habitats
5	Air Quality	5.3	Dust
		5.2	Gaseous Emissions
		5.3	Smelting and Roasting
6	Noise and and Vibration		
7	Energy Use		
8	Visual Impact		

Table 1 Mining Potential Environmental Elements[6]

Refer to these recommended practices, a set of mitigation actions can be formed with relevant environmental element topics for road construction in project document such as General Notes for execution guideline or Detail Information for engineering stage. Using these General Notes as bid document reference shall assist contractor composed their mitigation plan with the cost associated to client, and to be used further as contractor performance indicator besides common progress performance.

Environmental elements related to the environmental aspects of mining road construction and mitigation actions[7] can be described as follows:

1. **Element 1 Water Use and Quality**
   Sub Element 1.1 Water Use, 1.2 Water Quality and 1.3 Stormwater
   - Objectives:
     - ✓ Efficient raw water consumption.
     - ✓ Minimizing the negative impact of waste water or other waste discharge to the environment.
   - Mitigation Actions:
     - ✓ Install water recycling process system.
     - ✓ Install septic tank system with treatment process.
     - ✓ Install bund protection perimeter for fuel tanks.
     - ✓ Install oil or grease trap sumps with spill kits.
     - ✓ Install temporary drainage system for stormwater (side ditches, sand traps, sediment ponds).
   - IFC Requirements:
     Present in Table 2 the effluent limit values from IFC

Pollutants		Value		Remark
Total Suspended Sediment	TSS	50	mg/litre	Stormwater
Biological Oxygen Demand	BOD	50	mg/litre	Stormwater
	BOD	30	mg/litre	Sanitair waste water
Chemical Oxygen Demand	COD	150	mg/litre	Stormwater
	COD	125	mg/litre	Sanitair waste water
Total Phosphorus		2	mg/litre	
Coliform Bacteria		400 MPN/100 mlitre		Sanitair waste water
	pH	6-9		
Oil & Grease		10	mg/litre	

Table 2 IFC Effluent Limit Values[8]

Special attention reqired for TSS limit value since this requirement is quite challenging for temporary design system compare with Indonesian requirement (100-200 mg/litre).

2. **Element 2 Wastes**
   Sub Element 2.2 General Non Hazardous Waste & 2.3 Hazardous Waste
   - Objective:
     - ✓ Minimizing the negative impact of wastes or litters to the environment.
   - Mitigation Actions:
     - ✓ Install waste bins with separation category.
     - ✓ Build centralized waste disposal area (litters and hazardous waste).
     - ✓ Assign licensed company for waste hazardous management and disposal.
   - IFC Requirement: no requirement

3. **Element 4 Land Use and Biodiversity**
   Sub Element 4.1 Terrestrial Habitats & 4.2 Aquatic Habitats
   - Objective:
     - ✓ Minimizing the negative impact of land clearing to soil, vegetation and fauna habitats.
   - Mitigation Actions:
     - ✓ Establish land clearing procedure as regulation. Deforestation can be performed with client approval for working request in advance and notification statement for immediate action with refurbishment plan. Cutting trees using dozing method should be minimized (more combination with hand chain saw method). Tree logs and top soil must be stored separately in dedicated area with proper maintenance plan. Burning method is not allowed for forest clearance.
     - ✓ Perform slope management plan for road sections. Slope is made with certain methods (safe slope angle, silt fence, benching, mulch or geofabric material, slope net...etc) to prevent soil erosion with drainage systems.
     - ✓ Revegetation effort can be discussed with contractor based on project conditions.

- ✓ If road section is located in a particular habitat, road design should consider additional crossing structure for the fauna.
- ✓ Design for temporary river crossing structure must consider protection of river environment and must be submitted in advance for client approval.

- IFC Requirement: no requirement

4. **Element 5 Air Quality**

Sub Element 5.1 Dust

- Objective:
  - ✓ Minimizing the negative impact of dust generated during construction process.
- Mitigation Actions:
  - ✓ Apply dust supression system (wetting down for road sections and truck tyres, use of all weather surfaces for pavement).
  - ✓ Protect exposed soils and other erodible materials with mulch or geofabric (especially for non traffic areas).
  - ✓ Install wind fences wherever appropriate.
  - ✓ As much as possible construction traffic should stay on defined roads (stated in construction method of work).
- IFC Requirement:
  No requirement from IFC. For consideration, Indonesian standard requirement is max 10 mg/m3 (breathing dust) and 5 mg/m3 (inhalation dust) during eight hours dust measurement.

5. **Element 6 Noise and Vibration (no sub elements)**

- Objective:
  - ✓ Minimizing noise and vibration disturbance during construction process.
- Mitigation Actions:
  - ✓ Install proper sound barriers and/or noise contaminents with enclosures and curtain close with source equipment.
  - ✓ Install natural barriers at facility boundaries such as vegetation curtains or soil berms.
  - ✓ When required blasting method, use as much as possible low explosive blasting energy type.
  - ✓ Traffic management (optimum or alternate route avoiding community area and apply speed limit regulation).
- IFC Requirement:
  IFC standard is 60 dBA for operation areas (process plants, workshop...etc).

In following section will be described cost calculation process of mitigation actions using project case study. Some unit costs taken from vendors proposal combined with existing unit costs from previous projects implemented on site. These unit costs then multiply with bill of quantity provided by design team and in the end change into percentage value for comparison with other project references.

Environmental Mitigation Cost Calculation for Project Case Study

Project Data

Case study selected for this paper is taken from one section of connection road to the processing plant area. The sequence descriptions of project data present as follows[9]:

- *Project Name* — Road to Processing Plant Section 2.
- *Project Description* — Total road length is 1.973 km and 10 meter pavement width divided into two lanes included shoulders.
- *Project Duration* — Estimated duration is six months from contract award.
- *Project Location* — Halmahera North Maluku, Indonesia.

