Summary of:

REGIONAL GEOLOGICAL HAZARD STUDIES (FLOODING, COASTAL HAZARD AND LANDSLIDE) OF COVALIMA MUNICIPALITY

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Timor-Leste is a small and mountainous island country, located between Indonesia and Australia, with a population of about 1.5 million. Administratively the island composes of 13 Municipalities, including Ainaro, Aileu, Baucau, Bobonaro, Covalima, Dili, Ermera, Liquiça, Lautem, Manatuto, Manufahi, RAEOA, and Viqueque. The island consists of different types of Geological conditions, made some areas are prone to geological hazards, such as landslides or unstable slopes, flooding, and other sediment-related hazard. Timor-Leste is vulnerable to natural hazards including floods, strong winds, landslides, earthquakes, and tsunamis, these hazards are common causing significant damages to the country (RMSI, 2015). In Timor-Leste, high occasional rainfall, steep slope, high weathering rates and slope material with low shear resistance or high clay content are the main preconditions for landslide (NDMD, 2010). Local communities are vulnerable in many areas, and disasters can cause people's livelihoods to become unsustainable. In addition to El-Nino, the la Nina weather phenomena has also had a significant impact on Timor-Leste communities, both positive, in terms of improving agricultural production and water security, and negative in terms of increased landslides and soil erosion. (RMSI, 2015). On the other hand, Flooding is one of the major hazards in many parts of the world, the potential for extreme weather events such as heavy rains and floods is expected to rise as a global climate warms (Becker and Grunewald, 2003; WMO, 2003). There are two most common types of flood in Timor-Leste territory namely: Flash Flood and Riverine Flood. In the country flood is one of the most common hazards among all other kinds of hazards, resulted from the combination of heavy rainfall with high precipitation, steep topography, and man-made activities including the improper drainage designs. Coastal flooding occurs when the lower elevation land along the coastal area is flooded by the seawater. The sea level rise (coastal flooding) of an area is caused from several factors, such as; severe weather events, large waves, high tide levels, and the topography of the coast. The extent of coastal flooding is a function of the elevation inland flood waters penetrate which is controlled by the topography of the coastal land exposed to flooding. The Geological Hazard studies is focused on Covalima

Municipality, hence currently the Government of Timor-Leste is focused on Tasi Mane Project, therefore it is important for Intituto do Petróleo e Geologia (IPG) as a government public Institution for Geoscience research to conduct a study along the South Coast of Timor-Leste (Covalima Municipality).

The aims of this study are to conduct a regional geological hazard studies and maps which includes, Landslide, Flooding and Coastal Geo-hazard in the Covalima Municipality. The result of this study also can be served as the basic information to the relevant ministries on considering the geological hazard to plan and implement to the development of the country overall.

The study concludes that in general, Covalima Municipality, is prone to Geological Hazard occurrences, due to its geological characteristics and conditions. The various geological hazard which has been occurred throughout the year, and there are some areas that is identified within the Municipalities. Flooding is mainly caused by natural weather events such as heavy rainfall for a short period of time, prolonged, extensive rainfall and/or high conditions. Moreover, other manmade factors also contribute to the widespread effect of flooding such as poor or improper drainage designs, inadequate maintenance of water courses, inappropriate development in floodplains and construction of numerous infrastructures that prevents rainfall from draining away naturally. This includes roads and carparks that are impermeable to water (covered by pavements). They can increase the risk of flooding from rainwater runoff. Flood events are a part of nature. They have existed and will continue to exist. As far as feasible, human interference into the processes of nature should be reversed, compensated and, in the future, prevented. On the other hand, the applications of Flood hazard map, it can be used by policy makers, decision makers, planners and other parties to plan and implement an effective system of the flood management in Timor-Leste, as a basis for future master plan and safe development. The authorities can take necessary actions to reduce the impacts on various economic sectors such as Agricultural Area, Dry Land, Forested Land, Settlements and Industrial Land, Commercial Agriculture, Urban area, Housing, Tourism, Industry and Production. The flood hazard map produced by IPG, will help the government of Timor-Leste and local authorities to understand the severities or impacts of flood hazards in the areas identified as hazard-prone and therefore to develop necessary mitigating measures and preparedness plans. There are things which must be considered in minimizing/reducing the Flood occurrences as follows:

In order to achieve control over the flow and height of the water carried by the river, the channel, flood plain or watershed must undergo some physical alterations including:

- River walls/floodwalls and Drainage System must be improved to confine flood waters to a floodway, thereby reducing flood damage.
- Channel improvements and seepage control which include, removing the sediments loaded along the channel, clearing to remove garbage, trees and other obstructions; lining with concrete to increase efficiency river channel's flow path, deepening and widening the channel in order to increase size of waterways.

To protect against flooding, certain Land Use Policies must be developed; such as:

- Designated Floodways and encroachment lines and no construction or land filling should be permitted along the floodway; this is done to ensure that the flow of water is not obstructed.
- Building Codes: These are standards for construction of buildings and other structures and, if enforced, can reduce damages to buildings in flood-prone areas. Some requirements include, the establishment of basement elevations and first flood elevations consistent with potential flood levels, ensuring that buildings have adequate structural strength which would likely withstand water pressure or the high velocity of flowing water, prohibiting the use of equipment that might be hazardous to life when submerged and installing proper anchorage to prevent the floatation of buildings (CDEMA, 2010).

