TECHNICAL ARTICLE

Preliminary Understanding of the Seti River Debris-Flood in Pokhara, Nepal, on May 5th, 2012

— A Report based on a Quick Field Visit Program —

N. P. Bhandary[*§¢], R. K. Dahal[**¢], and M. Okamura[*§]
*Graduate School of Science and Engineering, Ehime University, netra@ehime-u.ac.jp
**Department of Geology, Tri-Chandra Campus, Tribhuvan University, Nepal
**Currently: JSPS Post-doc Research Fellow, Ehime University
§The Japanese Geotechnical Society; ¢Nepal Geotechnical Society

1. BACKGROUND

First and foremost, this report consists of the details and understanding from a two-day field visit program of a recent high-altitude rock slope failure-induced debris-flood disaster in Nepal as a part of ATC3 activities. ATC3 is one of the technical committees of Asian member societies of ISSMGE, and it concerns geotechnical issues of natural hazards, particularly in the Asian nations. This committee is currently chaired by Ikuo Towhata for a 4-year term, and is primarily working on slope problems. On 16-20 May 2012, one of the committee members, the third author of this report visited the disaster-hit area in Nepal and conducted a quick field survey together with two members of Nepal Geotechnical Society, the first and second authors of this report.

On 5 May 2012 (referred to 1255 hereinafter in this report), one of the most popular tourist destinations of Nepal, the city of Pokhara, witnessed a devastating debris flow in the upstream and a heavy debris-mixed flood in the downstream of Seti River (Fig. 1), also known locally as Seti Khola, which literally means a white river owing to the fact that the river water is usually grayish white. According to the Home Ministry of Nepal, which also looks after the disaster-related issues in the nation, 71 people are believed to have been killed in the disaster, but the confirmed death toll has only remained somewhere at 31 while the rest are still in missing status (Kathmandu Post, 2012). Except for three Ukrainian tourists, this number mainly includes local people, some of whom were picnicking at one of the popular picnic spots in the river upstream (i.e., Kharpani area, Fig. 1), some 20 km north of central Pokhara. This area was also popular for a hot spring, which on the day of the disaster is believed to have attracted more than 30 locals. Various media reported that the international tourists from Ukraine were also on a trekking tour to the hot spring area, which is locally known as Tatopani.

On the 5th May morning, around 8:55AM, a Russian pilot (Capt. Alexander Maximov) of an ultra light aircraft owned and operated by Avia Club Nepal in Pokhara for the purpose of pleasure flights over the Pokhara Valley and Annapurna range of mountains, while flying close to the Mt. Macchapucchre area, witnessed a cloud of dust over the Annapurna Greater Depression (Dahal et al. 2012; Fig. 1), also known in scientific community as Sabche Cirque (Skermer and VanDine, 2005). He seems to have immediately suspected of a massive snow avalanche in the area and to have also decided to inform of the possible danger to the Pokhara Airport control tower. According to a brief interview taken by the authors, Capt. Maximov seems to have first landed at Pokhara airport and then to have flown again to the same area with another passenger, but to witness that the Seti River was full of massive debris flow and flood in the upstream. This led him to communicate with the control tower immediately and inform of a possible disaster in the Pokhara City, which fortunately helped many people escape the disaster in the downstream area. The information provided and its immediate dissemination to public through FM radios and cell phone messages largely helped many people stay alert as well as capture live scenes of the debris flow and flood in their still and video cameras including cell phones, which were and are still available in the internet (i.e., through YouTube, Facebook, and various websites).

SETI RIVER DEBRIS-FLOOD (Continued)

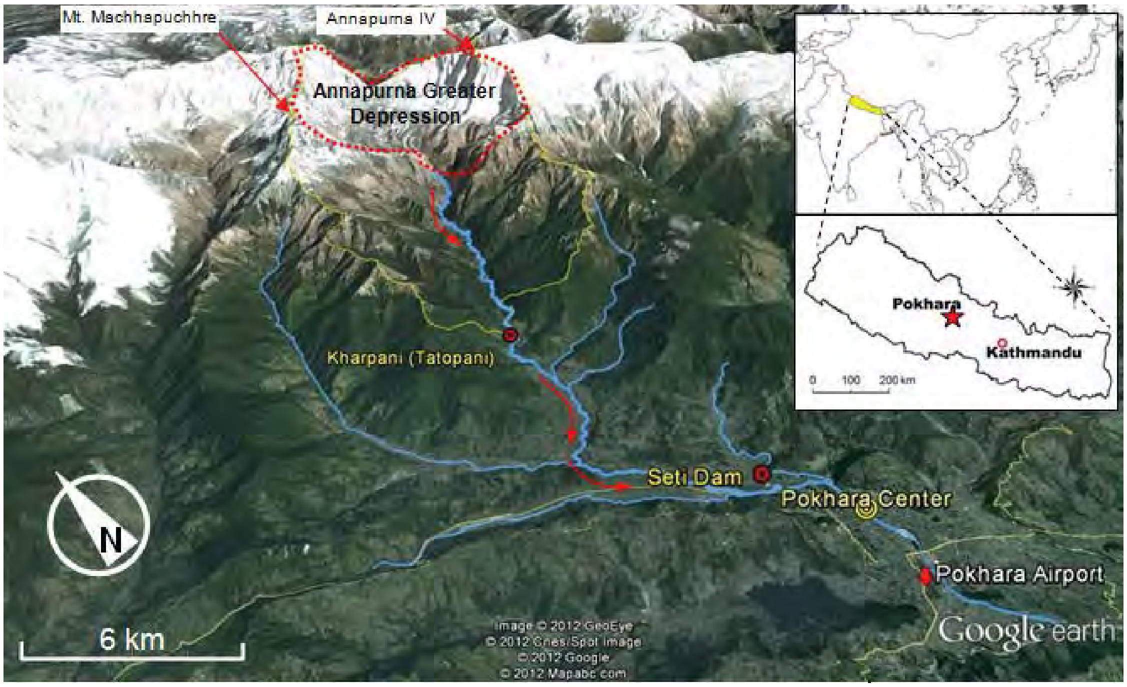

Fig. 1: A bird's eye view of Seti River, Pokhara City, and Annapurna Range (Google earth, Imagery date: 2012.1.29).

