Practical ACTION CONSULTING

Digital and Spatial Technologies for Disaster Governance

SUBMITTED BY: PRACTICAL ACTION CONSULTING PVT. LTD., KATHMANDU, NEPAL

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Project partners: NAXA Pvt. Ltd.; Young Innovations Pvt. Ltd.; International Institute for Applied Systems Analysis (IIASA)

Contents

Acronyms

API	Application Program Interfaces
COVID	CoronaVirus Disease
DECDG	Development Economics Data Group
DEM	Digital Elevation Model
GEE	Google Earth Engine
GIS	Geographic Information System
GPSDD	Global Partnership for Sustainable Development Data
IIASA	International Institute for Applied Systems Analysis
JS	Java Script
MCE	Multi Criteria Evaluation
OSM	OpenStreetMap
RAP	Risk Assessment Platform
SDG	Sustainable Development Goals
SMCE	Spatial Multi-Criteria Evaluation
SSACD	South Asia Disaster Risk Management and Climate Change unit
TFSCB	Trust Fund for Statistical Capacity Building III

Executive Summary

Disasters, be it natural or man-made, are major barriers to sustainable development and livelihoods across the world. The impacts of disasters vary around the world due to topographical features of hazards and differences in vulnerability. The devastation caused due to these disasters is more severe in the least developed and developing countries. A number of factors including lack of data in understanding the underlying risks, lack of data-driven planning, poverty and poor governance would contribute to the increased vulnerability to disasters in these countries. Nepal being a least developed country with diverse topographical features encounters with recurrent hazards, among which landslides and floods are most disastrous to human lives and properties. In this context, we have piloted an approach of using open data, analytical models and cloud computing resources to better understand the impacts of landslides and floods in the four selected urban/rural municipalities of Nepal. We have developed a private repository to access the available open data, their sources and different analytical models, which can be effectively used in risk assessment of natural hazards in Nepal and used those data in a risk assessment platform to assess the risks of the natural hazards. The pilot assessment is conducted in a GIS-based web platform, which uses Google Earth Engine in the backend to process different data layers on hazards, exposures and vulnerabilities to generate risk information regarding specific hazard. The platform allows user to input specific datasets, define assessment criteria and produce a result for a selected administrative unit using multi-criteria evaluation method.

This approach was instrumental in conducting local level risk assessment of floods and landslides using open data and cloud computing. Results produced from the study sites indicate a great potential on scaling up this approach to other locations of Nepal as well so as to understand associated risks in other thematic areas including agriculture, health and infrastructure.

1. Project Background

Nepal is prone to various natural disasters due to its diverse and complex topography coupled with active tectonic plates. The situation is made worse with inadequate capacity to cope with such disasters. Deficiency of data on disaster risk assessment has led to a huge loss of human lives and economic assets in Nepal. The government of Nepal, in its new federal structure, has been trying its best to strengthen the institutional setup and improve the data system, data availability and accessibility. At provincial and local levels, there are disaster management committees that are responsible to work on these issues. However, these authorities are having difficulty in making proper decisions due to the constant lack of evidence and reliable data.

This project, Digital and Spatial Technologies for Disaster Governance, submitted in response to the 2018 call for proposals by the World Bank's Development Economics Data Group (DECDG) and the Global Partnership for Sustainable Development Data (GPSDD), is supported by the World Bank's Trust Fund for Statistical Capacity Building III (TFSCB-III) with financing from the United Kingdom's Foreign, Commonwealth & Development Office, the Department of Foreign Affairs and Trade of Ireland, and the Governments of Canada and Korea.

In this context, the project explores the use of readily available open data sources (including open geospatial mapping) and open computing resources relevant to disaster risk assessments and preparedness strategies in Nepal and incorporate these data and resources for the development of a private repository and web-based risk assessment tool for Multi-Hazard Risk Assessment and Visualization.

1.1 Contributes to Sustainable Development Goals (SDGs)

This project contributes to the Sustainable Development Goal 9: Industry, Innovation and Infrastructure through better understanding of potential impact of hazards in critical infrastructure by using openly available data and analytical tool. It also contributes to the Sustainable Development Goal 11: Sustainable cities and communities by better understanding natural hazards and capacities in terms of Disaster Risk Reduction. Similarly, the results and learning from this assignment can be used to inform data-driven climate action, goal 13.

