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FCSEC Technical Report
Volume 3

The Mayon 2006 Debris Flows

The Destructive Path of Typhoon Reming

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October 2007

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The Mayon 2006 Debris Flow[1]

The Destructive Path of Typhoon Reming (Int'l Name: Durian)

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Key words : landslide, debris flow, flashflood, hazard mapping, early warning system, public information & education campaign

Abstract

The Philippines geographical location and natural conditions expose the country to hydrometeorological hazards like landslide, debris flow and flashfloods. Records of unusually high precipitation events contribute to the increasing trends in the occurrence of water-related and sediment-induced disasters in the country. It has almost been a year since the disaster in Southern Leyte province occurred. About 1,000 people died in the landslide that buried Barangay Guinsaugon in St. Bernard town.

Ten months after the tragedy, another misfortune happened. Super typhoon "Reming" crippled the Bicol Region, especially the province of Albay, after pummeling it with strong winds and heavy rains that resulted in debris flows. One thousand bodies are believed to have been buried in the debris and mud that swept over the towns of Santo Domingo, Daraga and Guinobatan and Legazpi City.

Coping with floods and sediment disasters has always been a challenge to the Philippine Government. The Department of Public Works and Highways (DPWH) - the engineering and construction arm of the government listed in its Medium Term DPWH Infrastructure Development Plan (2004-2010) the promotion of non-structural measures on top of primed structural measures to reduce the vulnerability of societies to floods.

Priorities for non-structural measures include the development of multi-hazard maps for all regions in the Philippines by delineating the attendant geologic and hydro-meteorological hazards, establishment of community based early warning system and promotion of awareness to communities at risk through public information and education campaign. On the other hand, structural measures are aimed in providing adequate flood control and sabo facilities in all flood/sediment disaster prone areas.

This paper discusses the result of damage investigation and disaster survey of Region V conducted by Japanese Survey Team together with JICA Experts and staff from FCSEC from 10-16 December 2006.

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[1] FCSEC Technical Paper Vol. 3, October 2007
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1. Physical Setting and Hazards Around Mayon

1.1 Topography

Figure1 Province of Albay, Bicol Region
Source : JICA-FCSEC-Japan Survey Team December 2006

Bicol Region or Region V is one of the 16 regions of the Philippines occupying the Bicol Peninsula at the southeastern end of Luzon island. The Bicol Region stretches towards the Pacific Ocean for more than 160 miles and is composed of four contiguous provinces: Albay, Camarines Sur, Camarines Norte, Sorsogon and two island provinces of Catanduanes and Masbate. It has a total land area of 17,632,400 square kilometers.

1.2 Meteorology and Hydrology

The western and southern parts of the Bicol Region along Camarines Sur and Camarines Norte and Albay do not have pronounced dry and wet seasons. Rainfall in this areas are evenly distributed the year round, which make them suited to agriculture. The eastern and northern portion of the region are characterized by a definite absence of dry season with a very pronounced maximum rain period from November to January. As of 2000, the Bicol Region registered a population of about 4,755,076 which represented 8% of the country's total population.

According to the climatological classification in the Philippines, the eastern part of the Albay Province belongs to Type II climate and the western part belongs to Type IV. The area around Mayon is characterized by an indistinct dry season and a very pronounced maximum rainfall period from September to January. The long-term annual rainfall observed from 1961 to 1995 at Legazpi Station of PAGASA is 3,354mm. Total rainy days per year in Legazpi is measured as 221 days (60%) on the average. According to the data on tropical cyclones that affected the Bicol Region during the period 1987-1996, 8.4 tropical cyclones pass over the region in a year on average.