Initially believed and largely reported to have been a glacier lake outburst flood (abbreviated and commonly known as GLOF), it was again falsely reported to have been a landslide dam outburst flood (abbreviated as LDOF) (ICIMOD 2012a, 2012b, 2012c) based on speculations and visual confirmation of comparatively fresh landslide failure near the right bank slope of the river at a location close to the river source. The speculations of GLOF were rumored by the public and non-scientific community mainly because the risk of GLOF in recent years, owing particularly to climate change and global warming, has significantly increased with the swelling of glacier lakes in the Nepal Himalaya. Later, ICIMOD (International Center for Integrated Mountain Development) experts clarified that the possibilities of GLOF in this particular region, where there are very few glaciers and most of them do not form glacier lakes, were little (Kathmandu Post, 2012b), which probably led them to speculate the mechanism of landslide dam outburst flood (LDOF) for the debris and flood event witnessed in a completely dry time. Although it is not unusual to see a flood or debris flow in Nepal even in summer and dry periods, according to various reports, Pokhara area has witnessed this kind of debris and flash flood disaster in the Seti River in about 60 years.

As one of the interesting but less understood disaster phenomena, this flash flood event in the Seti River of Pokhara Valley and devastating debris flow in the river upstream has attracted many national and international researchers. Immediately after the disaster, many different speculations were made to understand the real cause. Difficult accessibility and less understood fragility of the mountains in the source area were probably the main reasons behind unconfirmed and only speculated interpretations of the disaster mechanism. So, in order to understand a little more about the damage process and finding out the exact cause of debris flow and flash flood, the authors' team headed for a field survey after two weeks from the disaster day. Efforts are made in this report to present a post-disaster scenario of the major disaster-hit areas and the general findings out of an inspectional field investigation program.

SETI RIVER DEBRIS-FLOOD (Continued)

2. DISASTER AREA OUTLINE

2.1. Human Settlement

Pokhara Valley is situated at the foot of the Annapurna Range of the High Himalayan Mountains (as shown in Fig. 1). The city of Pokhara currently accommodates about 250,000 registered inhabitants (Wikipedia, 2012; as of 2009) and the valley accommodates nearly half a million people (estimated figure), who have primarily settled over terraced deposits of the Seti River transported in the long geological past by glaciers and glacial debris (referred in Skermer and VanDine, 2005). The Seti River flows through almost the middle of the city, and in the heart of the city it narrows down to a few meters of width and several tens of meters of depth in the form of a gorge. If dammed up somewhere in the downstream, the risk of inundation at several locations of the Pokhara City are very high. A 3D view and elevation information of the Pokhara Valley and Seti River watershed are presented in Fig. 2.

2.2. Historical Evidences of Glacial/Debris Material Deposit

Pokhara Valley sits over the gigantic debris fan of a cataclysmic flashflood which geologists say was caused by the Seti River bursting through a landslide or avalanche dam in its headwaters below Annapurna IV about 800 years ago. They have found a soft conglomerate layer on top of granite bedrock behind Machhapuchhre (Fig. 1), which they say is where the rockfall, probably caused by an earthquake, occurred in the 15th century.

As also mentioned above, the geology of the disaster area is characterized basically of terraced glacial debris deposits, which are adequately cemented due to presence of calcium carbonate produced out of calcareous rock mass in the Annapurna mountain range. Because of this cementation, at many locations through the course of the Seti River, especially in the upstream, the river banks measure more than a hundred meters and are terraced in 3-4 layers (Fig. 3).

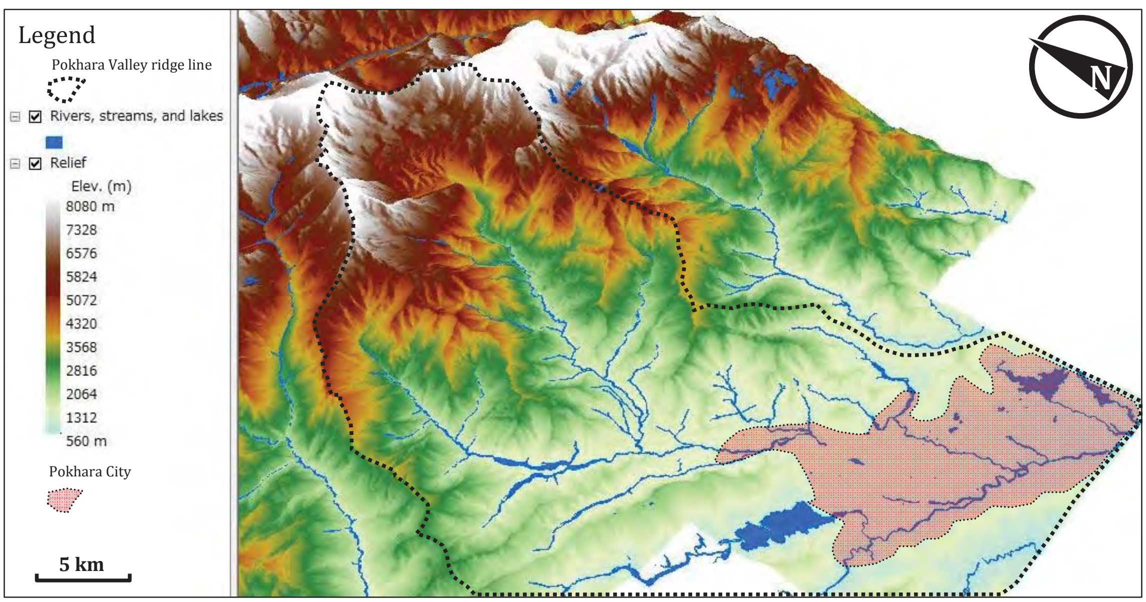

Fig. 2: A 3D view of the Pokhara Valley and Seti River watershed.

