**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

NASA Goddard Space Flight Center

**Himalaya Disasters III**

Utilizing NASA Earth Observations to Expand the Modeling Capabilities of the Landslide Identification Product and Developing an Automated Landslide Detection Product in Nepal

**Objective:**

To conduct three complimentary activities to better characterize landslide hazards in Nepal: 1) Improve the accuracy and availability of current landslide event information by automating the Sudden Landslide Identification Product (SLIP), 2) build a web-based tool that utilizes crowd-sourcing to identify and map landslides at their source, and 3) enhance the appearance, usability, and significance of the hazard assessment model and SLIP through the creation of a mobile phone application.

**Community Concern:**

Nepal is a hotspot for landslide activity due to its mountainous topography, complex terrain, and monsoon rains. On average, landslides cause hundreds of fatalities and millions of dollars in losses in this region annually. This is often due to landslides impacting poorly constructed buildings, vulnerable settlement locations and significant landslide susceptibility. In the wake of the M7.8 Gorkha earthquake, which occurred on April 25, 2015, landslides were a significant induced hazard that are likely to increase in frequency and severity during the upcoming monsoon season. The devastating Gorkha earthquake has caused increased scrutiny on the region resulting in an influx of international organizations mapping landslides and providing high-resolution imagery of the area. This presents an exciting research opportunity to develop near real-time automatic detection products from superior data, as well as improve and disseminate a hazard assessment and decision support tool for end-users. Additionally, landslides often obstruct valley bottoms, which dams rivers and exacerbates flood potential. With current underestimation of landslide impacts and the increasing trend in frequency and intensity of landslide events due to anthropogenic factors, this work is critical even outside the scope of the earthquake.

**Partner Organizations:**

International Centre for Integrated Mountain Development [ICIMOD) [Collaborator, End-user, Boundary Organization; POCs: Basanta Shrestha (Director Strategic Cooperation), Birendra Bajracharya (Regional Programme Manager), Manchiraju Sri Ramachandra Murthy (Theme Leader for Geospatial Solutions), Deo Raj Gurung (Remote Sensing Specialist), Sebastian Wesselman (Senior Geospatial Capacity Building Specialist)]

The current end-user for this project is the International Centre for Integrated Mountain Development (ICIMOD), an intergovernmental organization that serves eight regional entities located within the Hindu Kush Himalayan region, including Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal, and Pakistan. Through partnerships with regional institutions, ICIMOD is able to serve as a regional knowledge hub that provides its end-users with insight on how climate change and globalization impact the fragile mountainous ecosystems.

Throughout the previous term, the team maintained contact with Deo Raj Gurung and Sebastion Wesselman through email and phone conversations. Both ICIMOD representatives provided datasets that were necessary for the landslide hazard analysis. As of now, few efforts have been made to use remotely sensed information to document landslide locations and estimate potential landslide conditions in near real-time within the region. The detection product produced in this study will assist ICIMOD and other aid organizations to identify landslides affecting remote areas in near real-time, drastically improving their ability to provide necessary support. The deliverables produced this past term have been sent to the ICIMOD representatives through email, and the team is working with ICIMOD to discuss current findings as well as plan complementary work related to this hazard. The goal of the third term is to translate information gathered from the hazard assessment model and SLIP into a usable workspace through the creation of a mobile dashboard, as well as creating a method for people to report events themselves, which will become yet another important tool in the disaster relief effort.

**Decision Making Process:**

While there has been published research in Nepal on landslides and landslide hazards, there is currently no regionally consistent system to integrate data, easily visualize information and share this information through a social networking and crowd sourced environment. Leveraging research and capabilities that have already been developed through funded NASA ROSES work, the proposed DEVELOP project will expand the capabilities of the current landslide hazard system to provide ICIMOD and other end-users access to landslide hazard assessment and remote sensing information that they can then use to improve situational awareness for these hazards and improve disaster response.

**Earth Observations:**

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| --- | --- | --- |
| **Platform** | **Sensor/Algorithm** | **Geophysical Parameter** |
| **Aqua and Terra** | MODIS | Land cover and vegetation products |
| **Landsat 8** | OLI and TIRS | Visible detection of landslide scars |
| **GPM** | IMERG | 30 minute and daily precipitation estimates |
| **Shuttle** | SRTM | Topography |
| **Terra** | ASTER | Topography |

**NASA Earth Observations Highlighted:**

The MODIS, SRTM, and ASTER sensors will be utilized to gather environmental information such as land cover, vegetation, and elevation information that have an influence on an area’s susceptibility to landslide events. The Integrated Multi-satellitE Retrievals for GPM (IMERG) combines multiple constellation sensors from GPM to provide global precipitation estimates at a 0.1 degree resolution every 30 minutes. This work will compare the IMERG near real-time “early” product with TMPA real-time data to evaluate the triggering relationships between these two data sources for the 2015 monsoon season (something that has not yet been done and would represent a significant contribution to better understanding GPM behavior in this region). This data will then be used to conduct intensity and frequency analyses for the landslide events. Information from the Landsat 8 OLI and thermal sensors will be added to the current Sudden Landslide Identification Product (SLIP) algorithm to derive landslide event information for the region.