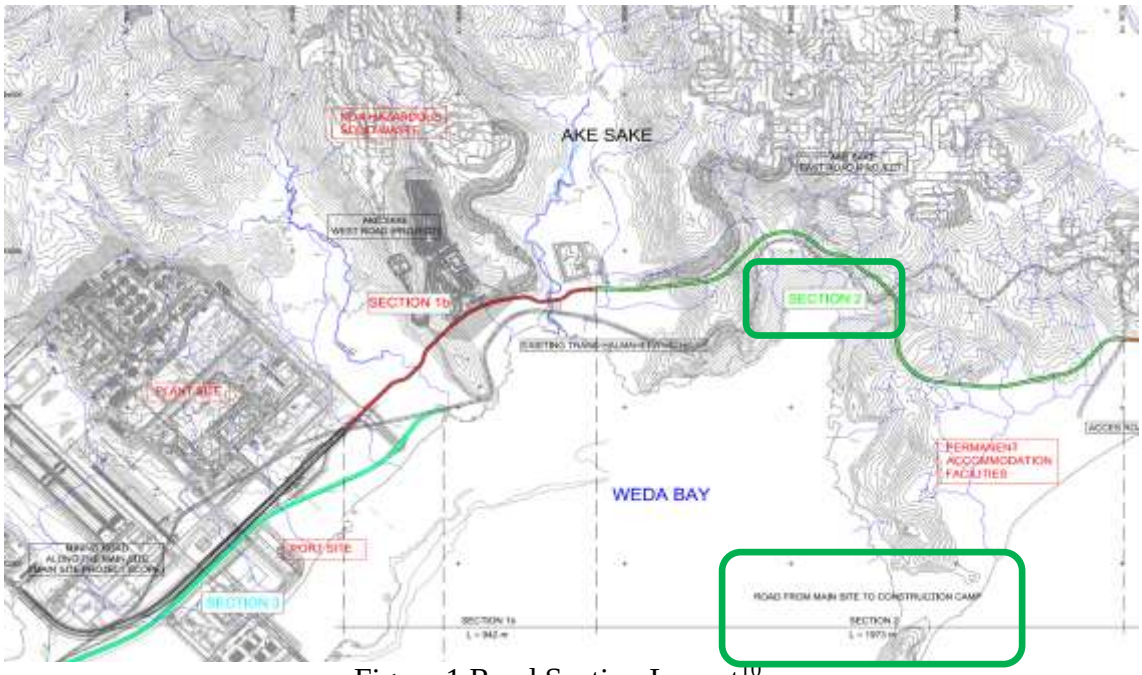

Figure 1 Road Section Layout[10]

- *Environmental Mitigation Plan*

  Identified mitigation plan for this project is described in following sections:

  ✓ **Dust Control**
  There are many methods available for dust control. The most common method is watering road with short time coverage and others using salts or chemical solutions (petroleum emulsions, surfactants, adhesives and polymers) with longer period of coverage[11]. Based on information provided by available specialist for chemical solution[12], average performance durations after application for active traffic area are between 12-18 months with EPA standard compliances equivalent with IFC requirement. Both methods had been selected for this project with application time strategy (chemical solution in advance and interval watering road during construction period), besides control application to vehicles or trucks (speed limit regulation, cover load

with tarpaulin, maintain distance between trucks and proper maintenance plan). Temporary wind barrier fence from tarpaulin will be applied for top soil stock pile with maintenance effort during construction period.

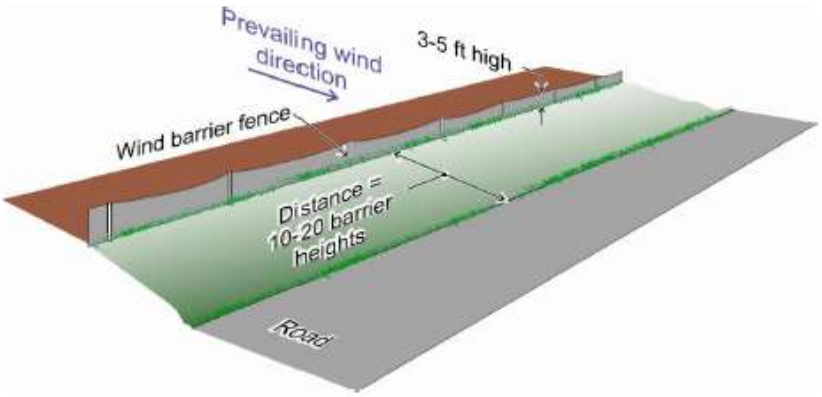

Figure 2 Example of Wind Barrier Fence[13]

- ✓ **Noise Control**
  Project location is in distance and separate with local village, therefore no physical sound barrier required except control application for vehicles or trucks same as mention before and make sure all trucks will pass the defined construction road.

- ✓ **Waste Control**
  Litters from separate bins will be collected in centralized waste area except for hazardous waste (should be handled by certified company).

- ✓ **Land Use and Erosion Control**
  No expected crossing structures for fauna or rivers since project area doesn't run through these critical areas. The implementation of forest clearance management as explained above with slope management and open areas protection are three important efforts for environmental control. For open areas protection, the combination techniques using silt fence and mulching (with grass or other local materials such as "*nipah*" roof) are the chosen methods for this project.

Figure 3 Methods for Open Areas Protection[14]

✓ **Waste Water Impact and Sediment Control**

Mitigation plan for this section was divided into two sub sections:

- Installation oil sump unit for equipment workshop and bio septic tank unit for utilities. Finally, for fuel tanks earth bund wall should be made according to safety standards. The cost for these installations usually included in general expenditure or preliminary items and not separately charged as well as other work units.