SETI RIVER DEBRIS-FLOOD (Continued)

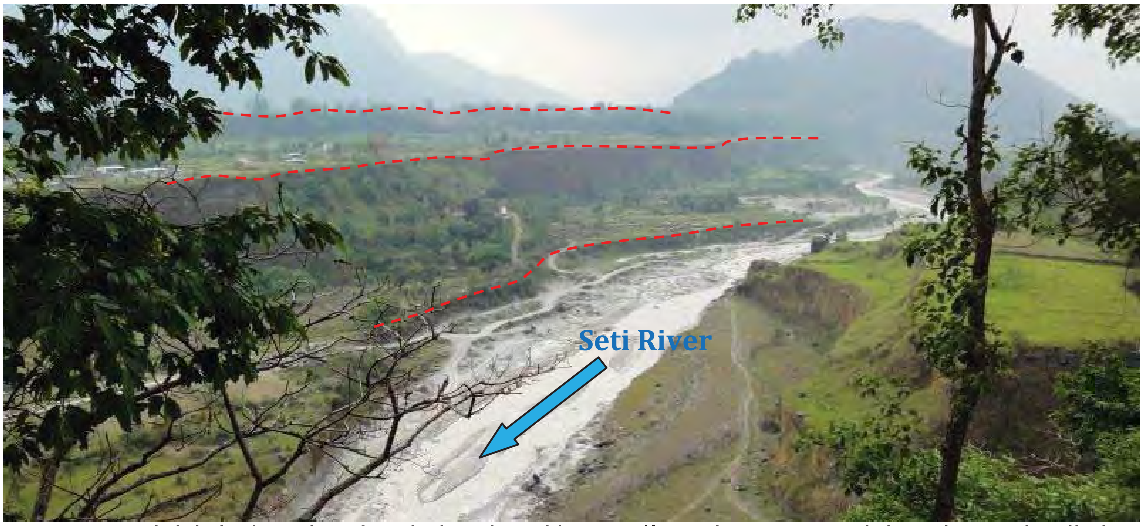

Fig. 3: Terraced debris deposits of Seti River in Pokhara Valley. These terraced deposits can be distinctly seen in the upstream but in fact, the present city of Pokhara also sits over such deposits (The location of this figure is indicated in Fig. 4).

2.3. Main Disaster-hit Areas

According to media reports and the authors' brief communication with the heads of the rescue and rehabilitation teams composed of Nepalese Army and Armed Police Force of Nepal, the main disaster-hit area, in terms of fatal loss as well as infrastructure and property damage, is Kharpani (Tatopani area).

3. DISASTER OUTLINE

Nepal usually suffers from water-induced disasters in monsoon period, which begins in June through September every year. Occasionally, however, these natural phenomena take place in peak summer as well, mainly because of the accelerated melting of the snow cap over the high Himalayan Mountains. This disaster probably has very little relation with the melting of snow and swollen river water. According to Petley and Stark (2012), the sole cause of the debris-flood is more or less confirmed to be rock slope failure (rather rock wedge fall) from an altitude of about 6,700 m on the southwest flank of the Annapurna IV (later discussed in detail in Section 5), which turns into a rock avalanche, probably mixed with the snow, and abruptly surges the Seti River water leading to powerful debris flow in the upstream and flash flood in the downstream.

As also stated in the beginning, the extent of disaster was heavily reduced by the voluntary efforts of Capt. Maximov. Yet, the fatal loss of more than 70, infrastructure and property loss of hundreds of millions of Nepalese Rupees (Note: 87 Rupees is equivalent to 1 US dollar), and higher possibilities of inundation at certain locations in Pokhara City significantly drew the concern of public, government, and national and international experts. Besides the 71 reported human deaths (including 40 unconfirmed deaths), the debris-flood swept away or destroyed 4 houses, 2 local temples, 16 temporarily erected sheds. 2 suspended trail bridges, 7 tractors, 3 mini trucks, and 1 van. Livestock loss including 52 goats and 17 cow and buffaloes was also reported (the data is based on the information provided by the rescue team). As people in the downstream were well informed of possible disaster, there was no fatal loss near the densely populated city area, but on the downstream of Kharpani, the flood swept several temporary sheds. In most occasions, the local people spent much of their time in the river for various purposes, e.g., collecting stones and sand, washing activities, dead body cremation, etc. Had there been no pre-information of the flash flood in the downstream area, the loss could have been unimaginably high. By the time the debris and flood water passed over the Set Dam (Fig. 1), what was flowing in the river visibly was muddy water with tree logs and smaller stone boulders. Most of the bigger rock and stone boulders that

SETI RIVER DEBRIS-FLOOD (Continued)

hit the Kharpani area were probably crushed into smaller pieces or might have stopped rolling in the midway, which led to reduced strength of the debris flood in the downstream. Except for a few people who were reported to have been swept away by the muddy flood water during their efforts to pull the tree logs out for the purpose of firewood or even handmade furniture near the Seti Dam, most people are believed to have been killed at Kharpani area itself. As such, there was very little damage in the downstream area, close to the Pokhara City.

4. FIELD VISIT PROGRAM

We headed for the disaster area on 18 May 2012 for the purpose of preliminary visual inspection of the debris source and disaster-hit areas of Kharpani and downstream locations (as indicated in Fig. 4). On the first day, we went up to Kharpani area, some 20 km upstream from central Pokhara and about 20 km downstream from the Annapurna Greater Depression (or Sabche Cirque), where most human casualties of this disaster are believed to have occurred in the debris mass of depth as much as 30 meters and width about 60 meters that travelled at an estimated speed of about 40 km/h through the section of Kharpani suspended trail bridge (Fig. 5). Also inspected on the same day were three other sections on the downstream: 1) about 1 km downstream from Kharpani, 2) about 8 km downstream from Kharpani, and 3) Seti dam (barrage) site, as indicated in Fig. 6.

