Date of Submission	23 March 2022

IPL Project Proposal Form 2022

1. **Project Title:** Climate Change-Induced Landslide Hazard Assessment - for Aiding Climate Resilient Planning for Road Infrastructure.

2. **Main Project Fields**

(1) Technology Development

B. Hazard Mapping

3. **Name of Project leader:** Dr. Peeranan Towashiraporn

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Core members of the Project

Names/Affiliations: Dr. I Putu Krishna Wijaya, Anggraini Dewi, Susantha Jayasinghe /ADPC

4. **Objectives**

This proposed study will investigate how the precipitation-induced landslide hazard are affected by climate change. More specifically, the study will develop a relation between the climate change scenarios, their impact on rainfall events and the landslide hazard of a study area. The results will guide short, medium and long-term infrastructure planning in landslide prone areas. This study also integrating between regional and site-specific landslide hazard assessment.

5. **Background Justification**

Climate change-induced extreme hydro-meteorological conditions have increased the prevalence of landslides that have attributed to significant damages to the transportation infrastructures such as roads and bridges. Long term planning for constructing and maintaining the transportation infrastructure, especially in landslide prone areas, need to consider the impact of climate change on the landslide hazard. To overcome these problems, studies focusing on climate-induced landslides are very important to be conducted. Unfortunately, only a few authors have tried to investigate the influence of climate change on landslides (Komori et al. 2018, Bernardie et al. 2021, and Kim et al. 2014). Gariano & Guzetti (2016) mentioned that in recent years, the proportion of papers on landslide-climate research has been lower than the overall landslide literature. In the context of climate change, no research has clearly defined the degree of damage on road infrastructures to future landslide area. Thus, integrating regional and site-specific landslide hazard assessment in short, medium, and long-term climate change projection is critical to ensure the most effective mitigation measures.

6. **Study Area**

The project will be applied in Java Island since more than 1,000 landslide events were reported in this most populous island in Indonesia where tens of thousands of people were impacted by the landslides.

7. **Project Duration**

The project duration is estimated to be started on 1st May 2022 and finished by 1th May 2026.

8. Resources necessary for the Project and their mobilization

Personnel, facilities	Budgets
Landslide specialist, DRM advisor, Risk Assessment Specialist, Climate Specialist	To be discussed
Landslide inventory	InSAR data
Elevation, slope, aspect	Open-source. DEM data from https://tanahair.indonesia.go.id/demnas/#/demnas
Land use	Open-source. Land use and land cover (https://livingatlas.arcgis.com/landcover/)
Lithology and lineaments	Open-source. Geological maps (https://geoportal.esdm.go.id/geologi/)
Streams	Open-source. (https://data.humdata.org/)
Mean annual rainfalls (baseline, 2030, 2050, 2080) derived from climate projection data - The NEX-GDDP (CMIP5 models)	Open-source. (https://www.nccs.nasa.gov/services/data-collections/land-based-products/nex-gddp)
r.avaflow	Open source computational framework for the landslide propagation.
Road inventory GIS & database	Ministry of Public Works and Housing of Republic of Indonesia (Kementerian PUPR)
High resolution DEM and orthophoto based on drone data of selected landslides	Drone survey

