ENVIRONMENTAL / ECOLOGICAL RISK ASSESSMENT

CHAPTER III

Bagtingon Small Reservoir Irrigation Project (BSRIP)

Barangay Bagtingon, Buenavista, Marinduque

3 Environmental Risk Assessment (ERA)

This section provides an overview of the Environmental Risk Assessment (ERA) for the Bagtingon SRIP. Specifically, an ERA describes the risks associated with the project relative to its surrounding ecosystems, including community health and safety. This ERA aims to build upon the initial assessment of the foreseen hazards as discussed in the Land, Water, Air, and People modules and further assess them in terms of likelihood of occurrences and magnitude of consequences (DENR EMB Region 6, n.d)[23].

Based on the EIA findings, the most common and significant sources of impacts resulting from project development include vegetation clearing, excavation activities, dust generation and water siltation, vehicular emissions, generation of solid waste, disposal of wastes on surface water, submersion of lands with vegetation, and tourism activities.

Table 3-1 Potential sources of environmental impacts

Sources	Project phase	
	Construction	Operation
Vegetation clearing	Yes	No
Excavation activities	Yes	No
Dust generation and water siltation	Yes	No
Vehicular emissions	Yes	No
Generation of solid wastes	Yes	Yes
Petroleum contamination on water bodies	Yes	No
Disposal of wastes on surface water	Yes	No
Submersion of lands with vegetation	Yes	No
Tourism activities	Yes	Yes

Although some of these sources are dependent on the proposed project's nature (.e.g. submersion of lands with vegetation for the reservoir), most of these are common among projects that will undergo construction of multiple components. The foreseen impacts were then assessed along the project's site susceptibility to natural hazards (summarized on Table 3-2) and proposed relevant mitigation and plans to be implemented throughout project life span.

[23] https://r6.emb.gov.ph/wp-content/uploads/2022/05/CHAPTER-3.0.pdf

Table 3-2 Project site's susceptibility to natural hazards

Hazard	Assessment
Seismic Hazards	
Ground Shaking	Generally Susceptible
Ground/ Surface Rupture	Safe; Approximately 4.8 km from the Central Marinduque Fault
Earthquake – Induced Landslide	Low Susceptibility
Liquefaction	Generally susceptible
Volcanic hazards	
Potentially Active Volcano	Mt. Malindig (10.3 km away)
Hydrologic hazards	
Flooding, Flash Flooding. Rain – Induced Landslide	Low Susceptibility

However, an Environmental Risk Assessment is needed to further delve on the physical risks associated with the proposed project (i.e. embankment dam). This section will provide a qualitative analysis for the risk assessment using descriptive scales of levels to describe the likelihood of an event and their associated impacts. For this ERA, the following processes were conducted:

- Identify condition, events that can trigger the physical risks
- Describe and assess the possible accident scenarios
- Describe acute and chronic hazards for man and the environment due to dam failure
- Assess if the project location is projected to have extreme climate events in 2020 and 2050

3.1 Risk Assessment

3.1.1 Establishing the context

NIA is proposing to construct the Bagtingon Small Reservoir Irrigation Project (BSRIP) covering eight barangays in the Municipality of Buenavista and one barangay in the Municipality of Gasan, in the Province of Marinduque. The project will involve the construction of a medium-sized embankment dam and its appurtenant structure to impound water during wet season to provide year-round irrigation.

The risk assessment process used the overall project context including the specific activities and project components that will be established per project phase. Understanding the existing baseline environmental conditions are also considered in this assessment. The findings on the project site's existing conditions are elaborated on Section 2.

According to FEMA in its report Federal Guidelines for Dam Safety Risk Management (2015) , the term *risk* in the context of dam safety is composed of the following components:

- Likelihood occurrence of a load (e.g. flood, earthquake, among others)
- Likelihood adverse structural response (e.g. dam failure, damaging spillway discharge)

- Magnitude of the consequences resulting from the adverse event (e.g. loss of life, economic/physical/structural damages)

3.1.2 Risk identification

3.1.2.1 Occurrence of a load

Based on the existing conditions of the project site, the likelihood occurrence of flood, earthquake landslides are summarized in Table 3-2. To summarize, the project's area of influence is on a site with low to moderate susceptibility to seismic, volcanic, and hydrologic hazards. This assessment is likely to be lessened if the project will be constructed in compliance of local laws (e.g. Philippine Structural Code and National Building Code) and considers international good practices.

3.1.2.2 Adverse structural response

Dam failure

International Commission on Large Dams (ICOLD) defines dam failure as the "collapse or movement of part of a dam or its foundation, such that the dam cannot retain water" (2015). ICOLD added that a dam failure generally results in the release of a significant quantity of water thereby imposing risk the people and environment downstream.