- The concept of temporary drainage system is made with combination using ditches and plastic membranes protection, rip rap transversal dike structures, sand traps and sediment ponds. Plastic membranes lining temporary ditches wall in order to prevent additional sediment volume while transversal dikes and sand traps will reduce the rate of sediment carried by water current. The remaining volume will be collected by sediment ponds at the end of drainage network with periodic maintenance and removal of sediment to be dumped in planned area.

Figure 4 Transversal Dike and Temporary V Ditch[15]

For sediment ponds, design team applied Stokes formula where the rate of deposition of sediment grains modeled according gradation. This method gives more adequate result for TSS requirement according to IFC, compared with common Universal Soil Loss Equation (USLE) that only focus on the amount of sediment produced during certain period.

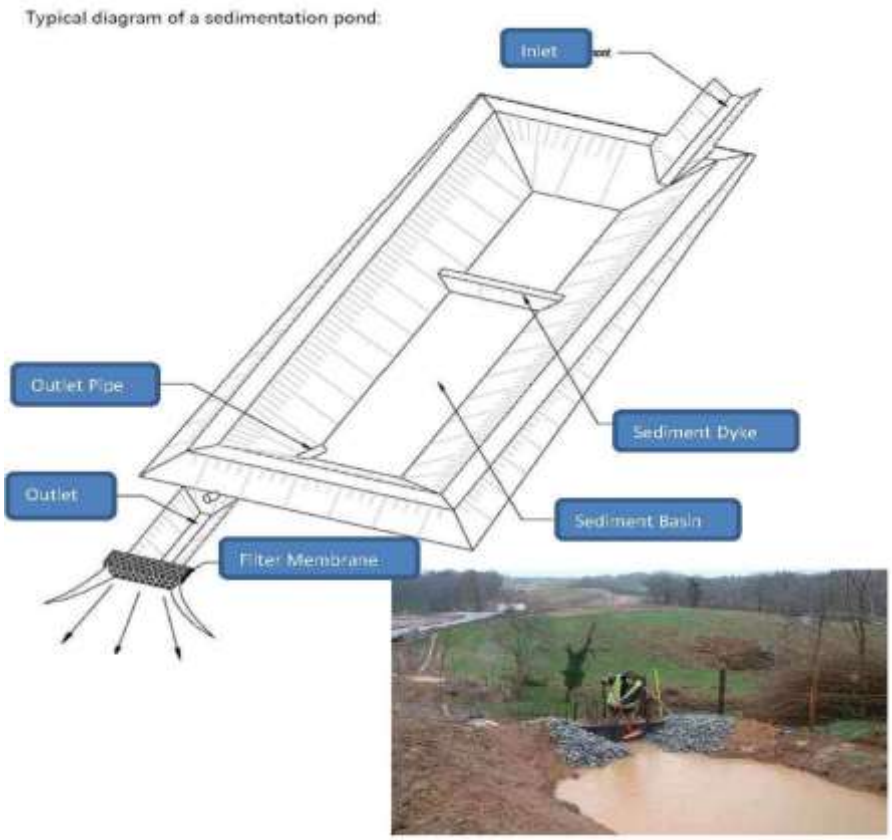

Figure 5 Sediment Pond Structure with Maintenance[16]

Cost Calculation

The process of calculating reliable mitigation cost estimate with respect to environmental elements that have been described previously were performed according to process developed by GAO as shown in following Figure 6:

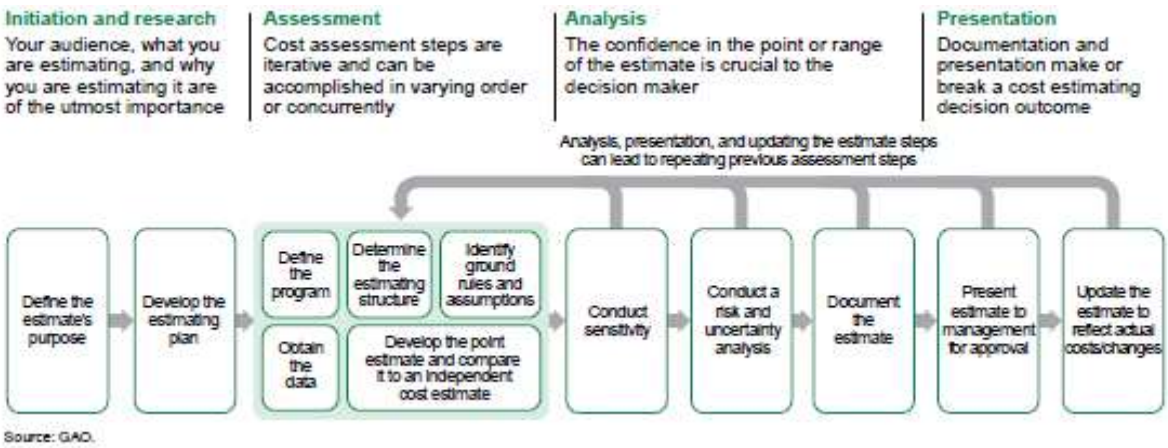

Figure 6 GAO Cost Estimation Process[17]

As shown in Figure 6, there are 12 steps for estimation which can be adjusted depending on project stage. The steps used for project case study are presented in Table 3 with remarks to the steps that are not used.

