| Date of Submission | 21 May 2016 |

IPL Project Annual Report Form 2016

1. Project Title : Development of landslide risk assessment technology along transportation arteries in Vietnam.

2. Main Project Fields
 (1) Technology Development
   A. Monitoring and Early Warning, B. Hazard Mapping, Vulnerability and Risk Assessment
 (2) Capacity Building
    A) Enhancing Human and Institutional Capacities
    B) Collating and Disseminating Information/ Knowledge
 (3) Mitigation, Preparedness and Recovery
   Preparedness, B. Mitigation, C. Recovery

3. Name of Project leader: Kyoji SASSA and Nguyen Xuan Khang

4. Affiliation: Director of the IPL World Centre, Kyoto, Japan, Director of Institute of Transport Science and Technology, Vietnam (ITST)
   Contact: E-mail: sassa@iclhq.org, Tel:+81(774)38-4834 (office), Tel:+81(90)8758-1405 (mobile)
   Contact: No. 1252 Lang Street, Dong Da District, Hanoi, Vietnam –Tel/Fax: (+84)37663403;
       (+84)37663977 E-mail: iclitst oda <oda.iclitst@gmail.com>, Dinh van Tien
       <dvtien.gbn@gmail.com>
   Core members of the Project:

     Khang Dang (International Consortium on Landslides (ICL) / VNU Science)
     Japan: Hirotaka Ochiai (Forestry and Forest Product Research Institute), Toyohiko Miyagi (Tohoku
       Gakuin University), (International Consortium on Landslides)
     Vietnam: Dinh Van Tien <dvtien.gbn@gmail.com>,
         Lam Huu Quang <lhqlinh@yahoo.com>

5. Objectives: (5 lines maximum)
   The objective is to contribute to landslide disaster reduction along main transport arteries and on residential areas through study on effective application of new technology on forecast, monitoring and treatment of landslides in Vietnam and other areas in the Greater Mekong Sub-region in close cooperation with Japanese universities and also ICL. The following targets are expected: a) Development of Landslide risk assessment technology suitable for the targeted areas in Vietnam. b) Capacity Development for research on landslide risk identification and hazard mapping. c) Social application over the regions.

6. Study Area: (2 lines maximum)
   Viet Nam , Japan , Countries in the Greater Mekong Sub-region (e.g. Laos and Myanmar)

7. Project Duration (1 line maximum)

~~5 years from March 2012 to March 2017~~

Due to recent rain-induced rapid landslides in Halong City, the project duration has been extended to further 3 years. Revised project duration is from March 2012 to March 2020

8. Report

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

Three groups of this project, mapping, testing and monitoring investigated landslides in Vietnam. Mapping group has made landslide distribution map along Ho Chie Minh Route, Hai van Station area, Route No. 6 and Route No.7 in 2011-2015. Testing group developed a high-stress undrained ring shear apparatus (up to 3 MPa) and applied it in Japan (Unzen Mayuyama) and in Vietnam (Hai van station landslide). Testing group improved an integrated simulation code (LS-RAPID) to simulate the initiation of landslide due to 10 minutes rainfall records as a trigger. The group developed a new simulation code (LS-Tsunami) to simulate the initiation and motion of landslide-induced tsunami in 2015. This LS-Tsunami was applied to Japan (1792 Mayuyama landslide-induced tsunami) and to Vietnam (Hai van station landslide and its triggering tsunami in Da-nang Bay). Monitoring group installed 19 long span extensometers, one total station with 30 prism, and 3 static GPS (GNSS) and two real time kinematic GPS (GNSS) and one deep geological drillings in the Hai van landslide in 2015. And those monitored data are transferred to the ITST in Hanoi.

9 Vietnam engineers are invited to Japan by this project in 2012, 2013, 2014, 2015 and also 2016. They have entered in Kyoto University, Tohoku Gakuin University, Shimane University, and Shizuoka university and studying landslides as master or doctor course students. One student obtained Ph.D in Kyoto University in 2015, one student took Ph.D in Tohoku Gakuin University in March 2016. One engineers from ITST took his Ph.D. by submitting papers in Tohoku Gakuin University in October 2016. 5 students took master's degrees in 2015. One student entered into Kyoto University Doctor course after the master course in 2016. He will take Ph.D within a few years.