1.2 Data Types and Technologies

The developed platform uses geo-spatial, demographic datasets and information from authentic news portals to pull the input data. Technology wise, it uses technology stack of Python (Django) for server-side system development and React JS on the client-side (web browser), comprises a large amount of effort to be put on the data communication through APIs between the backend and frontend systems. The platform allows semi-technical users to upload their own Vector and Raster datasets, carry out geo-data processing, analysis and result generation, while allow general users to visualize the results via the preprocessed data available on the system.

1.3 Project Objective

The objective of this project is to review the existing open data, analytical model and cloud computing resources and deploy them to potentially inform its disaster risk assessment and preparedness strategies in the respective study areas. This is being achieved by developing a GIS-based risk assessment platform and web-based data repository platform.

1.4 Brief description of the project area

The project area includes two urban municipalities Rajapur and Tikapur in the Terai plain (flood prone areas) along with two other units, one municipality and one rural municipality, Budhiganga and Bitthadchir respectively, which lie in the hilly region (landslide prone areas). The general information on demography, physiography and the most occurring disasters of the study sites are presented in **Table 1.**

Table 1: General information of the study sites

Local unit/ District	Population	Elevation	Most occurring disaster/s
Rajapur, Bardiya	59,553	123 - 166 m	Flood
Tikapur, Kailali	76,084	114 - 186 m	Flood
Budhiganga, Bajura	21,677	706 - 2449 m	Fire, Landslide, Thunderbolt
Bitthadchir, Bajhang	17,154	799 - 2747 m	Fire, Landslide