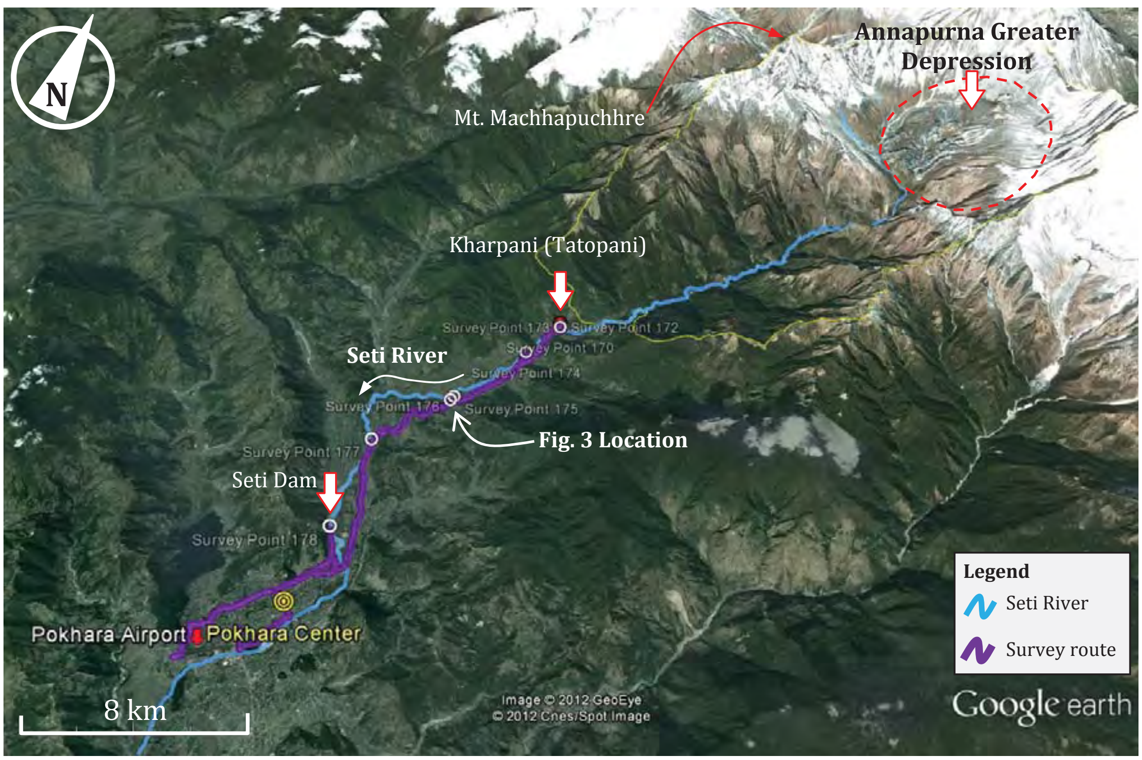

Fig. 4: Field survey (2012.5.19) route and survey points (Google earth, Imagery date: 2012.1.29).

On the second day (i.e., 19 May 2012), we conducted a one-hour aerial survey over the Seti River channel and the debris source area in the western slope of the Annapurna IV using a two-seater ultra light aircraft, which could fly at an altitude of 4,500 m. The flight course is shown in Fig. 7. Circling over the southern part of the Annapurna Greater Depression for about 10 times allowed us to capture some amazing scenes of the Annapurna IV southwest slopes, flow path of the debris-ice avalanche, and unbelievably beautiful sharp-edged ice-capped mountain ranges and pointed peaks of grayish white glacial flour (Fig. 8; the term 'glacial flour' has been adopted from Dahal et al. 2012).

SETI RIVER DEBRIS-FLOOD (Continued)

During the aerial survey, we could see no traces of landslide damming (as initially speculated by ICIMOD, 2012a, 2012b, and 2012c) in the upstream, but the gorge near the source (close to the point of confluence, Fig. 8) was so deep that no water could be seen from the sky. It might be possible however that the initial mass of avalanche debris suddenly filled the gorge and surged the water, which was powerful enough to cause the massive debris flow. The time difference between the first scene of the dust clouds over the Annapurna IV southwest slopes and the arrival of the debris flood in Kharpani area is more than evident that no landslide damming and its bursting could be so destructive in merely 40 minutes. According to Capt. Maximov, he first saw the dust clouds around 9:00AM (5 May 2012), and a photo taken by one of the picnicking college boys (Shiva Acharya, as reported by a vernacular national daily of Nepal, the Nagarik Daily; Nagarik 2012) at Tatopani area (Kharpani Area) just a few seconds before the debris flood hit the suspended trail bridge indicates that it was taken at 9:38AM. A simple calculation out of this reveals that the debris flood travelled about 20km (elevation difference: about 1,800m) in about 35 minutes, which is a very justifiable speed of a debris flow (mean gradient: 5 degrees, average speed: 10 m/s).

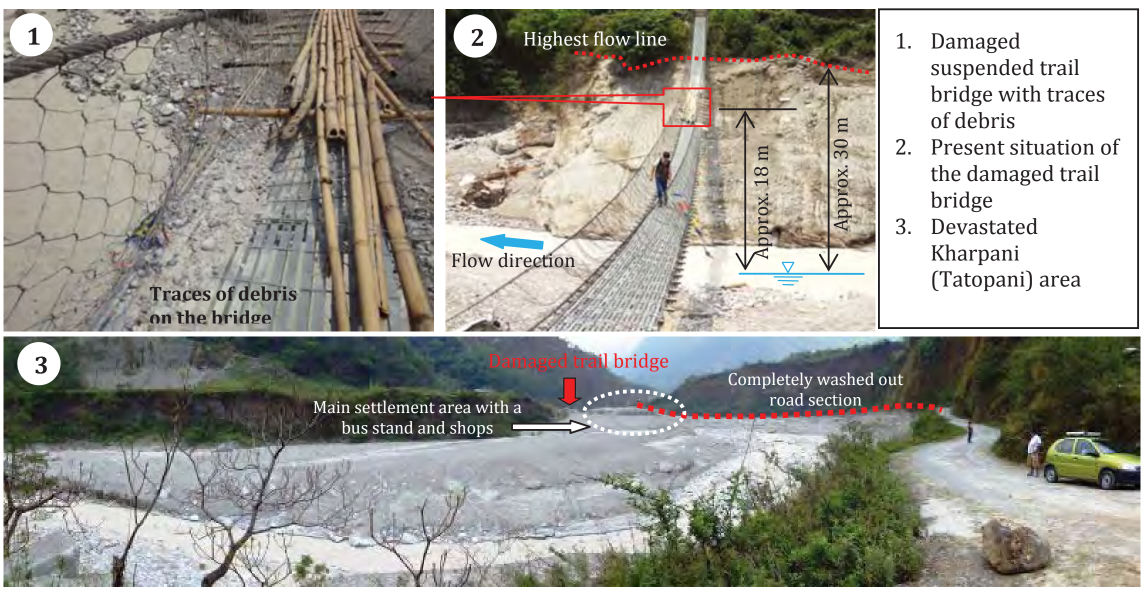

Fig. 5: Damaged suspended trail bridge in Kharpani (Tatopani) area and the devastated Kharpani area (see Fig. 4 for the location).