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

A shallow landslide during a heavy rains occurred in Ha Long City and killed 8 persons living in three houses in 2015. The group investigated the landslide and took samples and transported to Japan. The sample is being tested from January 2016. Large-scale landslides can trigger big disaster. However, a group of shallow surficial landslides caused a big disaster (74 persons were killed) in Hiroshima city in 2014. Similarly, heavy rainfalls in Vietnam caused many shallow landslide disasters. The group is now applying for another SATREPS project in Vietnam focusing the study of shallow surficial landslides to be implemented from 2017 to 2022. The current title is "Research and implementation of combined early warning and landuse change in vulnerable human settlements exposed to hazardous motion of debris". We developed a new method to identify the slightly moving area of landslides using the UAV photo and its PIV (Particle Image Velocimetry) technology. The first attempt to a landslide in Ha Long city was very successful. It detected the moving area and also the movement along the central line. The movement of trees and forest were identified. We plan to further develop this technology and apply for other landslides.

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

The subjects directly benefiting from the project's achievements include:

In Vietnam: people in 10 provinces frequently affected and the impact of the phenomenon of landslides

In Japan: The technology by UAV-PIV and UAV-Computer simulation (LS-RAPID) are very successful in Japan. This reliability of this technology will be further improved in the current years and applied to other Asian countries.

and a team of young engineers in the research institutes, universities and in technical management agencies in local conditions better awareness in order to prevent landslides as housing, farming and irrigation in mountainous conditions and applying appropriate technology to actively prevent, mitigate consequences natural disasters caused by landslides. In Laos and Myanmar: people in some mountainous locals and a division engineers in the agency and management consulting. Results can be disseminated to other developing countries in the region and the world to study and apply.

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

1. Sassa K, He B, Dang KQ, Nagai O (2014)   Plenary: Progress in Landslide Dynamics. Landslide Science for a Safer Geoenvironment, Proc. The Third World Landslide Forum, Springer, Vol. 1: 37-67

2. Kyoji Sassa (2014) Landslide Risk Assessment at Cultural Heritage. Keynote for XII International IAEG Congress, Torino, Engineering Geology for Society and Territory (eds: Giorgio Lollino etc) , Vol.2 Landslide Process :79-103

3. Kyoji Sassa, Khang Quang Dang, Bin He, Kaoru Takara, Kimio Inoue, Osamu Nagai (2014): Development of a new high-stress undrained ring shear apparatus and its application to the 1792 Unzen-Mayuyama megaslide in Japan. Contributed to Landslides. Vol.11, No.5: 827-842

4. Do Minh Duc, Nguyen Manh Hieu, Kyoji Sassa, Eisaku Hamasaki, Dang Quang Khang, Toyohiko Miyagi (2014). Analysis of a Deep-seated Landslide in the Phan Me Coal Mining Dump Site, Thai Nguyen Province, Vietnam. Proceedings of the World Landslide Forum 3, Vol.1, pp:373-377.

5. Dinh Van Tien, Nuguyen Khang, Toyohiko Miyagi, Eisaku Hamasaki, Shinro Abe (2014) Landslide Prevention and Mitigation in Humid Tropical Region. Proceedings of World Landslide Forum 3, Vol.4 (discussion volume), pp.716-724.

6. Pham Van Tien, Doan Minh Tam, Le Hong Luong (2014) Overview of Landslides in Vietnam and a research proposal of Master program in Kyoto University, Proceedings of World Landslide Forum 3, Beijing, Vol.4 (discussion volume), pp.673-678.

7. Le Hong Luong, Toyohiko Miyagi, Shinro Abe, EisakuHamasaki, Dinh Van Tien (2014), Detection of active landslide zone from aerial photograph interpretation and field survey in central provinces of Vietnam, Proceedings of World Landslide Forum 3, Beijing, Vol.1, 435-441.

8. Pham Van Tien (2014) Enhancement of Community-Based Landslide Risk Prevention and Reduction Capacity In Mountainous Regions in Vietnam. Development of an education teaching tools for disaster reduction program, Technology-Education Linkage Through Disaster Reduction Hyperbase U-Y-03 : 2013B, Kyoto University, pp:61-68.

9. Khang Dang, Kyoji Sassa, He Bin, Osamu Nagai (2014) Test results of a new high - stress ring shear apparatus (ICL - 2) developed for Vietnam Project , Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 32-41.

10. Le Hong Luong, Toyohiko Miyagi, Shinro Abe, Eisaku Hamasaki, Dinh Van Tien (2014) Landslide mapping and detection of active landslide area from aerial photograph interpretation and field survey in central provinces of Vietnam. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 42-49.

11. Tien Pham, Tam Doan, Luong Le (2014) Overview of Landslide Phenomena along Arterial Transport System in Vietnam, Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 57-61

12. Doan Huy Loi, Huynh Thanh Binh, Do Ngoc Ha (2014) Characteristic of landslides in Ho Chi Minh road, Vietnam. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 62-66.