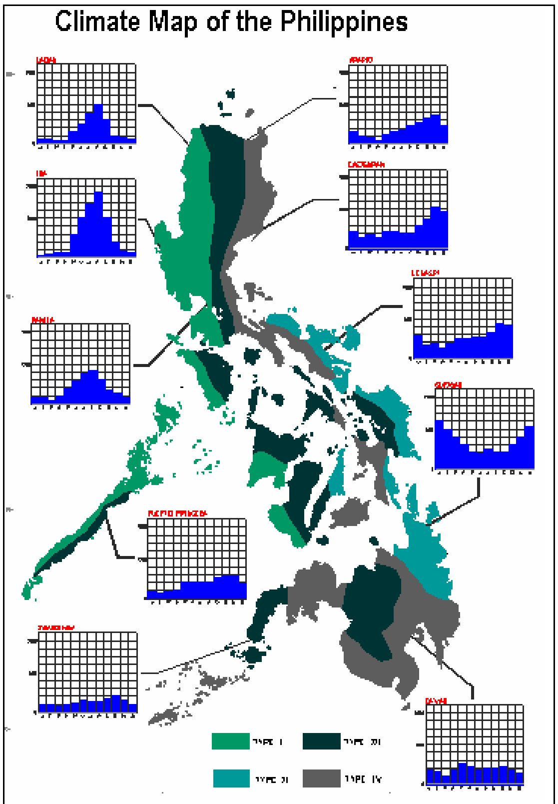

Figure2 Climate Map of the Philippines
Source : Study on Flood Control Project Implementation System for Principal Rivers in the Philippines Sept. 2004

1.3 Geology

Pre-Mayon volcanic rocks that are found in the hills of Ligao, Sto. Domingo, Malilipot and Guinobatan consist of partly weathered dacite and andesite. Lava flows deposited on volcanic mountain slope consist of andesite lava. Riverbed material is also composed largely of hardrock (andesite, basaltic andesite) and porous rock. Pyroclastic flow deposit area is composed of ash and dark gray scoria fall deposit, primary pyroclastic flow deposit and secondary debris flow.[6]

2. Geomorphologic Classification of Mayon Volcano

Figure3 Wide photo of Mt. Mayon showing the Busay gully where widespread debris flow occurred.
Source : JICA-FCSEC-Japan Survey Team December 2006

Mayon Volcano is classified as strata volcano or composite cone. It consists of deposits fromed basically by four (4) major types of volcaniclastic material: lava flows, airfall deposition, pyroclastic flows, and lahar flows triggered by rainfall.

The 2,462-meter Mayon, is famous among local and foreign tourists for its near-perfect conical shape despite dozens of eruptions in the past three centuries. Mayon is the most active volcano in the Philippines, which erupts every ten (10) years. The eruption of February 24, 2000 was Mayon's 47th since its first recorded upheaval in 1616. Mayon's last major eruption was in February 1993, when 70 people died and more than 50,000 people were evacuated. Its deadliest eruption was in February 1, 1814 when the the entire town of Cagsawa was burried. Debris flow including lahar flow refers to the massflow phenomenon containing volcanic materials and resulting deposit thereof. At Mayon Volcano, lahar is one of the most persistent hazards occuring not only during eruptive periods but also during repose periods. Lahars at Mayon are primarily triggered by intense precipitation upon loose, unconsolidated materials.[7]

3. Typhoon Reming

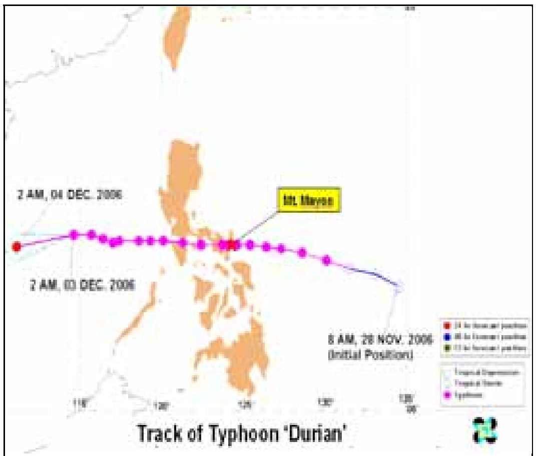

Figure4 Monitored typhoon track of Typhoon Durian which made landfall on Bicol on November, 30, 2006.
Source : PAGASA

On the international front, the Tropical Rainfall Measuring Mission (TRMM) satellite captured the track of Typhoon Durian (locally known as "Reming") on November 29, by which time the storm had reached super typhoon status, with winds of 240 kph (150 mph).