**Ancillary Datasets:**

SEDAC Socio-economic variables CIESIN – provides socio-economic indicator datasets

ICIMOD Landslide Dataset 1992-2010 – provides regional landslide data

ICIMOD Lithology Dataset – supplies regional geological information

ICIMOD Rain Gage Dataset – provides hydrological data for the Koshi River Basin

USGS Landscan 2011 – offers accurate global population information

USGS HydroSHEDS – provides river feature data

OpenStreetMap – presents updated and accurate road records

ISRIC SoilGrids 1km – supplies global soil property information at 1-kilometer resolution

**Models:**

Landslide Hazard Assessment System (POC: Dalia Kirschbaum, NASA GSFC)

**Decision Support Tools & Analyses:**

|  |  |  |
| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Improved Global Landslide Inventory capabilities | Identification of landslides using remote sensing imagery in near real-time will assist in improving situational awareness of existing or past events within affected areas | [Existing] Online landslide editor, global landslide catalog (Dr. Kirschbaum),[In development by DEVELOP students] Sudden Landslide Identification Product |
| Regional Landslide Hazard Assessment System | Estimation of potential landslide activity in near real-time provides end-users with a landslide hazard identification system to improve information flow in order for further investigation of affected areas. Helpful for resource allocation and preventative measures | [Current system] Landslide Hazard Assessment for Situational Awareness (LHASA). Will utilize model developed by Dr. Kirschbaum |
| Web-based tool to acquire crowd-sourced landslide reports | Use information provided by citizen scientists in affected areas to report landslides and improve efficiency and efficacy of disaster relief efforts  | Regional and local emergency response, government or decision-making personnel |

*Improved Global Landslide Inventory Capabilities* – This will be an expansion and automation of SLIP with the objective of providing a more accurate and complete view of landslide hazards. This will make Dr. Kirschbaum’s Global Landslide Catalog more comprehensive, as well as providing local and regional emergency response with a landslide detection system.

*Regional Landslide Hazard Assessment System* – Together with ICIMOD, the proposed work will develop products and databases complementary to the landslide hazard model developed by Dr. Dalia Kirschbaum and her team with direct guidance from end users. Dr. Dalia Kirschbaum has a NASA ROSES funded project through SERVIR to conduct a feasibility study of the SERVIR-Himalaya node for potential transfer of the landslide hazard model to this area. The proposed project builds off of this research to develop new tools and products for Nepal.

*Web-Based Tool to Acquire Crowd-Sourced Landslide Reports –* This work will expand a web-based tool already developed as a prototype that will allows users to easily report a landslide or other disaster. Information reported will include location and disaster type, which will be used in regional and local emergency response. Furthermore, this information will be added to the online landslide system, and can be used in future analysis.

**Project Details:**

**National Application Area Addressed:** Disasters

**Source of Project Idea:** This work is supported by the SERVIR Science Team and builds on previous research in this field, particularly from science advisor Dr. Kirschbaum.

**Study Location:** The Koshi River Basin; Nepal, China, and India

**Period being Studied:** Retrospective analysis (1998-2015) and nearreal-time

**Advisor:** Dalia Kirschbaum, NASA GSFC

**# of Participants Requested:** 4

**Project Timeline:** 3 Terms: 2015 Spring to 2015 Fall

**Multi-Term Objectives:**

* **Term 1** – The first term involved data acquisition, processing and image analysis of landslide information. There was already a wealth of potential landslide data in Nepal available through publications and via ICIMOD. Students worked to update landslide events within the landslide editor framework that was recently launched, as well as to develop a methodology for image analysis of landslides using remote sensing data. Students also transitioned the landslide hazard assessment model to the Koshi River Basin and enhanced its capabilities. The team worked very closely with ICIMOD personnel to define the key products of interest to ICIMOD and its end users. By the end of the term, the team used the landslide inventory information obtained from their research to develop and test a susceptibility map and hazard assessment model for the region.
* **Term 2** – The second term focused on fully implementing and evaluating the Himalayan node hazard assessment model. The SLIP product was modified using infrared information so that it is able to accurately identify landslide events. The susceptibility map underwent a sensitivity analysis to eliminate any model inputs that are not significant, and the hazard assessment model was calibrated with new GPM rainfall information that enhanced the models accuracy.
* **Term 3 (Proposed Term)** – The goal of the third term is to translate the available information and products into a usable workspace. The SLIP product will be automated using R software to increase the availability of current landslide event information for the region, and an interactive dashboard for the hazard assessment model and SLIP will be created to enhance the availability of landslide hazard information for disaster forecasting decisions.

**Software & Scripting Requested:**

R – Automation of Landslide Detection, Dynamic Landslide Model

ArcGIS – Raster Manipulation/Analysis, Image Enhancement & Map Creation of Landsat TM, NPP VIIRS, Aqua/Terra MODIS

ENVI – Landsat Imagery Manipulation

MATLAB – TRMM Processing

Python – Hazard Model Calibration