Divisons	Steps	Description	Proceed	Remarks
A Initiation and research	1	Define the estimate's purpose	Yes	
	2	Develop the estimating plan	Yes	
B Assessment	3	Define the program	Yes	
	4	Determine the estimating structure	Yes	
	5	Identify the ground rules and assumptions	Yes	
	6	Obtain the data	Yes	
	7	Develop the point estimate and compare it to and independent cost estimate	Partial	Except comparison to independent cost estimate [no necessary required at this stage]
C Analysis	8	Conduct sensitivity	Yes	
	9	Conduct a risk and uncertainty analysis	Yes	
	10	Document the estimate	Yes	
D Presentation	11	Present estimate to management for approval	No	Not yet as final result, will be updated in the next stage
	12	Update the estimate to reflect actual costs/changes	No	The project has not been in the implementation stage

Table 3 GAO Cost Estimation Process for Project Case Study[18]

Calculation stages follow the process as described above will be explained in the following sequences:

- **Estimation Purpose and Plan**
  The objective is developing cost estimation Class 3 according to AACE for budget control as described in Figure 7 with plus minus 10 to 20% accuracy level. The output from this simulation will provide the order of magnitude of mitigation cost for financial budgeting process. Within reasonable time approved by management, the

work will be carried out with support from design team and engineer who is responsible for this work package.

	Primary Characteristic	*Secondary Characteristic*			
ESTIMATE CLASS	**LEVEL OF PROJECT DEFINITION** Expressed as % of complete definition	**END USAGE** Typical purpose of estimate	**METHODOLOGY** Typical estimating method	**EXPECTED ACCURACY RANGE** Typical variation in low and high ranges [a]	**PREPARATION EFFORT** Typical degree of effort relative to least cost index of 1 [b]
Class 5	0% to 2%	Concept Screening	Capacity Factored, Parametric Models, Judgment, or Analogy	L: -20% to -50% H: +30% to +100%	1
Class 4	1% to 15%	Study or Feasibility	Equipment Factored or Parametric Models	L: -15% to -30% H: +20% to +50%	2 to 4
Class 3	10% to 40%	Budget, Authorization, or Control	Semi-Detailed Unit Costs with Assembly Level Line Items	L: -10% to -20% H: +10% to +30%	3 to 10
Class 2	30% to 70%	Control or Bid/ Tender	Detailed Unit Cost with Forced Detailed Take-Off	L: -5% to -15% H: +5% to +20%	4 to 20
Class 1	50% to 100%	Check Estimate or Bid/Tender	Detailed Unit Cost with Detailed Take-Off	L: -3% to -10% H: +3% to +15%	5 to 100

Notes:
[a] The state of process technology and availability of applicable reference cost data affect the range markedly. The +/- value represents typical percentage variation of actual costs from the cost estimate after application of contingency (typically at a 50% level of confidence) for given scope.
[b] If the range index value of "1" represents 0.005% of project costs, then an index value of 100 represents 0.5%. Estimate preparation effort is highly dependent upon the size of the project and the quality of estimating data and tools.

Figure 7 AACE Cost Estimation Class 3 for Project Case Study[19]

- **Estimation Outline**
  Relevant with previous technical descriptions, outline estimation will be divided into four group cost center: dust control, noise control, land use and erosion control and waste water impact & sediment control.

- **Volumes and Unit Prices References**
  - Volumes of work taken from bill of quantity document produced by design team.
  - Unit Prices
    There are two references for estimation:
    a. Cost proposals provided by vendors[20].
    b. Resources or similar working prices that have been used for other project within company operation on site[21].

- **Assumptions Used in the Estimation**
  - Negligible cost escalation factor for the planned project duration of less than one year.
  - Total cost not including Value at Tax (VAT) according to Indonesia regulation.

- Additional costs for risk analysis will be calculated separately.
- Maintenance cost factors are calculated by giving monthly presentations from total construction cost of each cost center that will be used during operational stage (larger maintenance cost is given to temporary drainage systems as the final protection boundary to original environment condition) .

- **Work Breakdown Structure (WBS)**
  Cost calculations will be performed for temporary work in addition to other permanent works to meet the IFC requirements. These works are grouped into environmental block with WBS structure breakdown until level 4 present in Figure 8.