According to Zhong et al., (2021), embankment dams are prone to fail under external loads (e.g. earthquakes and floods). Moreover, modeling technologies found that dam failure are closely related with dam geometries, structures, materials, and hydrodynamic conditions. The following are typical failure modes of embankment dams (New Hampshire Department of Environmental Services 2020):

Hydraulic failures

Hydraulic failures relate to the uncontrolled flow of water over or adjacent to the embankment due to the erosive action of water on the embankment slopes. Embankment dams are not designed for overtopping and thus are susceptible to erosion. However, a dam can withstand limited overtopping under the following conditions:

- The embankment dam is on well-vegetated earth
- The top is level and water flows over the top and down the face in an evenly distributed sheet and not being concentrated in an area

Hydraulic failures are related to the following:

- Overtopping, or uncontrolled flow of water over and adjacent to the embankment
- Wave erosion, or notching of upstream face by wave action reduces the embankment cross section thickness and weakens embankment material
- Top erosion, or erosion of downstream toe of the earth slope caused by misdirected spillway outlet discharge
- Gullying, or rainfall erosion of embankment slopes that can be caused by traffic of people and vehicles

Seepage failures

At some extent, all dams have some seepage since the impounded water seeks paths of least resistance through the dam and its foundation. However, the seepage must be controlled in velocity and quantity. Uncontrolled seepage will result in eroding fine soil material to form a cavity

to the pond that leads to failure of the embankment. This action is called “piping”. According to New Hampshire Department of Environmental Services (2020) seepage failure comprise of around 40% of all embankment failures.

Tree roots can be used as smooth surface for seepage to pass. When trees dies, their decaying roots leave passageways for seepage to concentrate in. Another alternatives are pipes through the embankment.

Structural failures

Structural failures may be slide, or displacement of the embankment’s material. Irregularities such as sloughs, bulges or cracks are signs of instability leading to structural failures.

Others

Tree growth on an earthfill embankment can also contribute to a dam failure. In instance, trees growing directly on the top of the structure could lead to hydraulic failure since it can displace embankment materials. Trees can also contribute to seepage failure by creating seepage paths through the earthen embankment.

Damaging spillway discharge

Insufficient capacity of the spillway to discharge can also result in overtopping failure in dams (Azha, 2023). Movable gates are commonly installed above the dam crest to control discharge and permit maximum use of storage volume.

3.1.2.3 Impacts of dam failure to the environment and community health and safety[24]

Flooding

During a dam failure, the most acute impact to the community below are their immediate inundation-- including their homes, community facilities (e.g. schools, hospitals, workplace) and critical infrastructures . For the project, the least number of municipalities affected will be two (i.e. Municipalities of Buenavista and Gasan) since they both host the irrigation water source.

Property damage

Assets of the host communities will also be affected. These assets may comprise of their economic, social, environmental, and industrial assets, among others. Personal assets composed of homes and contents of the residence are the primary concern of the community members.

Environmental damage

Environmental assets such as rivers, lakes, ponds, wildlife habitat, and threatened/ endangered species are also needed to be considered.

Long terms consequence include disruption to ecosystems, loss of fresh water resources, and contamination of water bodies.

Infrastructure destruction

Other notable assets that can potentially be affected are the dam structure itself, transportation, water source, and other utilities (power and communication).

[24] https://www.sms-tsunami-warning.com/pages/consequences_of_dam_failure

Economic consequences

Aside from the immediate loss of properties due to inundation, economic losses due to costly recovery efforts are also considered.

Long-term resettlement

Communities will have to resettle once their residences will not be fit for settlement due to unsafe conditions. This can result in long-term resettlement due to inefficient recovery and rehabilitation efforts. Resettling people will also imply relocating them away from their livelihood, and social protection/ networks (schools, social circles, etc.).

Legal and regulatory consequences

Since the proponent is legally responsible for all operation and maintenance task for the project, they will be liable in the unlikely event of a dam failure. Investigations in terms of existing guidelines and processes conducted for the project will be conducted, thereby also exposing the organization in a reputational risk.

Injuries and loss of life

Dam failure, if not mitigated promptly, may also lead to injury and loss of life among community members within the dam vicinity.