Fig. 6: Seti Dam area, about 4 km upstream from Pokhara city center (most live videos and photos of the flood freely available in the net were taken at this point). The dam structure has sustained the damage, mainly because at this point the debris was composed of less destructive material such as tree logs and finer particles.

SETI RIVER DEBRIS-FLOOD (Continued)

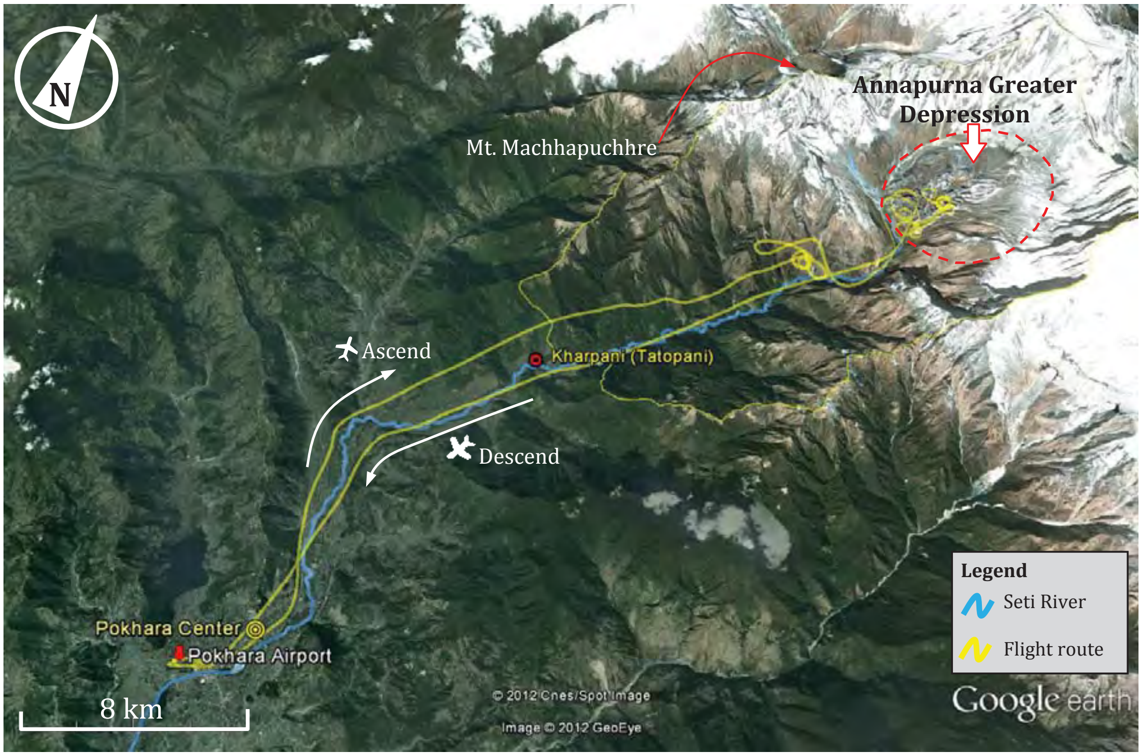

Fig. 7: Aerial survey route (2012.5.19) over the Seti River, up to the source area of Annapurna Greater Depression (Google earth, Imagery date: 2012.1.29).

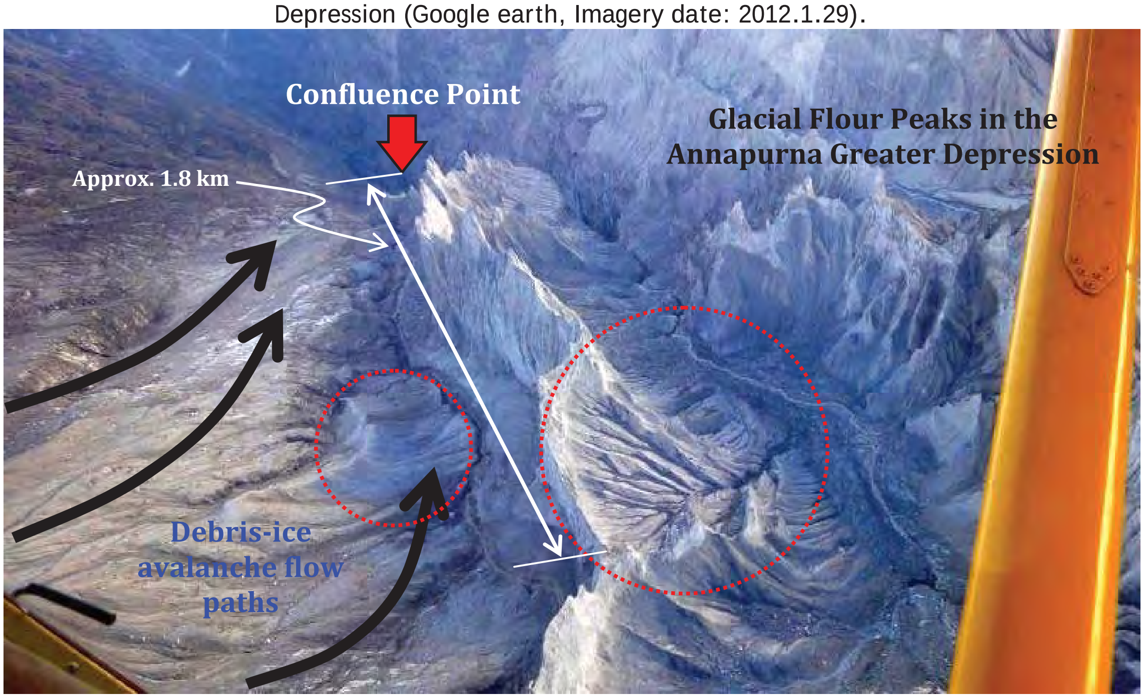

Fig. 8: Sharp-ridged ice-capped glacial flour mountains in the Annapurna Greater Depression and the flow path of the debris-ice avalanche. The big dotted circle shows wet gullies (rather valleys), which evidence that the ice caps (i.e., the whiter mass on the top) over the mountains are melting while the small circle indicates a portion of the frozen debris mass (whiter than the surrounding), which may help speculate that it was not only debris avalanche but also ice/snow mixed avalanche of debris.