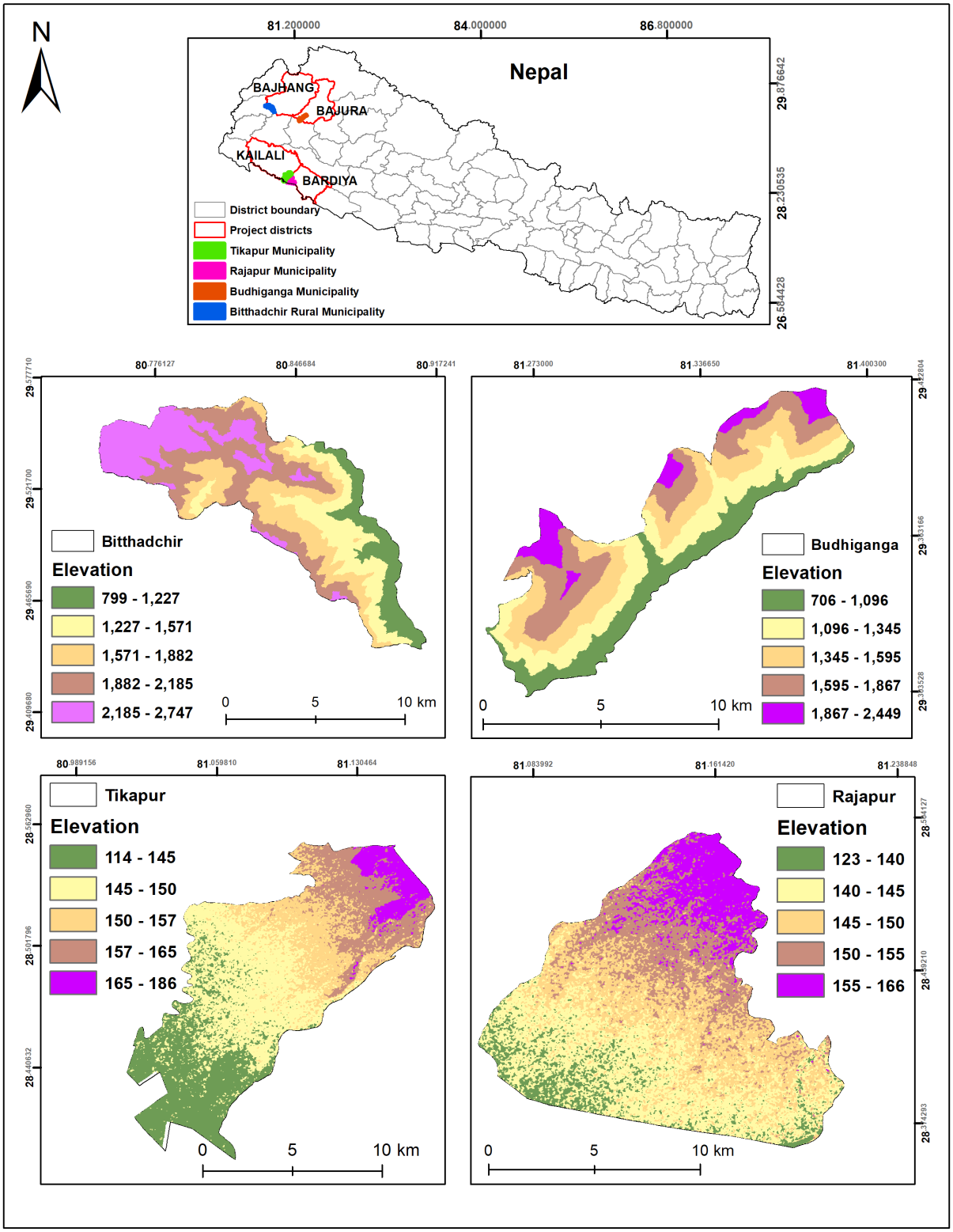

Figure 1: Study area

2. Methodology/approach

We adopted mixed exploratory sequential, consultative and experimental approaches to first explore the currently available open datasets relevant to disaster risk assessment in Nepal. Secondly, we did a rigorous consultation with thematic experts and specialists to verify the collected datasets and their usability. In the final step, we developed a GIS-based web platform capable of conducting disaster risk assessment by utilizing available open data and cloud computing resources identified in the first step.

The developed platform uses a multi criteria evaluation (MCE) method to carry out risk assessment by risk zonation based on the weightage of the number of attributes with certain criteria for exposure, hazard and proximity.

3. Updates and Achievements

3.1 Platform design and development

The project has developed two systems, interlinked with each other; private repository and risk assessment platform. The technical development process starts with some core setup of data modules in the backend, development of Application Program Interfaces (APIs), and design implementation in the frontend.

3.1.1 The Nepal Disaster Risk Portal is a private repository platform that contains information on datasets related to disasters modelling; information on different analytical models primarily focused on flood and landslides; computing resources; model output collecting data from risk assessment platform; and disaster related news collected from different authentic news sources. The platform has a dashboard through which users can gain an overview about each module. The primary objective of the portal is to maintain and learn about different computational models and applicable data and resources to assess disaster risk in the context of Nepal. However this information could be applied elsewhere as well. The repository consists of four different modules comprising datasets, analytical models, computing resources and news feed in the frontend for users to access. There's also a user administration interface to manage the users of the system.