13. Sakae Mukoyama, Kyoji Sassa, Doan Huy Loi , Hirotaka Ochiai , Toyohiko Miyagi (2014) Identification of slope deformation by the Particle Imaging Velocimetry (PIV) Analysis of air photos or laser scanning images in different periods. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 76-81.

14. Keisuke Takimoto, Shiho Asano, Osamu Nagai, Hiroshi Fukuoka and Kyoji Sassa (2014) Development of integrated data and Web - based analysis software for Vietnam. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 82-86.

15. Toyohiko Miyagi (2014) Landslide mapping and the risk evaluation by aerial photo interpretation in Vietnam. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 87-95.

16. Shinro Abe, Dinh Van Tien, Hiroyuki Yoshimatsu, Tatsuya Shibasaki, Toyohiko Miyagi (2014) Topographic and geological factors of landslides along Ho Chi Minh Route in central Vietnam. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 107-118.

17. Ngo Doan Dung Ngo Doan Dung, Eisaku Hamasaki, Tatsuya Shibasaki, Toyohiko Miyagi, Hiromu Daimaru, Dinh Van Tien, Le Hong Luong (2014) Change the safety factors by the series of land deformation at a typical landslide along the National Road No.6, Vietnam . Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 119-122.

18. Eisaku Hamasaki, Toyohiko Miyagi, Dinh Van Tien, Ngo Doan Dung (2014) Objective Function based AHP Risk Evaluation System in Humid Tropical Regions. Proc. SATREPS 2014 Workshop "Landslide Risk AssessmentTechnology", pp: 123-127.

19. Shoichiro Uchiyama and Toyohiko Miyagi (2014) Application of Digital Surface Model due to Structure from Motion. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 128-136.

20. Lam Huu Quang, Dang Quang Khang, Pham Van Tien, Doan Huy Loi, Nguyen Kim Thanh (2014) Recent Development of the New High Stress Undrained Ring Shear Apparatus (ICL - 2) and its Application. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 168-173.

21. Bin He, Kyoji Sassa, Osamu Nagai, Takara Kaoru (2014) Simulation of a rapid and long-travelling landslide using 2D-RAPID and LS-RAPID 3D Models. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 174-178.

22. Hirotaka Ochiai, Yasuhiko Okada, Mark Reid, Kyoji Sassa (2014) Landslide experiments on natural slopes and indoor landslide flume tests by artificial rainfall. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 179-184

23. Dang Vinh, Huynh Thanh Binh, Do Ngoc Ha (2014) Landslides on the road in Vietnam - Monitoring and solutions for landslide risk Reduction. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 185-189.

24. Shiho Asano, Shinro Abe, Osamu Nagai (2014) Development of landslide monitoring and data transfer

system in the Hai van station landslide and the initial extensometer monitoring result behind the station. Proc. SATREPS 2014 Workshop "Landslide Risk Assessment Technology", pp: 190-194

25. Kyoji Sassa (2016) Preface: Thematic issue for Mapping Group of SATREPS Project "Development of landslide risk assessment technology along transportation arteries in Vietnam" 2011-2017. Special issue in Geomophology, Journal of Japanese Geomorphological Union, pp:5-8

26. MIYAGI Toyohiko, Dinh Van TIEN, Nguyen Xuan KHAN (2016) Landslide topography mapping and development of risk evaluation technology in a tropical strongly weathered humid tropical zone. Special issue of Special issue in Geomophology, Journal of Japanese Geomorphological Union, pp: 1-3.

27. Kyoji Sassa, Khang Quang Dang, Hideaki Yanagisawa, Bin He (2016) A new landslide-induced tsunami simulation model and its application to the 1792 Unzen-Mayuyama landslide-and-tsunami disaster, Landslides Vol.13, No.6: 1405-1419.

28. Dang K, Sassa K, Fukuoka H, Sakai N, Sato Y, Takara K, Lam H Q, Doan H L, Pham V T, Nguyen D H (2016) Mechanism of two rapid and long runout landslides in the 16 April 2016 Kumamoto earthquake using a ring-shear apparatus and computer simulation (LS-RAPID). Landslides Vol.13 (6): 1525-1534.

29. Doan Huy Loi, Lam Huu Quang, Kyoji Sassa, Kaoru Takara, Khang Dang, Nguyen Kim Thanh, Pham Van Tien (2017) The 28 July 2015 rapid landslide at Ha Long City, Quang Ninh, Vietnam Landslides (published online first : DOI: 10.1007/s10346-017-0814-y)