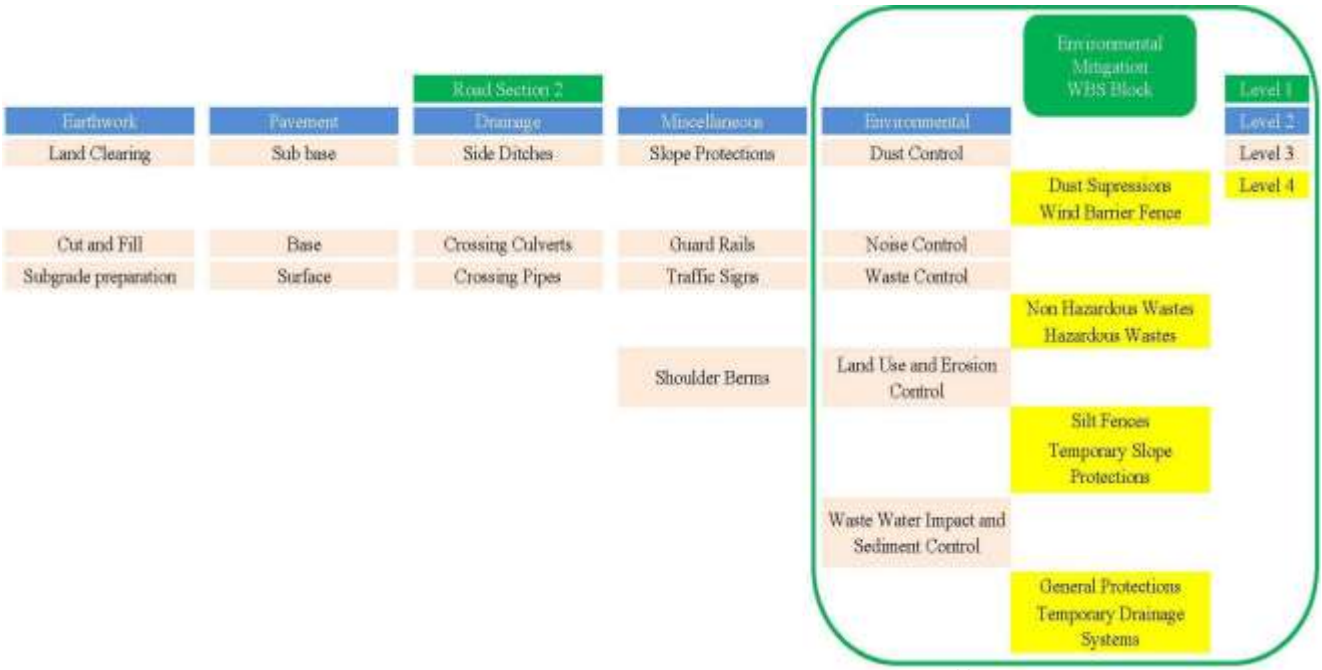

Figure 8 Project Case Study Work Breakdown Structure[22]

- **Detail Calculation**
  Present in Table 4 detailed calculation of costs for environmental mitigation with taken assumptions. Unit prices and used factors of each work already breakdown into detail of resources: material, labor, equipment and subcontractor based on references that have been mentioned in previous steps.

No	Description	Taken Qty		Unit Prices [USD] Material	Labor	Equipment	Subcont	Amount [USD]	Remark
1	**Dust Control**								
1.1	*Dust supression methods*	*1.00*	*ls*						
1.1.1	Application chemical solution for road	19,730.00	m2				1.50	29,595.00	Estimated only 1 time in advance
1.1.2	Watering road:								
-	Water truck 5000 litre	600.00	unit-hours			24.74		14,845.36	Incl.fuel & operator
-	Local labor-daily	720.00	man-hours		2.25			1,618.14	
1.2	*Wind barrier fence*	*300.00*	*mt*						
1.2.1	Top soil stock pile area:								
-	Tarpauline covers	16.00	sheets	28.00				448.00	
-	Support pool and consumables	300.00	m1	2.00				600.00	
-	Local labor-installation	384.00	man-hours		2.25			863.01	
1.2.2	Maintenance wind barrier fence	4.00	months				38.00	152.00	Estimated 2%/mo from construction cost
							Sub total 1	**48,122.00**	
2	**Noise Control**								
	NA-cost incl.in method of work strategy								
							Sub total 2	**0.00**	
3	**Waste Control**								
3.1	*Non hazardous wastes handling*	*1.00*	*ls*						
3.1.1	Project temporary facilities:								
-	Litter bins with separated category	6.00	nos	200.00				1,200.00	
-	Local labor-wastes collections & disposal area operation	2,400.00	man-hours		2.25			5,393.81	
-	Pick up 4x4	3.00	unit months			3,608.25		10,824.74	Incl.fuel & operator
3.1.2	Centralized garbage disposal area:								
-	Refurbishment container 40 ft with canopy	1.00	unit	2,500.00				2,500.00	
-	Operational disposal area	5.00	months	600.00		200.00		4,000.00	
3.2	*Hazardous wastes handling*	*1.00*	*ls*						
3.2.1	Project temporary facilities:								
-	Assignment to certified or licensed company	1.00	ls				10,000.00	10,000.00	
							Sub total 3	**33,918.00**	

No	Description	Taken Qty		Unit Prices [USD] Material	Labor	Equipment	Subcont	Amount [USD]	Remark
4	**Land Use and Erosion Control**								
4.1	*Silt fences*	*5,200.00*	*mt*						
4.1.1	Cut and fill area:								
-	Geotextile material	5,200.00	m1	8.00				41,600.00	
-	Support pool and consumables	5,200.00	m1	0.50				2,600.00	
-	Local labor-installation	672.00	man-hours		2.25			1,510.27	
4.1.2	Maintenance silt fences	3.00	months				914.00	2,742.00	Estimated 2%/mo from construction cost
4.2	*Temporary slope protections*	*1.00*	*ls*						
4.2.1	Cut and fill area:								
-	"Nipah" roof	5,500.00	m2				1.00	5,500.00	Program for local community [CSR]
-	Grassing	15,500.00	m2				3.00	46,500.00	Program for local community [CSR]
-	Benching:	*1,900.00*	m2						
	Excavator PC 200	190.00	unit-hours			65.00		12,350.00	Incl.fuel & operator
4.2.2	Maintenance slope protections	3.00	months				1,287.00	3,861.00	Estimated 2%/mo from construction cost
							Sub total 4	**116,663.00**	
5	**Waste Water Impact and Sediment Control**								
5.1	*General protections*	*1.00*	*ls*						
5.1.1	Project temporary facilities:								
-	Bio septic tanks c/w bio action media	2.00	unit				200.00	400.00	Incl.installation
-	Oil traps	2.00	unit				300.00	600.00	For equipment workshop area, incl.installation
-	Bund wall for fuel storage tank:								
	Tarpauline covers	4.00	sheets	28.00				112.00	
	Granular bund wall	24.00	m3	50.00	10.00	3.00		1,512.00	
	Excavator PC 200	4.00	unit-hours			65.00		260.00	Incl.fuel & operator
	Local labor-installation	16.00	man-hours		2.25			35.96	
5.2	*Temporary drainage systems*	*1.00*	*ls*						
5.2.1	Sediment ponds:								
-	Excavation:	*1,747.00*	m3						
	Excavator PC 200	87.35	unit-hours			65.00		5,677.75	Incl.fuel & operator
	Local labor-support	24.00	man-hours		2.25			53.94	
-	Backfill:	*2,225.00*	m3						
	Excavator PC 200	178.00	unit-hours			65.00		11,570.00	Incl.fuel & operator
	Local labor-support	16.00	man-hours		2.25			35.96	