Typhoon Durian made landfall on the South eastern part of the Luzon island on November 30, 2006. The weather bureau, Philippine Atmospheric, Geophysical, Astronomical Services and Administration (PAGASA) recorded sustained winds of 190 kilometers per hour (118 mph) with gusts to 225 kph (140 mph) when the storm made landfall.

The 24th tropical depression from the Western Pacific, it formed in the early morning of Nov. 26 (local time), south of Guam and became a tropical storm, named Durian, later the same day.

[6] Final Report, Volume II: Main Report Master Plan and Feasibility Study, The Study on Comprehensive Disaster Prevention Around Mayon Volcano JICA/DPWH, 2000.
[7] Umbal, J.V., Masigla, L.,M., Geronimo, S., Lahar Hazard Risk Assessment of Mayon Volcano, Phivolcs Technical Report, 1984.

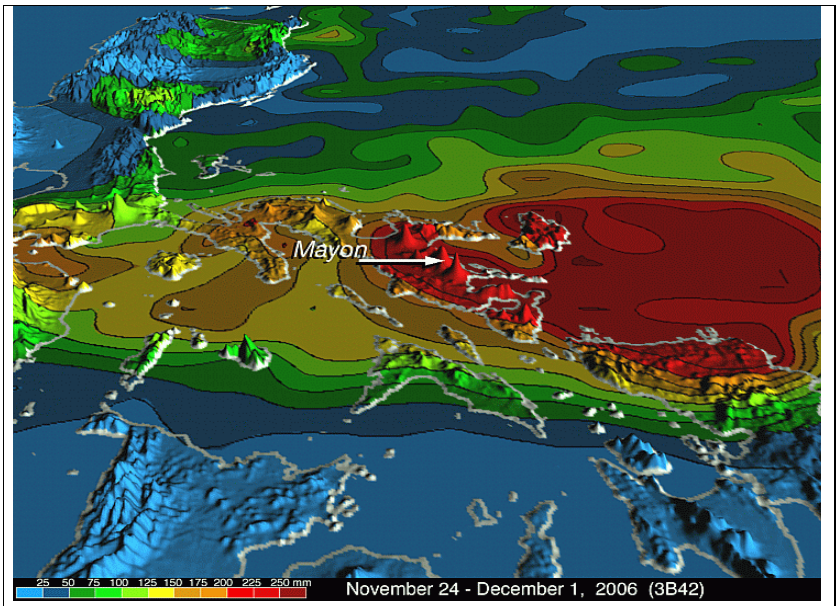

Figure5 Multi-level Precipitation Analysis of Durian showing high concentration of rainfall in the Province of Bicol, including Mt. Mayon
Source : NASA Tropical Rainfall Measuring Mission

The image above taken at 6:50am local time as Durian was bearing down in Albay in the Central Philippines. The image also shows the accumulated rainfall intensity as it affected Mt. Mayon. Durian eyewall passed slowed down over Albay before continuing westward through the central Philippines.