SETI RIVER DEBRIS-FLOOD (Continued)

6. SCIENTIFIC ASPECT

Speculations made by various quarters led probably to wrong understanding of the mechanism involved in inducing the debris-flood in preliminary stage, but by tracing back the origin of seismic signals recorded in the global seismic network, Dr. Colin Stark of Columbia University (USA), who was closely working with Dr. David Petley of Durham University (UK), concluded that the seismic signals were generated by a massive landslide near the Annapurna IV (Petley, 2012a). Then, with the help of pre- and post-disaster satellite images Petley and Stark (2012) confirmed that the trigger of the debris-flood was rock slope failure of an estimated volume of 22 million cubic meters in the southwest flank of the Annapurna IV (also available in NASA 2012a; Petley 2012b; Petley 2012c). The Petley and Stark (2012) interpretation that the rock slope failure triggered the debris-flood in Seti River has also been confirmed by us through the comparison of a few pre- and post-disaster photographs taken by ourselves and provided by Avia Club Nepal (Fig. 9). Based on this interpretation, we have illustrated the process from rock slope failure to flow of disintegrated debris mass, probably mixed with ice and snow, into the Seti Gorge at the point of confluence in Fig. 10.

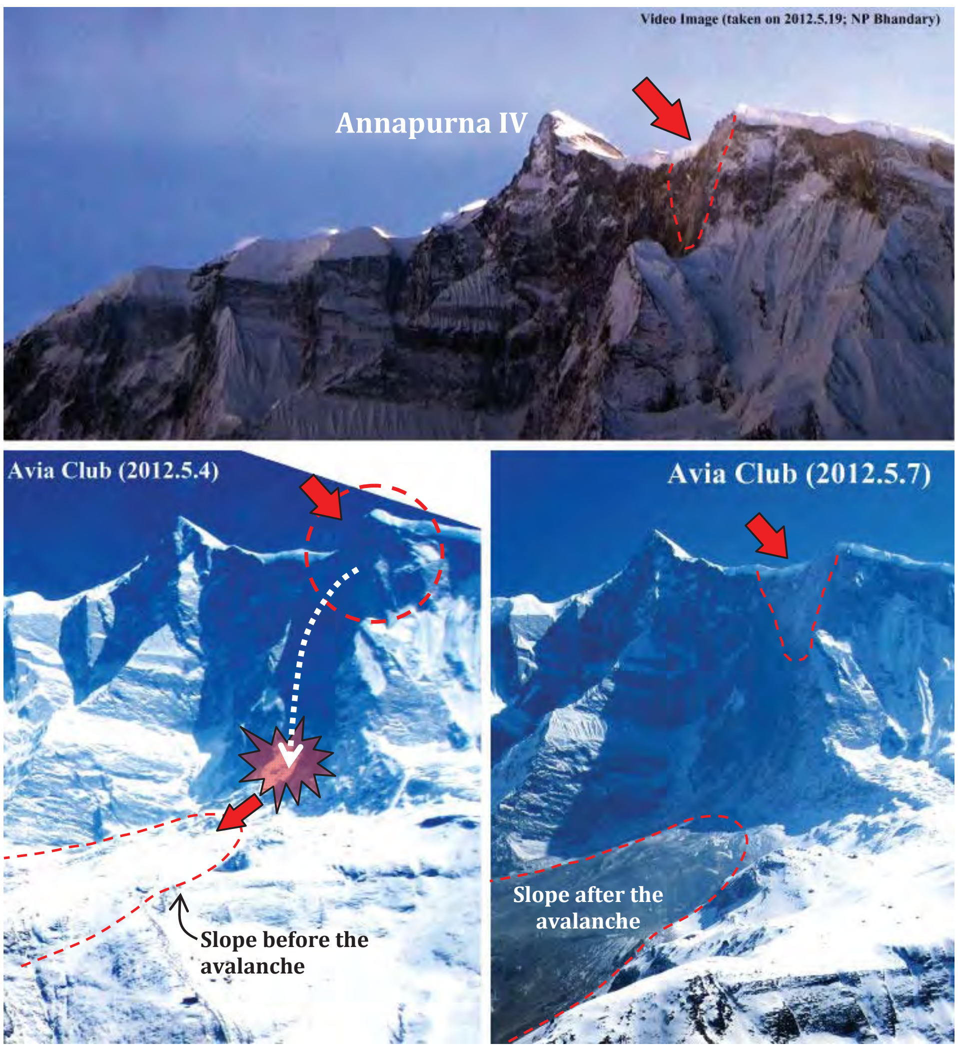

Fig. 9: Comparison of pre- and post-failure states of Annapurna IV southwest flank captured on 4th May, 7th May, and 19th May images. The tip of the ridge seen on 4th May image (circled) is missing on 7th and 19th May images, which was first confirmed by Petley et al. (2012) through satellite images and later confirmed with the help of the Avia Club-provided photo of 7th May.