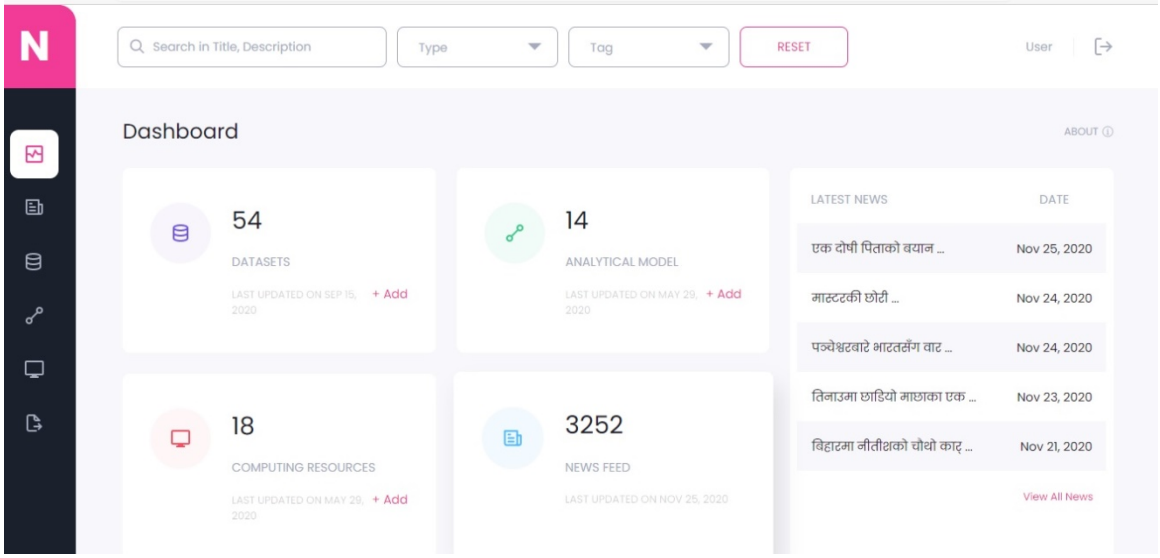

Figure 2: Overview of Repository

A) **Dataset**: This module contains information on open data, data repository systems and data platforms. Each item in the dataset module has a list of associated metadata that would further help understand the dataset. The metadata contains fields like data type, tags, title, description and other associated information. The dataset module is linked with the analytical models such that the users may see which dataset could be used in different analytical models.

B) **Analytical model**: This module contains the information on various analytical models. Currently this module contains hydrological, flood and landslide models and

could be updated to include more as new models are available. This module can be expanded to contain models for other hazards like fire, lightning and so on.

C) **Computing resources**: This module includes a wide range of applications from data processing, data synthesis, analysis, modelling, visualization and decision support. It also includes cloud computing services to host the applications and data. The module maintains the cloud computing and software systems that are used in the disaster risk assessment processes.

D) **News feed**: This module contains news related to disasters from different news portals. There's a scraping application (running in the backend system) that pulls news from major news portals, looks for certain keywords related to disasters like floods, landslides and stores the news that are of our interest. The scraping application works with both English and Nepali language based news sources.

E) **Model output**: This module contains information from the Risk Assessment Platform related to different kinds of hazards and disasters. There's a background process that pulls information from Risk Assessment Platform and lists all the outputs. Clicking on the respective model output should take you straight to the final output page on the risk assessment portal.

3.1.2 The risk assessment platform

The Risk Assessment Platform (RAP) is an online tool that is designed to perform risk assessment using the Spatial Multi-Criteria Evaluation (SMCE) method[1]. This methodology is used to carry out risk assessments with spatial overlay of hazard layers, exposure layers, and vulnerabilities defined by attributes of the layers. We have undertaken the approach of calculating risks as a function of hazard and vulnerability (exposure being a key part of the parameter defined for vulnerability). It uses a powerful computational resource in the backend, the Google Earth Engine, to perform spatial overlay analysis using the custom criteria set by users. The platform has facilities to upload or import hazard, exposure and vulnerability datasets and create custom criteria by defining parameters and assigning weights to perform risk assessments. It is a user-controlled platform, whose end product is a risk map classified into different risk categories that depend on the type of data input and weightage assigned to each parameter. Figure below highlights the workflow from input to result generation. Both of these systems can be accessed only by designated users provided with login credentials.