3.2 Recommendations for potential accident scenarios

Based on the information presented in the previous sections, there are multiple accident scenarios leading to dam failure that can result in environmental, economic and physical damages. The table below provides recommendations per dam failure scenarios

Table 3-3 Recommendations for potential accident scenarios

Dam failure scenario	Potential causes	Recommendation
Hydraulic failures	• Overtopping • Wave erosion • Top erosion • Gullying	• Maintain a well-vegetated earth on the embankment • Maintain a level top and ensure water flows over the top and down the face in an evenly distributed sheet and prevent concentration on one area
Seepage failures	• Continuous seepage flow	• Maintain spillway gates

Dam failure scenario	Potential causes	Recommendation
	though the dam or its foundation • Piping erosion	at optimal condition • Installation of toe drains, relief wells, or inverted filters
Structural failure	• Unstable/ inadequate design of the dam • Improper stabilization of slopes	• Build the embankment dam based on the National Building Code, Structural Code, and NIA guidelines and international good practices (e.g. ICOLD, etc.) • Proper and regular maintenance of dam structure
Others	• Improper planning of reforestations plans • Improper maintenance of dam structure	

3.3 The project and climate change

Based on the assessment related to climate change in Section 2.3, the adverse impacts of climate change already exists and will intensity overtime if mitigation measures preventing greenhouse gas emissions are not implemented at an intensive level. The project site has a generally low to moderate susceptibility to natural hazards (e.g. landslides, flood, and erosion). However, given that the Philippines is one of the countries foreseen to have greatest risk to climate-related hazards, the low to moderate susceptibility may intensify overtime especially under the 2020 and 2050 climate change scenarios:

- Increased temperature
- Wetter wet season, drier dry season
- Frequency and intensity of extreme weather events

The climate change scenarios along the project site's susceptibility to seismic, hydrologic, and volcanic hazards will likely contribute to a higher probability of dam failure scenarios since failures are mostly dependent on the likelihood of occurrence of a load especially flood, landslide, and earthquake. Section 2.3 also stated that it is foreseen that in 2020 and 2050, higher temperatures, lesser dry days but more rainy days will occur.

3.4 Risk assessment

For the risk assessment, the context, likelihood (load and failure scenarios), and magnitude of consequences were considered and rating based on two scenarios (i.e. pre- and post-control). Mitigation measures discussed in the Section 2 are also included in the assessment.

Pre-control risk assessment for dam failure due to natural hazards during common scenarios (i.e. normal activities construction and operation of dam) are generally assessment as High to Moderate. Environmental damage, economical damage, and injuries/loss of life are generally rated as high since these impacts are usually long-term and irreversible. Meanwhile, since climate change will most likely intensity the risks related to extreme weather events, pre-control risks are rated as High.

The magnitude are then lowered to Low or Moderate during the post-control scenario since it is assumed that the listed mitigation measures are properly implemented thereby lessening the risk of the impacts from occurring.

Table 3-4 Risk assessment related to dam failure due to natural hazards and extreme weather events

Hazards	Impacts/ consequence	Risk	Pre-control magnitude	Mitigation measures	Post-control magnitude
Construction and operation of dam					
Dam failure related to natural hazards	Flooding	Environmental	Moderate	• Maintain a well-vegetated earth on the embankment • Maintain a level top and ensure water flows over the top and down the face in an evenly distributed sheet and prevent concentration on one area • Maintain spillway gates at optimal condition • Installation of toe drains, relief wells, or inverted filters • Inform and consult LGUs regarding irregular data resulting from regular monitoring of dam	Low
	Property damage	Environment Economic	Moderate		Low
	Environmental damage	Environment Economic	High		Moderate
	Infrastructure destruction	Environmental Economic	Moderate		Low
	Economic consequence	Environment Economic Social	High		Low
	Long-term resettlement	Social Economic	Moderate		
	Legal and regulatory consequences	Reputational	High		Moderate

	Injuries and loss of life	Community health and safety	High	• Designate safety officers for the dam • Implement health and safety training • Develop and implement Emergency Response Plan • Build the embankment dam based on the National Building Code, Structural Code, and NIA guidelines and international good practices (e.g. ICOLD, etc.) • Proper and regular maintenance of dam structure • Incorporate climate change and disaster risk in the Project design and operation • Conduct engineering, geological, and geotechnical studies around the project footprint to determine areas that are prone to geohazards. • Follow provisions of the National Building Code and Structural Code of the Philippines • Design and implement measures to proactively reinforce and strengthen potential unstable sites such as stockpiles, borrow sites, and cut slopes, among others • Conduct regular site monitoring especially after heavy rains or extreme weather events • Place warning signages in potentially unstable areas	Moderate

				• Limit access to project premises Conduct IECs on safety measures related to landslides and other extreme weather events/ natural calamities. • Implement emergency warning system for the project's surrounding communities	
Climate change scenarios					
Dam failure due to extreme weather events	Flooding	Environment	High	Same as above	Moderate
	Property damage	Environment Economic	High		Moderate
	Environmental damage	Environmental Economic	High		Moderate
	Infrastructure destruction	Environment Economic	High		Moderate
	Economic consequence	Economic	High		Moderate
	Long-term resettlement	Social Economic	High		Moderate
	Legal and regulatory consequences	Reputational	High		Moderate
	Injuries and loss of life	Community health and safety	High		Moderate