SETI RIVER DEBRIS-FLOOD (Continued)

Thus, based on the above interpretation, the scientific aspects of the 1255 Seti River disasters can be discussed in three stages: 1) rock slope failure at an altitude of about 6,700 m and its fall off a height of about 1,500 m (Fig. 10), 2) breakage of the failed rock mass into pieces and debris (probably mixed with the snow and ice mass) travel through the Annapurna IV southwest slopes up to the river confluence (see Fig. 8 and Fig. 10), and 3) generation of debris slurry at the confluence point and its flow downstream. In the first process, many different factors may be involved in preparing and inducing the failure, such as contraction and expansion of rock mass due to climate change effects, annual temperature variations, stress release due to reduction in snow/ice cover, tectonic activities and resulting uplift of the rock mass, expansion of ice mass in the rock mass joints, external forces of frequent imperceptible earthquakes and amplitude excitation at higher altitudes, etc. The second process can also be explained from impact energy principle. The extensive potential energy of the failed rock mass over a height of about 1,500 meters could have been unimaginably high to break the failed rock wedge, which might have been partly disintegrated due to the factors listed in the first process, into pieces or even to pulverize it. As the southwest slopes of the Annapurna IV (see Fig. 10), where the failed rock mass is supposed to have disintegrated into pieces producing a large amount of dust clouds, have an average gradient of about 18 degrees, the debris mass with boulders as big as several meters of effective diameter might have slid or rolled over thick ice mass or even over the glaciers at a very high speed. Chances are also high that the ice/snow cover on the slope also failed in the form of a debris-ice avalanche, and due to great frictional heat produced because of the debris movement, the ice or snow mass might have melted in a very short time leading to even accelerated movement of the debris towards the point of confluence (Fig. 8 and Fig. 10). A few things in the second process remain unconfirmed, but more or less through the image analysis, the failed rock mass has been confirmed to have traveled from the point of impact to the point of confluence by ordinary mechanism of material movement over a mountain slope although the mechanism of abrupt disintegration or pulverization of the failed rock mass needs to be addressed more scientifically.

The third process however still remains unclear, mainly because the amount of water that flowed in Seti on the day of disaster was so high that the ordinary flow, which was roughly estimated by the authors to be around 10 m^3/s on 18 May 2012 at Kharpani area and it could have been even less in the upstream on 5 May 2012, cannot be expected to turn into a flood unless and until the flow is dammed up for several days or weeks. The time difference of only about 38 minutes from the first witness of the dust clouds over Annapurna IV southwest slopes and arrival of the debris-flood at Kharpani (a distance of about 25 km), as already mentioned, confirms that the river water was probably never dammed up. The only speculations that could be made for this particular process may be: 1) the debris avalanche turned into a debris-ice avalanche and in the process of flow, the whole ice/snow mass over the Annapurna IV southwest slopes melted due to frictional heat by the time the avalanche arrived at the point of confluence or after falling into the gorge bottom at this point (authors' speculation), or 2) near the point of confluence, there are hidden huge pockets of water, which might have been broken by the debris mass (speculated by Shrestha et al., 2012a, 2012b), or 3) there was a large hidden lake beneath the point of confluence or a little below this point, which was suddenly filled out by the debris leading to surged water (somewhat similar to Shrestha et al. 2012a, but speculated by the authors), or 4) a mixed process of the above three speculations. We hope our future investigation programs will reveal further the mechanism behind the above three processes of the Seti River debris-flood disasters.

SETI RIVER DEBRIS-FLOOD (Continued)

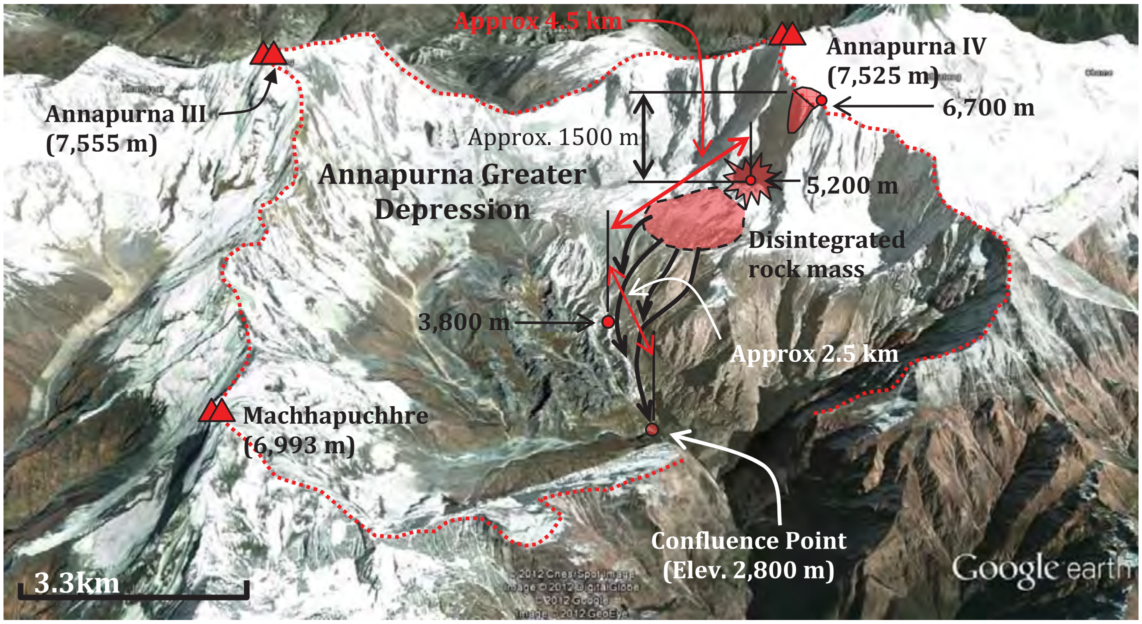

Fig. 10: Illustrated rock slope failure in the southwest flank of Annapurna IV including approximate fall height and distances traveled until the failed and disintegrated or probably pulverized rock mass entered the Seti gorge at the point of confluence. (Google earth, Imagery date: 2011.12.30).

7. CONCLUDING REMARKS

Based on the visual survey we conducted and on available pre- and post-disaster images and reports, we have also confirmed that the debris-flood in the Seti River was triggered by the high-altitude massive rock slope failure. However, we still largely speculate that it was debris-ice avalanche generated out of the failed rock mass at the southwest flank of the Annapurna IV, which caused the debris-flood in the Seti River. The mechanisms involved in this type of debris flow and flash flood have certainly drawn a great interest of scientific community, not only for the purpose of understanding the disaster mechanism and mitigating future losses in similar hazardous zones in Nepal and the Himalaya, but also as a science involved in one of the amazing natural processes in the High Himalayas.