[1] http://www.charim.net/methodology/65

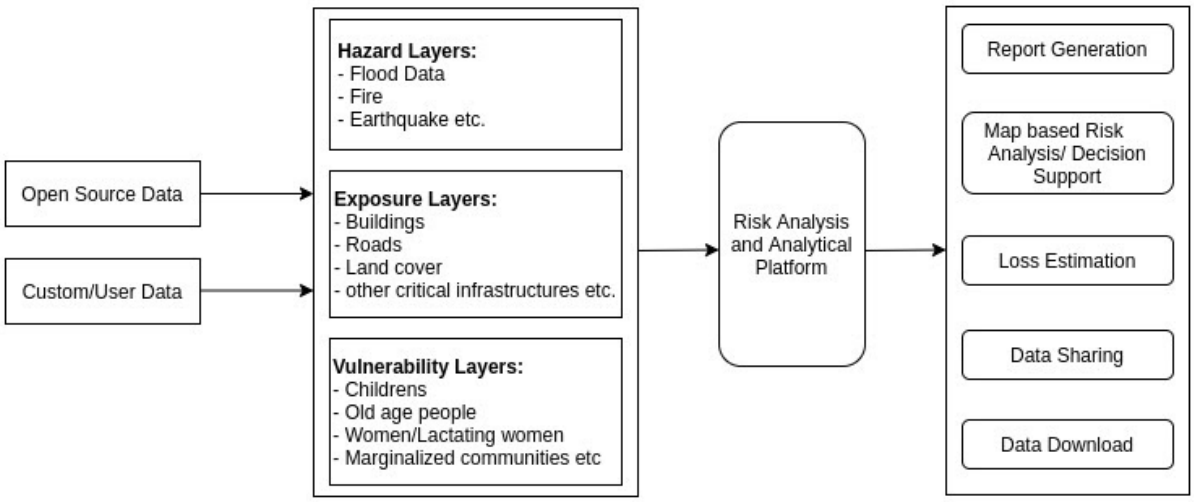

Figure 3: System Workflow

3.2 Datasets upload, processing and visualization

The private repository requires an upload of datasets and analytical models relevant to disasters, especially floods and landslides. Various datasets on hazard, exposure and vulnerability, such as csv datasets (population, households), raster data (Digital Elevation Model-DEM, susceptibility maps) and vector data (administrative boundaries, waterways, buildings) have been uploaded from different sources in the dataset module of the repository. Similarly, different analytical models on floods and landslides with information about its features, uses, limitations and data needs are uploaded on another module of the dashboard. The repository also consists of computing resources and news feed module. This module consists of information on different computing resources along with its source URL and daily update of news related to disasters from different news portals, respectively. The available open datasets with a specific focus on the project study areas are also added in the repository.

The risk assessment platform can be used for overall risk assessment for technical users where users can add their own projects, upload datasets as per their need, define parameters, give weightage and visualize their results. In addition, visualization of the risk assessment of the project created could be done as well by importing datasets from Google Earth Engine (Backend API), OpenStreetMap (OSM) data.