No	Description	Taken Qty		Unit Prices [USD] Material	Labor	Equipment	Subcont	Amount [USD]	Remark
-	Rock rip rap:	127.00	m3						
	Excavator PC 200	6.35	unit-hours			65.00		412.75	Incl.fuel & operator
	Grouted rock lines [rock dykes]	38.00	m3				117.00	4,448.00	Program for local community [CSR]
-	Surface lining:	378.00	m2						
	Tarpauline covers	6.00	sheets	28.00				168.00	
	Local labor-installation	32.00	man-hours		2.25			71.92	
5.2.2	Maintenance sediment ponds	4.00	months				3,365.00	13,460.00	Estimated 15%/mo from construction cost
5.2.3	Sand traps:								
-	Unit sand traps	15.00	nos				35.00	525.00	Program for local community [CSR]
-	Excavation:	259.00	m3						
	Excavator PC 200	12.95	unit-hours			65.00		841.75	Incl.fuel & operator
	Local labor-support	16.00	man-hours		2.25			35.96	
-	Surface lining:	482.00	m2						
	Tarpauline covers	6.00	sheets	28.00				168.00	
	Local labor-installation	32.00	man-hours		2.25			71.92	
5.2.4	Maintenance sand traps	4.00	months				246.00	984.00	Estimated 15%/mo from construction cost
5.2.5	Transversal dykes:								
-	Rock rip rap	385.00	m3				117.00	45,045.00	Program for local community [CSR]
5.2.6	Temporary ditches:	5,650.00	m1						
-	Excavation:	706.25	m3						
	Excavator PC 200	35.31	unit-hours			65.00		2,295.31	Incl.fuel & operator
	Local labor-support	504.00	man-hours		2.25			1,132.70	
-	Surface lining:								
	Tarpauline covers	57.00	sheets	28.00				1,596.00	
	Local labor-installation	168.00	man-hours		2.25			377.57	
5.2.7	Maintenance temporary ditches	4.00	months				810.00	3,240.00	Estimated 15%/mo from construction cost
							Sub total 5	95,129.48	
							Total 1 + 2 + 3 + 4 + 5	293,833.00	
							Percentage from construction cost	3.13%	

Note: Using factorized original unit prices

Table 4 Environmental Mitigation Cost for Project Case Study[23]

Percentage value of environmental mitigation cost from this simulation is 3.13% from total estimated cost. This percentage will be used as basic reference to produce more detailed estimation for bidding process.

- **Sensitivity Analysis**

  GAO process also required sensitivity analysis in order to assess the important element composing cost estimate. The Author produces sensitivity analysis with spider plot[24] for project case study present in following Table 5 and Figure 9:

No	Descriptions		Cost [USD]
1	Dust Control	- Dust Supressions	46,059.00
		- Wind Barrier Fences	2,063.00
2	Waste Control	- Non Hazardous & Hazardous Wastes Handling	33,919.00
3	Land Use and Erosion Control	- Silt Fences	48,452.00
		- Temporary Slope Protections	68,211.00
4	Waste Impact and Sediment Control	- General Protections	2,920.00
		- Sediment Ponds	35,896.00
		- Sand Traps	2,627.00
		- Transversal Dykes	45,045.00
		- Temporary Ditches	8,642.00
		Total	293,834.00

Factor Changes	Dust Supressions	Wind Barrier Fences	Non Hazardous & Hazardous Wastes Handling	Silt Fences	Temporary Slope Protections	General Protections	Sediment Ponds	Sand Traps	Transversal Dykes	Temporary Ditches
-30%	280,015.27	293,213.92	283,857.25	279,297.14	273,369.52	292,956.83	283,083.93	293,044.83	280,319.32	291,240.35
-25%	282,318.19	293,317.07	285,353.16	281,719.75	276,780.07	293,102.83	284,858.74	293,176.16	282,571.57	291,672.43
-20%	284,821.12	293,420.22	287,049.11	284,142.37	280,190.62	293,248.83	286,653.56	293,307.49	284,823.82	292,104.50
-15%	286,924.04	293,523.37	288,745.04	286,564.98	283,601.17	293,394.83	288,448.37	293,438.83	287,076.07	292,536.58
-10%	289,226.97	293,626.52	290,440.96	288,987.59	287,011.72	293,540.82	290,243.19	293,570.16	289,328.32	292,968.66
-5%	291,529.89	293,729.67	292,136.89	291,410.21	290,422.27	293,686.82	292,038.00	293,701.49	291,580.57	293,400.74
0%	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82	293,832.82
5%	296,135.75	293,935.97	295,528.75	296,255.43	297,243.37	293,978.82	295,627.64	293,964.15	296,085.07	294,264.90
10%	298,438.67	294,039.12	297,224.68	298,678.05	300,653.92	294,124.82	297,422.45	294,095.48	298,337.32	294,696.98
15%	300,741.60	294,142.27	298,920.60	301,100.68	304,064.47	294,270.81	299,217.27	294,226.81	300,589.57	295,129.06
20%	303,044.52	294,245.42	300,616.53	303,623.27	307,475.02	294,416.81	301,012.08	294,358.15	302,841.82	295,561.14
25%	305,347.45	294,348.57	302,312.46	305,945.89	310,885.57	294,562.81	302,806.90	294,489.48	305,094.07	295,993.22
30%	307,650.37	294,451.72	304,008.39	308,368.50	314,296.12	294,708.81	304,601.71	294,620.81	307,346.32	296,425.29

Table 5 Sensitivity Analysis-Raw Data and Simulation[25]