Global warming and climate change have also been time and again talked of to have extended significant impact on the melting rate of snow cover and glaciers on the Himalayan Mountains leading to largely swollen volumes of glacier lakes. Although the cause of this particular disaster event may not be directly attributed to climate change effects, the process of rock slope failure, probable melting of the snow/ice on the slope or its immediate transformation into snow/ice avalanche triggered by the rock mass failure, or accelerated melting of the debris-ice mix may be somehow related to the gradual effect of climate change on the Himalaya.

Moreover, the effects of climate change on the Himalaya in the last 10-15 years have been only talked of in terms of the risk of glacier lake outburst floods (GLOF). This particular disaster however has alarmed us of many similar disasters in future. It may not only happen in Pokhara, but many other areas in Nepal Himalaya may also be prone to witnessing a similar disaster in future. This largely necessitates some urgent plan to assess similar hazards in Nepal as well as the Himalaya. Furthermore, to mitigate potential disaster risk in Pokhara as well as other identified places, some early warning mechanism must be established. Particularly in Pokhara which feeds Nepal through its significant contribution in tourism sector a debris-flood disaster early warning system is of immediate need.

SETI RIVER DEBRIS-FLOOD (Continued)

ACKNOWLEDGEMENTS

First of all, the cooperation received from ATC3 Chairman Prof. Ikuo Towhata of the University of Tokyo for making this investigation program a part of the ATC3 activities is sincerely acknowledged. President of Nepal Geotechnical Society Mr. Tuk Lal Adhikari also helped in making it a joint effort of with the ATC3 and provided some preliminary information to the authors. Avia Club Nepal Manager Mr. Pravin Gauchan fully cooperated with the authors during the negotiations for the aerial survey, and Capt. Alexander Maximov and Capt. Stephen Shrestha made all their great efforts to show the authors the Annapurna Greater Depression, the Seti River source, and the avalanche origin, Rescue Team of the Nepalese Army and Armed Police Force of Nepal is also appreciated for explaining to the authors the devastated situation of the Kharpani area.

REFERENCES

Dahal, R. K., Bhandary, N. P., Okamura, M. 2012. Why 1255 flash flood in the Seti River? – A Brief Report, http://www.ranjan.net.np/ranjan/index.php/in-english-seti (Published: 2012.5.27; Accessed: 2012.5.27)

ICIMOD, 2012a. Flash flood in Nepal causes loss of life and property, http://www.icimod.org/?q=7122 (Published: 2012.5.6; Accessed: 2012.5.12).

ICIMOD, 2012b. Flash flood on 5 May, 2012 in Seti River, Pokhara, Nepal, http://geoportal.icimod.org/NAE/NewsDetail.aspx?NewsID=318 (Published: 2012.5.7; Accessed: 2012.5.10)

ICIMOD, 2012c. Seti flash flood reconnaissance visit, http://www.icimod.org/?q=7134 (Published: 2012.5…; Accessed: 2012.5.22)

Kathmandu Post, 2012a. New insight into Seti Flood cause, Post Report, The Kathmandu Post, 2012.5.12.

Kathmandu Post, 2012b. Seti flash flood not from glacial lake outburst, suggest experts, Post Report, The Kathmandu Post, 2012.5.6

Nagarik 2012. A photo report on the front page of Nagarik Daily, a vernacular national daily newspaper of Nepal, 2012.5.9

NASA, 2012a. Landslide and Deadly Flood in Nepal: Image of the Day, http://earthobservatory.nasa.gov/IOTD/view.php?id=78070&src=iotdrss (Published: 2012.5.24; Accessed: 2012.5.24)

NASA, 2012b. Aftermath of the Seti River Landslide http://earthobservatory.nasa.gov/IOTD/view.php?id=78117 (Published: 2012.5.29; Accessed: 2012.6.2)

Petley, D., 2012a. Using seismic data to analyse the Seti River landslide in Nepal, http://blogs.agu.org/landslideblog/2012/05/09/using-seismic-data-to-analyse-the-seti-river-landslide-in-nepal/ (Published: 2012.5.9; Accessed: 2012.5.10)

Petley, D., 2012b. More information on the landslide that caused the Seti Flood in Nepal, http://blogs.agu.org/landslideblog/2012/05/12/more-information-on-the-landslide-that-caused-the-seti-flood-in-nepal/ (Published: 2012.5.12; Accessed: 2012.5.13)

Petley, D., 2012c. More information about the Seti River landslide and debris flood in Nepal, http://blogs.agu.org/landslideblog/2012/05/30/more-information-about-the-seti-river-landslide-and-debris-flood-in-nepal/ (Published: 2012.5.30; Accessed: 2012.5.31)

Petley, D. and Stark C. P., 2012. Understanding the Seti River landslide in Nepal http://blogs.agu.org/landslideblog/2012/05/23/understanding-the-seti-river-landslide-in-nepal/ (Published: 2012.5.23; Accessed: 2012.5.25)

Skermer, N. A. and VanDine, D. F., 2005. Debris Flows in History: Alpine Debris Flows (Asia), Chapter 3, "Debris-flow Hazards and Related Phenomena," eds. M. Jakob and O. Hungr, 2005, Springer-Verlag.

Shrestha, A. B., Mool, P., Kargel, J., Shrestha, R. B., Bajracharya, S., Bajracharya, S., and Tandukar, D., 2012a. Quest to unravel the cause of the Seti flash flood, 5 May 2012, ICIMOD, http://www.icimod.org/?q=7377, (Published: 2012.6.25; Accessed: 2012.7.6)

Shrestha, A. B., 2012b. 5 May: Quest to unravel the cause of the Seti flash flood, ICIMOD http://www.icimod.org/?q=7462 (Published: 2012.7.3; Accessed: 2012.7.6)

Wikipedia, 2012: http://en.wikipedia.org/wiki/Pokhara (Accessed: 2012.6.30)