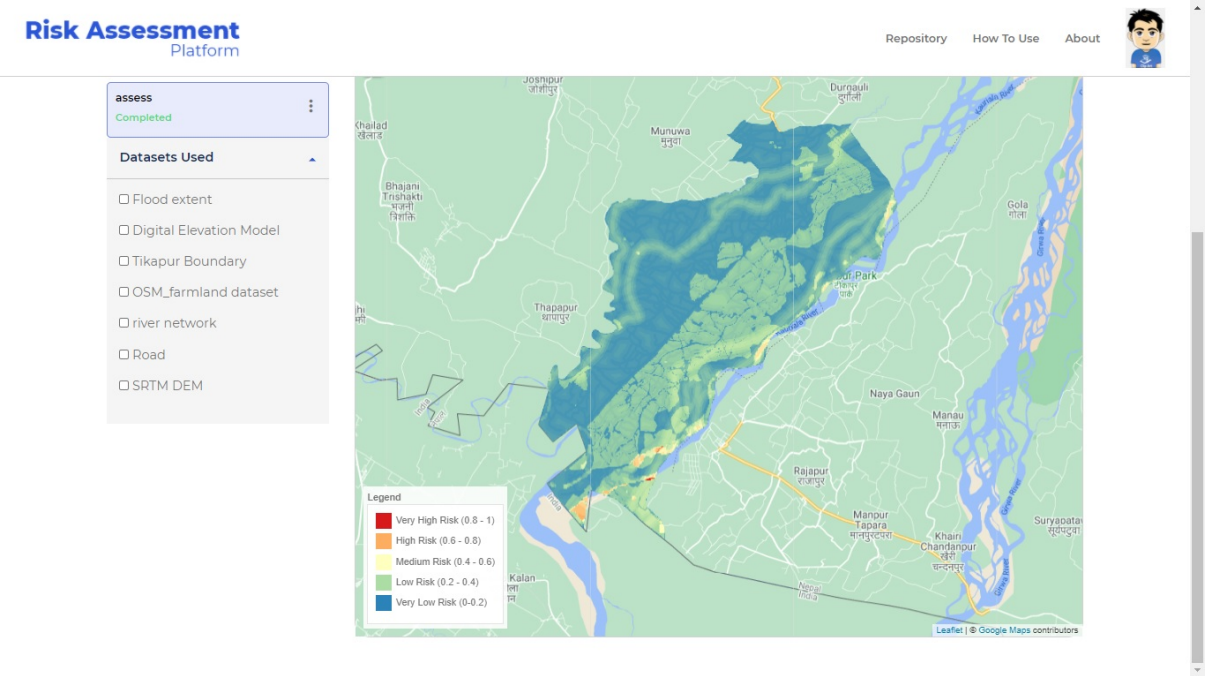

Figure 4: Flood Risk Assessment created for Tikapur Rural municipality

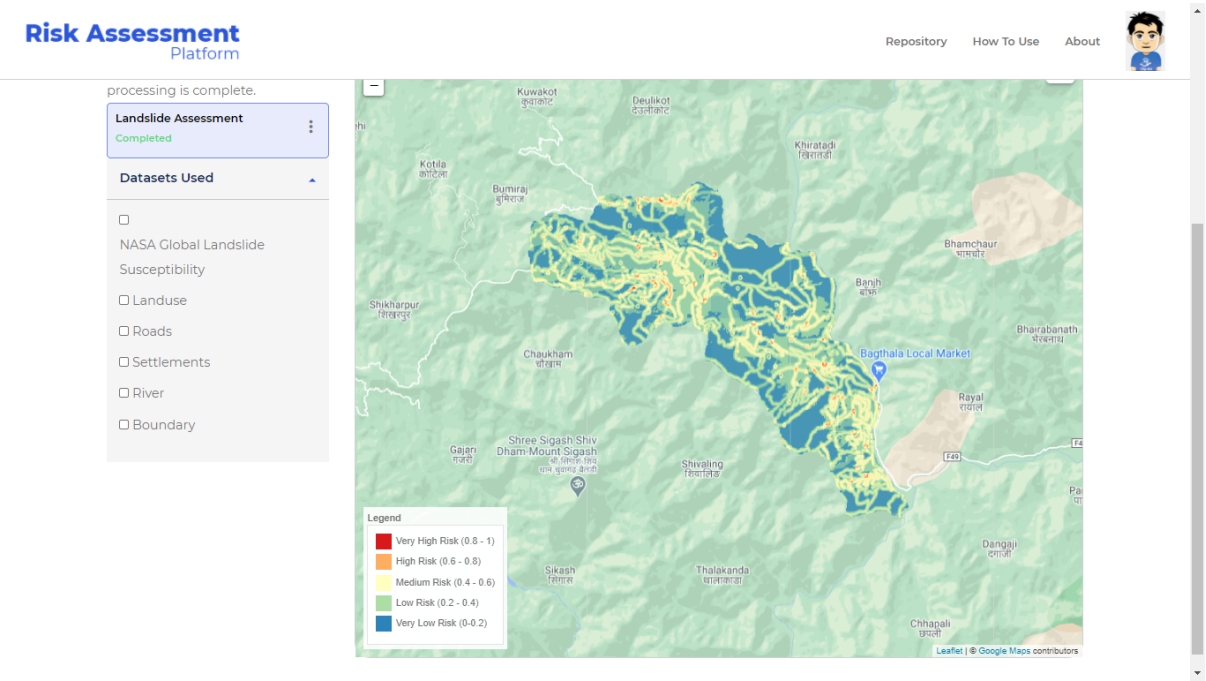

Figure 5: Landslide Risk Assessment created for Bitthadchir rural municipality

3.3 Testing of the Risk Assessment Platform

Testing of the Risk Assessment Platform was carried out virtually due to the current COVID-19 situation, which could bring diverse group of participants regardless of the geography, expertise and experience. The participants included the technical partners, internal experts of Practical Action team, experts from various technical backgrounds like agriculture, health, IT, geology, hydrology and also graduate students from Far Western University. The demo presentations were given by the technical partners followed by two-way discussions. The participants shared some of their observations and suggestions too. As the platform is totally

user-controlled and depends on user judgement for uploading datasets to set parameters and assign weights, participants suggested the platform to be more scientific in terms of weighting by considering a statistical weighting mechanism rather than expert judgment in order to make it more useful and effective for decision making and policy level planning. The participants suggested having in-built data in the platform, which will be helpful to assess the risks directly through the platform without relying on other sources. The suggestion was also to enhance the platform by further working out on hazard zonation and hazard assessment part as well, since this will help to generate hazard datasets from the tool itself and can be further used for risk assessment.