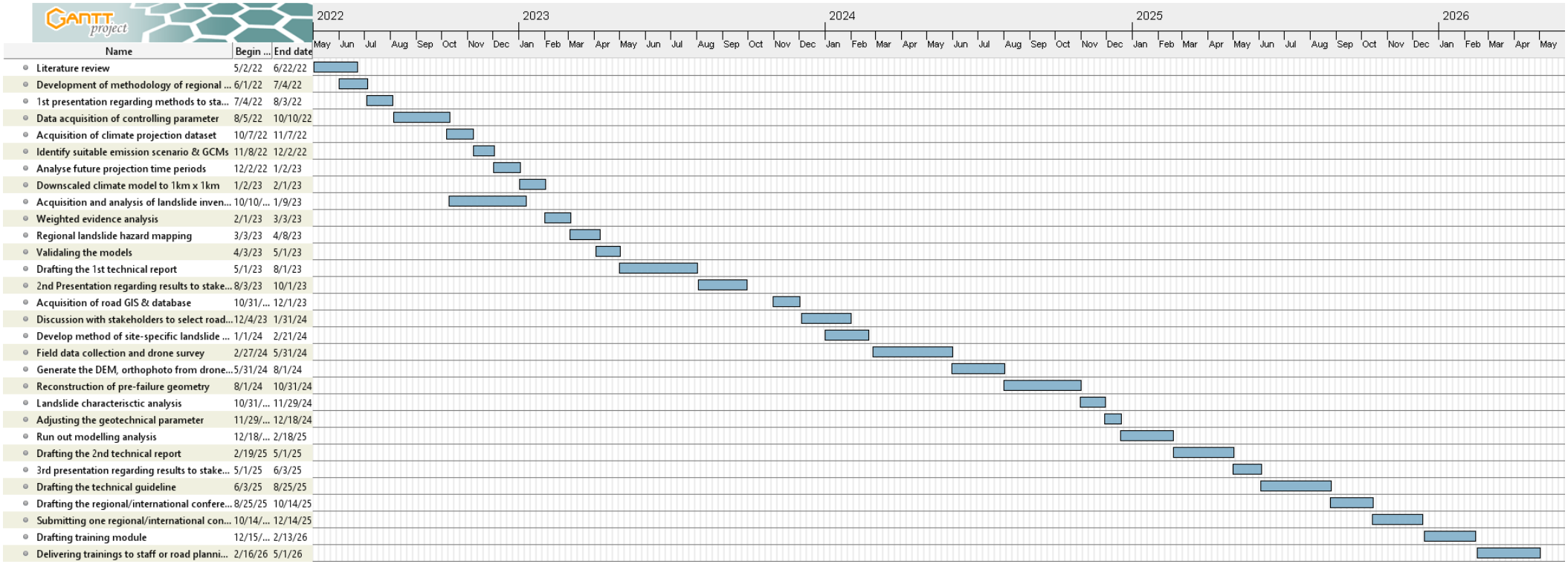
9. **Project Description**

In this project, a comprehensive regional to site-specific landslide hazard mapping will be performed. Concerning the regional landslide hazard mapping, we will model extreme rainfall scenarios for the current 1976-2005 baseline and future horizons of 2030, 2050, and 2080 to develop high-resolution 1km x 1km mean precipitation datasets under RCP4.5 and RCP8.5. Based on these extreme precipitation scenarios, we will develop high-resolution regional landslide hazard models adopting weighted evidence methods using multi-variate factors. The models will be validated using the Receiver Operating Characteristic curve (ROC) approach (Figure 1).

In total there will be seven maps of landslide hazard that will develop from two RCP 4.5 and RCP 8.5 for time horizons 2030s, 2050s, and 2080s and baseline (1976-2005). The next step, the landslide hazard maps will be overlaid with the roads map, and the stakeholder (Ministry of Public Works and Housing of Republic of Indonesia) will select the road segments that are located in the high to very high susceptible zone for site-specific landslide hazard assessment (run out modelling). We will model the propagation of selected landslides along road segments using the run out modelling approach with the help of r.avaflow software (an advanced open-source computational framework for the landslide propagation, Mergili & Pudasaini, 2014-2021). The landslide run out models are able to determine physical outputs (run out distance, flow height, velocities, kinetic energy) and to determine the zones where the elements at risk (roads) can suffer an impact. These results can then be applied for vulnerability, risk calculations and further mitigation measures.

Several meetings will be held with the Ministry of Public Works and Housing of Republic of Indonesia (please see the detailed workplan) and by the end of 2026, we plan to conduct a series of training workshops for the relevant agencies and stakeholders such as Road Planning & Design Department of Ministry of Public Works and Housing of Republic of Indonesia (Kementerian PUPR), National Disaster Management Agency (BNPB) and Sub-national Disaster Management Agency (BPBD) of the project sites, Geological Agency (Badan Geologi ESDM), and academia.

10. **Work Plan/Expected Results**



Name	Begin ...	End date
Literature review	5/2/22	6/22/22
Development of methodology of regional ...	6/1/22	7/4/22
1st presentation regarding methods to sta...	7/4/22	8/3/22
Data acquisition of controlling parameter	8/5/22	10/10/22
Acquisition of climate projection dataset	10/7/22	11/7/22
Identify suitable emission scenario & GCMs	11/8/22	12/2/22
Analyse future projection time periods	12/2/22	1/2/23
Downscaled climate model to 1km x 1km	1/2/23	2/1/23
Acquisition and analysis of landslide inven...	10/10/...	1/9/23
Weighted evidence analysis	2/1/23	3/3/23
Regional landslide hazard mapping	3/3/23	4/8/23
Validaling the models	4/3/23	5/1/23
Drafting the 1st technical report	5/1/23	8/1/23
2nd Presentation regarding results to stake...	8/3/23	10/1/23
Acquisition of road GIS & database	10/31/...	12/1/23
Discussion with stakeholders to select road...	12/4/23	1/31/24
Develop method of site-specific landslide ...	1/1/24	2/21/24
Field data collection and drone survey	2/27/24	5/31/24
Generate the DEM, orthophoto from drone...	5/31/24	8/1/24
Reconstruction of pre-failure geometry	8/1/24	10/31/24
Landslide characterisctic analysis	10/31/...	11/29/24
Adjusting the geotechnical parameter	11/29/...	12/18/24
Run out modelling analysis	12/18/...	2/18/25
Drafting the 2nd technical report	2/19/25	5/1/25
3rd presentation regarding results to stake...	5/1/25	6/3/25
Drafting the technical guideline	6/3/25	8/25/25
Drafting the regional/international confere...	8/25/25	10/14/25
Submitting one regional/international con...	10/14/...	12/14/25
Drafting training module	12/15/...	2/13/26
Delivering trainings to staff or road planni...	2/16/26	5/1/26