Additional Mitigating Measures

- Flood Monitoring systems in order to measure the level of the flood water and rainfall intensities, it will also include flood proofing, flood forecasting, warning and evacuation systems, such as: Using the flood Early Warning Systems (EWS) in the flood prone areas in order to warn the residents and agencies of impending floodwaters on major rivers in the region so they can take action and prepare themselves before serious flooding occurs.
- Flood forecasting and warning is a prerequisite for successful mitigation of flood damage. Its effectiveness depends on the level of preparedness and correct response. Therefore, the responsible authorities should provide timely and reliable flood warning, flood forecasting and information (UN/ECE, 2000).
- In flood-prone areas, preventive measures should be taken to reduce possible adverse effects of floods on aquatic and terrestrial ecosystems, such as water and soil pollution. It

is necessary to distinguish between different kinds of flooding and the environmental conditions that contribute to the problem. For instance, there are significant differences between on the one hand sudden flooding in upstream or headwater areas where mitigating risk involves a wide range of innovative small-scale solutions and on the other hand lowland flooding where warning periods and the duration of flood events are longer and large-scale measure must be taken. Therefore, the effectiveness of the best practices described in part II depends on among other hydrological and environmental circumstances (UN/ECE, 2000).

- Human uses of floodplains should be adapted to the existing hazards. Appropriate instruments and measures should be developed for all flooding related problems: flooding, rising groundwater tables, sewage network disruption, erosion, mass deposition, landslides, ice flows, pollution. (UN/ECE, 2000).

On the other hand, based on the previous studies, resulted from the analysis using the raster dataset method shows that the Timor-Leste island is prone to the potentially occurrences of coastal flooding. The remote sensing interpretation to the field observation in the terrain resulted that; there are coherence between the data. The Covalima Municipality Coast of Timor-Leste is prone to the coastal inundation as well as coastal erosion due to their characteristics of lithology and the coastal behavior derived the unstable coasts. The coastal erosion is increasing due to the influence of sea level rise as shows in most of the areas; it is also demonstrating in most of the relevant literatures. The coastal hazard tends to increase and will affect more to the communities/ population/Suco lives along the coastlines. There are adaptation measures in reducing/minimizing the occurrences of coastal flooding/inundation, abrasion and erosion, which recommended by the IPCC AR4: to base the adaptation measures on the concept of Coastal Zone Management Strategy (IPCC CZMS), as follows:

1. To Protect Coastal Areas

This coastal management strategy is a measure to reduce/minimizing the hazard occurrences in the coastal areas, there are some strategies applied, such as; using the strategy of hard measures and soft measures. There are some examples of hard measures, like: Breakwaters, jetties groins, revetments, sea walls, dikes, storm surge barriers and closure dams, on the other hand the soft measures strategy such as; beach nourishments, dune construction/stabilization, cliff stabilization, mangrove and coastal forest re-planting.

2. To accommodate Hazard

This coastal management strategy is including, wetland restoration; flood warning systems, flood proofing, coastal zoning, and coastal setbacks. This management strategy is applicable to use in northern coast of Timor-Leste, mostly is urbanized areas.

3. To Retreat from the Coastline

These coastal management strategies are the last option to avoid or minimized the occurrences of the coastal hazard in an area and avoid the development in the areas vulnerable to the coastal hazard.

Other most affected Geological hazard in Covalima Municipality is Landslide. Landslide is one of the major hazard occurrences in Covalima Municipality, the Landslide Hazard occurrences preparedness plan, is started through the susceptibility mapping using ArcGIS program, on showing areas prone to potentially landslide occurrences, followed by the detail mapping of landslide hazard, where the result of the landslide hazard showing the area most affected by the landslide hazard.Detailed geotechnical mapping is necessary for future studies in the Covalima Municipality. Detailed engineering designed of drainage systems and the watershed system is important. Considering the geological condition of the area is necessarily important, hence one of the main geological phenomena affecting the occurrences of the landslide in Covalima Municipality is the Diapirism, by understanding the Diapirism phenomena in the area, could minimize the hazard impact occur in the area.

Other recommendation on Landslide Hazard occurrences in Covalima Municipality, including:

- It is necessary to conduct a detail and further study of Slope Stability Analysis along the high possibility of failure of a slope in Covalima Municipality (Highway).
- Relevant ministries or private companies need to take an emergency action on slope stabilization.
- The slope failure occurs throughout the years in Covalima Municipality, where the types of failures were: Rockfall, Translational, Rotational and Plane Failure.
- For Soil Materials Improvement of securing using plant materials, by using the Bio-organic/ (Bioengineering) Method.
- Improvement of surface soil to prevent erosion could be advisable using the shotcrete method.

- Detail engineering study and design of the road slopes before project implementation must be performed.
- A detail drilling, core sampling tang using the geophysical tools (resistivity meter) to have suitable subsurface data information for future detail study is highly recommended.
- Building Codes

These are standards for construction of buildings and other structures and, if enforced, can reduce damages to buildings in flood-prone areas.

The detail study and information regarding this study: please contact Instituto do Petróleo e Geologia (IPG) Rua, Delta I, Aimutin, Comoro, Dili, Timor-Leste. Phone: (+670) 3310179.