4. Limitations, Challenges and Risks, their Mitigation

4.1 Limitations of this platform

- The platform recognizes specific file formats, while users need to have basic understanding of standard data format of geospatial datasets.
- The uploaded data cannot be modified in the platform itself after being uploaded, due to which pre-processing of data in other platforms like GIS is required.
- The results could be biased based on the users' level of understanding and interpretation of each parameter, which can produce varying results.
- As the platform envisions risk assessment based on the hazard, exposure and vulnerability datasets, unavailability of such datasets for given study area may limit the results.

4.2 Risk and its Mitigation

Due to the COVID situation, the field visits for conducting testing and sharing of the platforms had to be done virtually. Conducting virtual workshops with the diverse participants and experts was challenging but it provided with an opportunity to bring in diverse experts from academia, development practitioners and students to strengthen the system. We were able to conduct 3 days virtual workshop to test risk assessment platform to our selected study areas.

5. Data Production and Disaggregation

Below table highlights the new data produced and disaggregated as part of this assignment.

Specific aspects	Outcomes
Have there been any final results or outcomes in which data or methods have allowed data to be produced: faster; in more inexpensive manner; at a higher resolution or granularity, or where there was no data before? If yes, please describe.	The outputs from the risk assessment platform have resulted in the production of risk maps of four local levels in the Sudurpaschim province (Province 7) of Nepal. Open data from various platforms were used in the risk assessment platform, which was further processed using spatial multi-criteria evaluation method and a risk

	map was produced for the four thematic areas; disaster, agriculture, infrastructure and health.
Project contribution to the production and/or use of data disaggregated by a) sex b) disability c) age, d) geography (or other)? If yes, please summarize the types of disaggregation and the context.	The project has contributed in the production of data in two geographical locations, that are in the lowlands (i.e. flood prone area) and the hills (i.e. landslide prone area).
Project contribution to the use and/or production of gender statistics	The project was designed considering the gender balance in the team. Similarly, the gender balance was carefully prioritised while conducting the workshops as well. The participation was well balanced in this aspect. However, the project has not contributed directly to the use or production of any gender statistics.

6. Lessons Learned

Using open data and Google Earth Engine was very helpful in filling the data gaps and also minimizing the technical difficulties due to limited computational powers. The collaboration between three partners was helpful in bringing inter-disciplinary knowledge of Disasters, risk assessment, geomatics, programming and software development. The successful testing of this approach in the four local units indicates its great potentiality to replicate in the similar geographical context and it also holds capability to be scaled up in the other geographical areas with some calibration.

More ground based data including high resolution drone imageries, household level gender disaggregated data, slope and aspect of geographical location and accurate institutional information would have helped to produce more accurate and robust results. Similar future assignment can focus on comparing the accuracy of earth observation data with ground based data.

7. Conclusions

We conclude that there is great potential and benefit of using open data, analytical models and cloud computing resources in better understanding of disasters in a data scarce region. This approach helps to fill significant gap in data availability in the local level as well as limitation of data processing in local machine. Analysis of different open layers combined with powerful processing capacity of Google Earth Engine provides faster and more reliable data to understand risks associated with disasters. Accuracy and credibility of open data has been a major concern in academic and action based researches, which could be addressed with robust field validation and testing the data produced from this research assignment.

During our literature review, we found that use of Earth observation products, open data and analytical models in the flood hazard and risks shows a growing interest in the field. However, the main focus of the contemporary literature is on the technology-specific applications for hazard mapping and for disaster management. To better understand the risks and mitigation measures of disasters, multi-sources data from different models and sources would be much beneficial. There is a great importance of these data in a digital web-based analytical platform, like the one this project developed, that can help for evidence – based decision making and planning processes.

Despite the availability of the open data, very less use of such data is observed for most of the flood in Nepalese context. This might be because of lack of access to technology and knowledge on how to use these available datasets. Also, most of the data are used for research purpose rather than decision making and informing policy making. Similarly, lack of disaggregated data for local and provincial level is a major challenge to provide specific information.

8. Acknowledgement

This report has been prepared based on the combined works of the project team of Practical Action Consulting Nepal (Lead), and partners - NAXA Private Limited, Young Innovation Private Limited and International Institute for Applied Systems Analysis (IIASA).

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