Date of Submission	30-March-2018

IPL Project (IPL - 213) Annual Report Form 2017
1 January 2017 to 31 December 2017

1. **Project Number (approved year) and Title:** IPL-213 (2016), Real-time Landslide Monitoring and Early warning System in Western Ghats & Himalayas, India.

2. **Main Project Fields:** Monitoring & Early Warning

3. **Name of Project Leader:** Dr. Maneesha Vinodini Ramesh, Professor & Director, Amrita Center for Wireless Networks & Applications,

Contact: Amrita School of Engineering, Amritapuri Campus, Amrita Vishwa Vidyapeetham, Amritapuri, Kollam, Kerala, PIN- 690525,

Email: maneesha@amrita.edu, maneeshasudheer@gmail.com

Core members of the Project: Names/Affiliations: (4 individuals maximum)
1. Dr. Venkat Rangan, Vice chancellor, Amrita Vishwa Vidyapeetham, Coimbatore, Tamilnadu, India

2. Dr. Nirmala Vasudevan, Associate Professor, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

3. Mr. Sangeeth Kumar, Research Associate, Amrita Vishwa Vidyapeetham, Amritapuri, Kerala, India

4. Ms. Hemalatha T, Research Associate, Amrita Vishwa Vidyapeetham, Amrita University, Kerala, India

4. **Objectives: (5 lines maximum)**
The objective is to enhance the existing large scale real-time landslide monitoring and early-warning system for landslide prone regions of Himalayas and Western Ghats using wireless sensor networks, Geotechnical devices, and satellite information. The above objective is achieved by increasing in-situ & remote measurements, developing thresholds for real-time data analysis, developing thresholds from landslide simulation setup, developing an enhanced slope stability model for landslide detection; developing automatic context aware data dissemination software for issuing alarms in real-time.

5. **Study Area: (2 lines maximum)**
In a selected landslide prone zone of The Himalayan Mountains & The Western Ghats.

6. **Project Duration (1 line maximum): 3 years**

7. **Report**

1) **Progress in the project: (30 lines maximum)**

The project was formally granted in November 2016. As mentioned in the deliverables section time frame in the proposal, we have progressed in the below sections

a) **Selection of site in Himalayas**

Multiple landslide prone sites in Himalayan ranges, which are located in different Indian districts of such as Uttarkhand, Sikkim, Darjeeling are visited. Experts and geologists help

was sought in identifying Predominant rocks, minerals and geologic formations in these districts. Old records of rainfall, land use, and landslide occurrence were consulted along with the additional information from residents and local administration. The impact of landslides in these locations on mankind are analyzed and a landslide prone region in Chandmari area of Sikkim district is selected for the project.

b) **Design of DEP and IWP**

The term "Deep Earth Probe" (DEP) refers to a combination of sensors or probes that are embedded as a single unit in a hole drilled into the earth's surface. DEPs contain sensors that are appropriate for landslide monitoring, such as piezometers, tensiometers, inclinometers, embedded with intelligent algorithms. All the DEPs are integrated with interfacing circuit for collecting data, power circuits for powering the system using a hybrid solar system, and a wireless system for real-time information. The DEPs are embedded with intelligent context aware, power aware, and decision making algorithms which makes DEPs an "Intelligent Wireless Probe" IWP.

c) **Pilot deployment: Preparatory steps**

We have conducted several detailed meetings with the stake holders for the initiation of the pilot deployment. These meetings will help in smooth functioning of our work. An expert committee has visited the filed in Sikkim to choose the location for deployment. We have also purchased our own drilling machine for deployment purposes, training for operating those machines are also been undertaken by the operator. Sensors for the deployment are calibrated in the laboratory. Design of interfacing circuits for the sensors are done and these circuits are also interfaced to wireless sensor motes. Laboratory trails are being carried out for data collection, aggregation and dissemination from the wireless sensor motes.

2) **Planned future activities or Statement of completion of the Project (15 lines maximum)**

Future activities include, designing of a suitable wireless link for data streaming from Sikkim to Amrita. Running field trials to decide on the optimal wireless link. Performing Electrical Resistivity Tomography (ERT) in the deployment site to study the geology of the site in detail and also to select locations for deployment of DEP's. Deployment of weather station and DEP's. Establishing wireless link and transmitting the data. Developing database and visualization applications for collecting and visualizing the data from the deployment site in Sikkim. Developing of complete decision support system and early warning system, which includes developing dynamic thresholds for sensors, developing slope stability models, developing forecast models and developing early warning system. We are also planning to create awareness program about landslides and the functioning of the system to local community. As part of capacity building, we are planning to involve local community using crowd sourcing mobile apps to collect data about rainfall, road blocks due to landslides, symptoms for landslides, etc.

3) **Beneficiaries of Project for Science, Education and/or Society (15 lines maximum)**

Beneficiary for science: This landslide research would lead to the development of low cost sensors for monitoring landslide prone terrains. The relations existing between vital parameters such as moisture, pore-water pressure, movement will be studied in laboratory and validated with the real-time data. Capacity building using mobile apps will open up landslide research in the directions of crowd sourcing, participatory sensing etc.

Beneficiary for education: This project will initiate many masters and doctoral students to work on landslide research, developing new methodologies etc. Capacity building and involving local

community in this landslide program will educate the community about landslides.

Beneficiary for society: Direct beneficiary from this project will be public people and their properties. Along with the people, the economic loss happening to the government will also be saved. The disaster management board of that region will also benefit from this project.

4) Results: (15 line maximum, e.g. publications)

Guntha, Ramesh, Sangeeth Kumar, and Balaji Hariharan. "Scalable, secure, fail safe, and high performance architecture for storage, analysis, and alerts in a multi-site landslide monitoring system." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Ramesh, Maneesha Vinodini, et al. "Wireless Sensor Networks for Early Warning of Landslides: Experiences from a Decade Long Deployment." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Ramesh, Maneesha Vinodini. "Slope Stability Investigation of Chandmari in Sikkim, Northeastern India." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Hemalatha, T., Maneesha Vinodini Ramesh, and Venkat P. Rangan. "Adaptive Learning Techniques for Landslide Forecasting and the Validation in a Real World Deployment." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Ramesh, Guntha, Hariharan Balaji, and T. Hemalatha. "High Performance Heterogeneous Data Storage System for High Frequency Sensor Data in a Landslide Laboratory." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Ramesh, Guntha, Hariharan Balaji, and T. Hemalatha. "High Performance Heterogeneous Data Storage System for High Frequency Sensor Data in a Landslide Laboratory." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Ramesh, Maneesha Vinodini. "Slope Stability Investigation of Chandmari in Sikkim, Northeastern India." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Kumar, Sangeeth, P. Venkat Rangan, and Maneesha Vinodini Ramesh. "Design and validation of wireless communication architecture for long term monitoring of landslides." *Workshop on World Landslide Forum*. Springer, Cham, 2017.

Note:
1) If you will change items 1)-6) from the proposal, please write the revised content in Red.
2) Please fill and submit this form by 30 March 2018 to ICL Network <icl-network@iclhq.org>