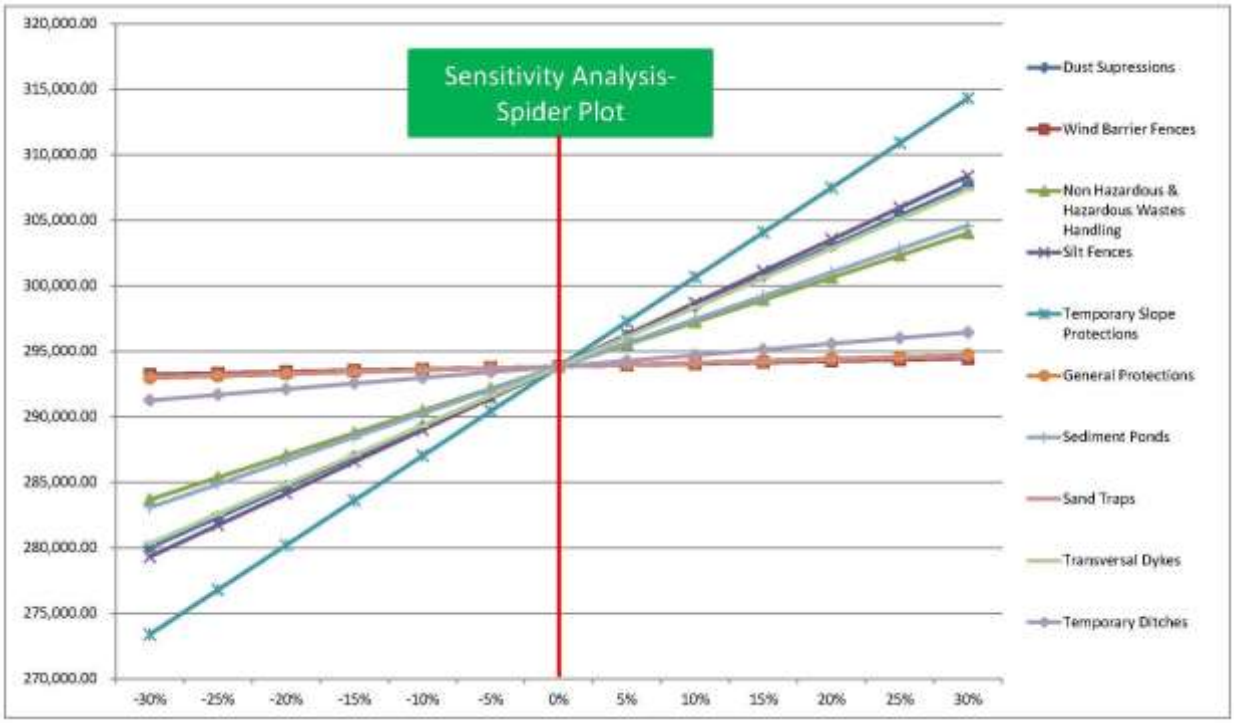

Figure 9 Sensitivity Analysis-Spider Plot[26]

There are four major elements for mitigation cost based on spider plot: temporary slope protections, silt fences, transversal dykes and dust control. It can be understood that these elements have the greatest value in comparison with other elements that determine cost changes for percentages between -30% to +30% in this simulation.

- **Risk Analysis**
  Expected Monetary Value (EMV) of risk events calculated in this step are the costs that probably incurred due to the failure of environmental mitigation system elements

as part of project WBS as presented in Table 6 with the ranking. It can be seen that temporary slope protections and drainage systems are the critical elements predicted by design team that will be affected by the accuracy of existing rainfall data available at the time of design process.

WBS Element	Description	Risk Event	Estimated Impact Value [USD] A	Estimated Probability B	Expected Monetary Value: EMV [USD] A * B	EMV Rank	Response Actions
1.2	Wind barrier fences	- Dust still comes out by strong wind	18,405.00	50.00%	9,202.50	3	Apply dust supression system for top surface of top soil
4.1	Silt fences	- Not enough lining of silt fences [higher run off water volume with debris than originally estimated]	14,536.00	30.00%	4,360.80	4	Add silt fences lining, approx 30% from original qty
4.2	Temporary slope protections	- Vetiver grass not growth as expected	193,750.00	15.00%	29,062.50	1	Replace vetiver grass with wire net protection, approx 50% from original qty
5.2	Temporary drainage systems	- Not enough sediment ponds [higher run off water volume with debris than originally estimated]	88,293.00	30.00%	26,487.90	2	Add pump units with collecting truck tanks
		- Rainfall data is not accurate [higher run off water volume than originally estimated]	10,000.00	30.00%	3,000.00	5	Add dedicated rainfall gauge for project location
				Total	69,113.70		
				Percentage from construction cost	0.74%		

Table 6 Risk Analysis for Environmental Mitigation Elements[27]

Total percentage for mitigation cost of project case study as shown in Table 4 and 6 is 3.87%, to be compared with a study taken in United States in year 2006 for road projects with equivalent environmental requirements based on NEPA standard, because historical data for environmental mitigation cost is not yet available in Indonesia (also limited in United States as stated in the document). According to this study, the average mitigation cost percentage was 4.4% for rural road project and 11.3% for urban or suburban road project from 29 project sample areas taken from five different states[28] as presented in Figure 10 with the value for project case study.