11. **Deliverables/Time Frame**

Deliverable	Timeline
Technical report of climate change-induced regional landslide hazard assessment for aiding climate resilient planning for road infrastructure.	8/1/2023
Technical report of run out models of site-specific landslide hazard assessment on selected road segments.	5/1/2025
Guideline of an integrated regional and site-specific landslide hazard assessment	8/25//2025
One International Conference paper	12/12/2025
Training Module for staff of road planning & design department	2/13/2026

12. **Project Beneficiaries**

Finally, the landslide hazard maps produced in the study is useful for planners and engineers for planning and designing roads and other infrastructures to obtain a better understanding of future climate-induced landslide and their potential impacts on road networks in a more precise way, for planning new roads and rehabilitation/retrofitting of the existing roads in the study area.

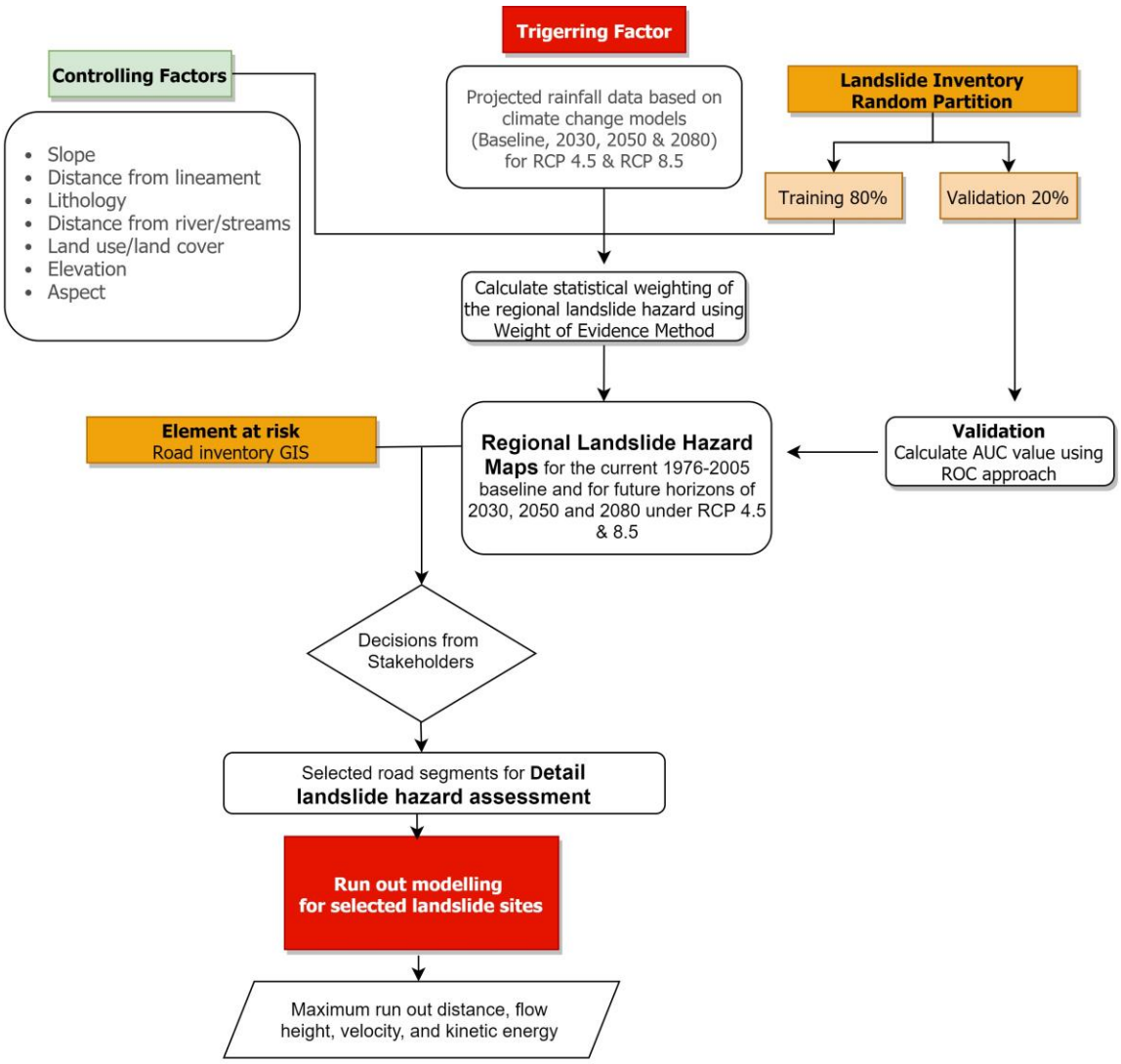


Figure 1. Flow chart of study framework.

References

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