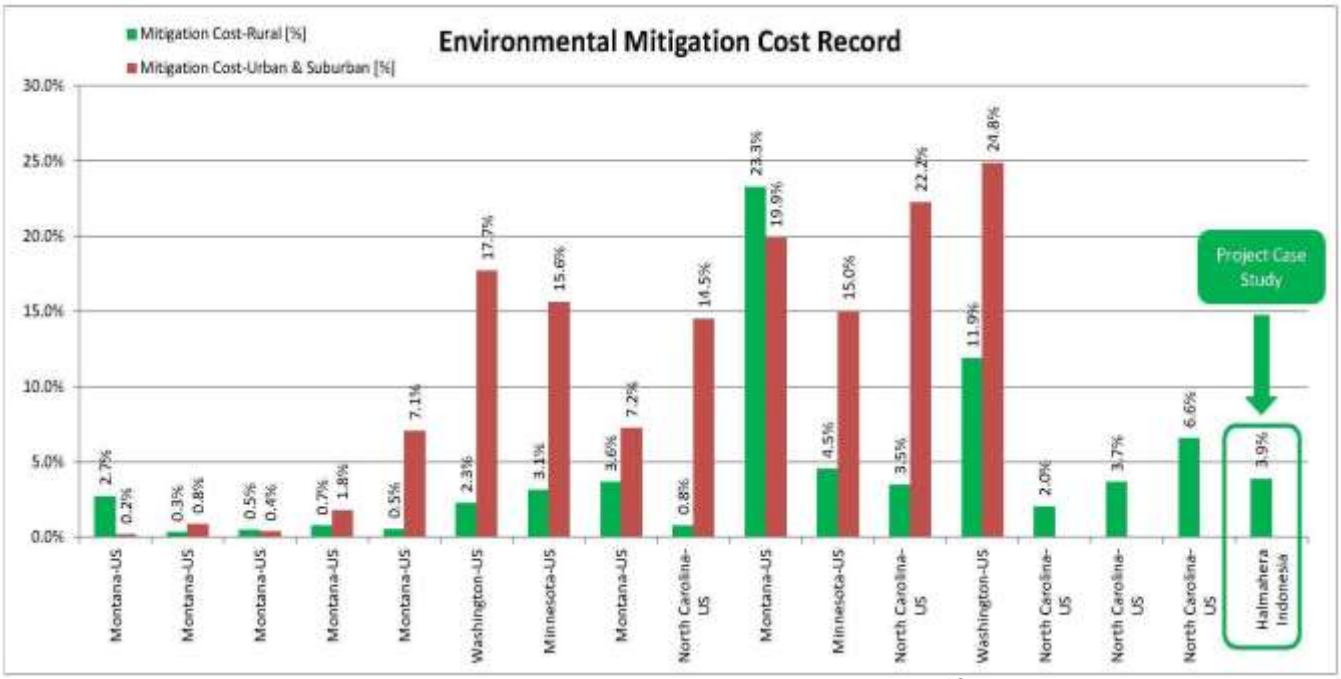

Figure 10 Environment Mitigation Costs Record[29]

Limitations of historical data record as mentioned above indicates that environmental awareness for project activities is raised just recently. Green construction program in Indonesia had just started in year 2008[30] for general infrastructure but not yet as the center of attention in mining industry. Until now, good mining practice in Indonesia still put the focus more to post mining reclamation program instead for construction activities unless it is required in advanced by financial institution as expressed before in introduction section (for capital access purpose). Project management trend today should integrate project objectives but also keep the environment safe for getting long term sustainability because it will provide balance and harmonize between economic, environmental and social interests[31].

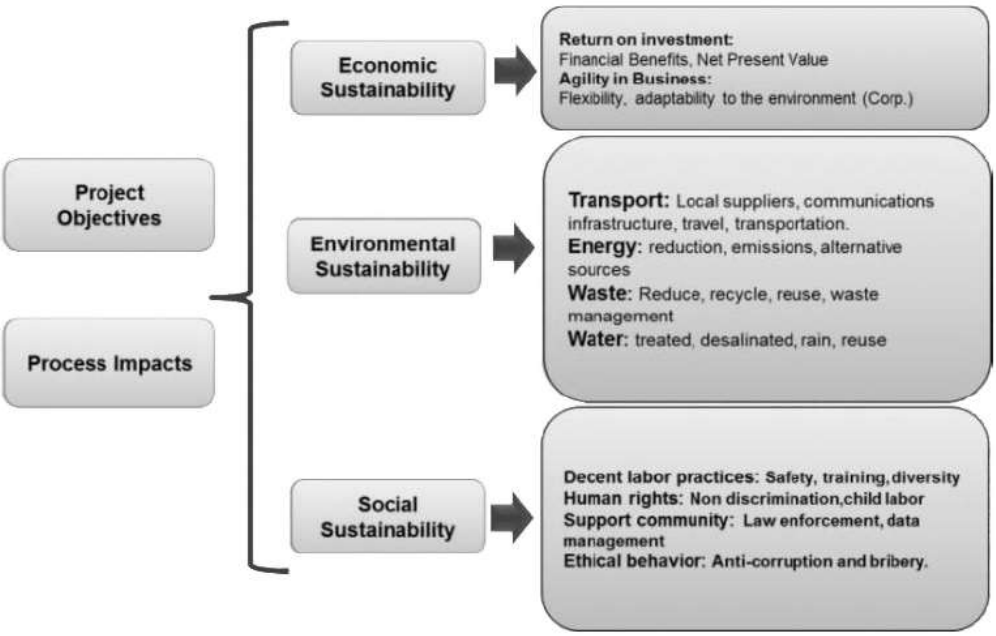

Figure 11 Integration Project Objectives and Process Impacts Checklist[32]

The integration of project objectives and process impacts analysis using checklist for all element through project lifecycle will be the key assurance of performing green project management for this sustainability and for the benefit of the next generation.

Conclusion

In this paper, the ultimate target set by the Author is to provide answer for two specific research questions as described in the introduction section. Based on results of project case study, the Author has demonstrated the application of IFC standard compliances and performed estimation cost following GAO process for environmental mitigation cost.

Further extension studies will be required in future using the same standard for upgrading the limited database of environmental cost as guideline for project implementation including the standard practice. It is important for having the environmental awareness through the integration between project objectives with environmental aspect and the application of strict regulation from government or financial institution for operation and financial access.

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