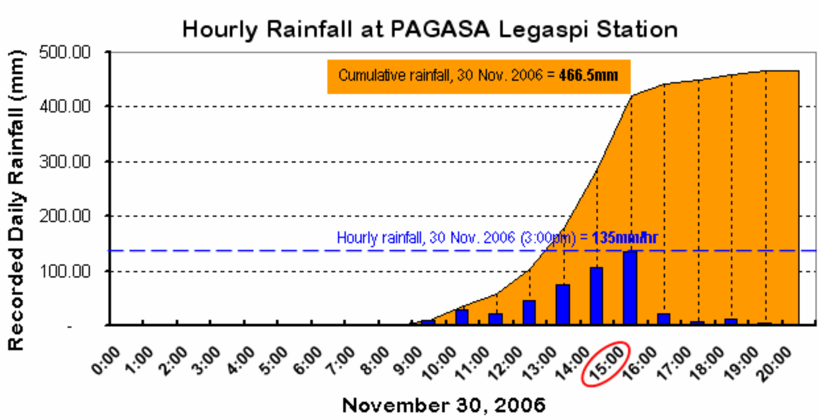

Figure6 PAGASA hourly rainfall of Typhoon Durian on 30 November 2006 which recorded cumulative rainfall of 466mm (40 year high).
Source : PAGASA Legazpi, Albay – Station 444

According to PAGASA, Typhoon Durian (Reming) generated 466 millimeters of rainfall for a 12-hour record (daily rainfall) on 30 November 2006, the day widespread debris flow occurred. It was 40 years ago when similar amount of rainfall was last recorded in the Province of Bicol. Typhoon Durian moved slowly over Legazpi and overwhelmed the area with rainfall intensity of 135 mm/hr (3:00pm hourly rainfall data).

4. Disaster Data

As of 16 Dec 2006, the Bicol Provincial Disaster Coordinating Council (PDCC) has reported 518 people confirmed dead and some 648 missing, while 45, 199 houses were partially damaged and 68, 617 houses were totally damaged. Summarized below is the data of affected people and properties in Region V, caused by Typhoon Reming.

Final Report on the Effects of Typhoon "Reming" on Region V

DATE : 16 December 2006

Affected Municipalities	Dead	Missing	Damaged Houses	
			Totally	Partially
Tiwi			4,157	5,492
TabacoCity	9		8,905	5,426
Malilipot	3	2	2,478	468
Bacacay	5		5,648	2,231
Sto. Domingo	24	6	3,855	3,106
Legazpi City	75	181	3,768	8,602
Manito	2		2,979	2,142
Rapu-rapu	15		2,742	1,184
Daraga	141	199		
Camalig	29	13	7,491	6,268
Guinobatan	197	243		
Oas	5	3	6,928	2,055
Ligao City	6		2,124	2,323
Pioduran	5	1	2,016	5,671
Polangui	1			
Libon	1		15,526	231
Total	518	648	68,617	45,199

Source : Bicol Provincial Disaster Coordinating Council / Provincial Disaster Operation Center

5. Japan - JICA – FCSEC –Survey Team Site Investigation

The Government of Japan sent experts from its Ministry of Land, Infrastructure and Transport (MLIT) weeks after the disaster. Together with the Japan International Cooperation Agency (JICA) Experts and staff from the Department of Public Works and Highways - Flood Control and Sabo Engineering Office (DPWH-FCSEC), the team conducted damage investigation of vital flood control and sabo structures and disaster survey of affected areas (10-16 December 2006). The Japan - JICA – FCSEC Survey Team is composed of the following:

Survey Team from Ministry of Land, Infrastructure and Transport of Japan (MLIT)

- Mr. Ryosuke Tsunaki - Director, Research Center for Disaster Risk Management, NLIM, Japan
- Mr. Wataru Sakurai - Senior Researcher, Volcano and Research Team Erosion and Sediment Control Research Group Public Works Research Institute, Japan
- Mr. Hidehiko Manzen - Manager of Planning Department, Sabo Technical Center

Survey Team of DPWH / Flood Control and Sabo Engineering Center (DPWH-FCSEC)

- Mr. Yoshio Tokunaga - JICA Chief Advisor, Project for Strengthening the Flood Management Function of DPWH
- Mr. Takeo Mitsunaga - JICA Sabo Engineering Expert
- Engr. Michael T. Alpasan - Engineer IV, FCSEC
- Engr. Jerry A. Fano - Engineer III, FCSEC

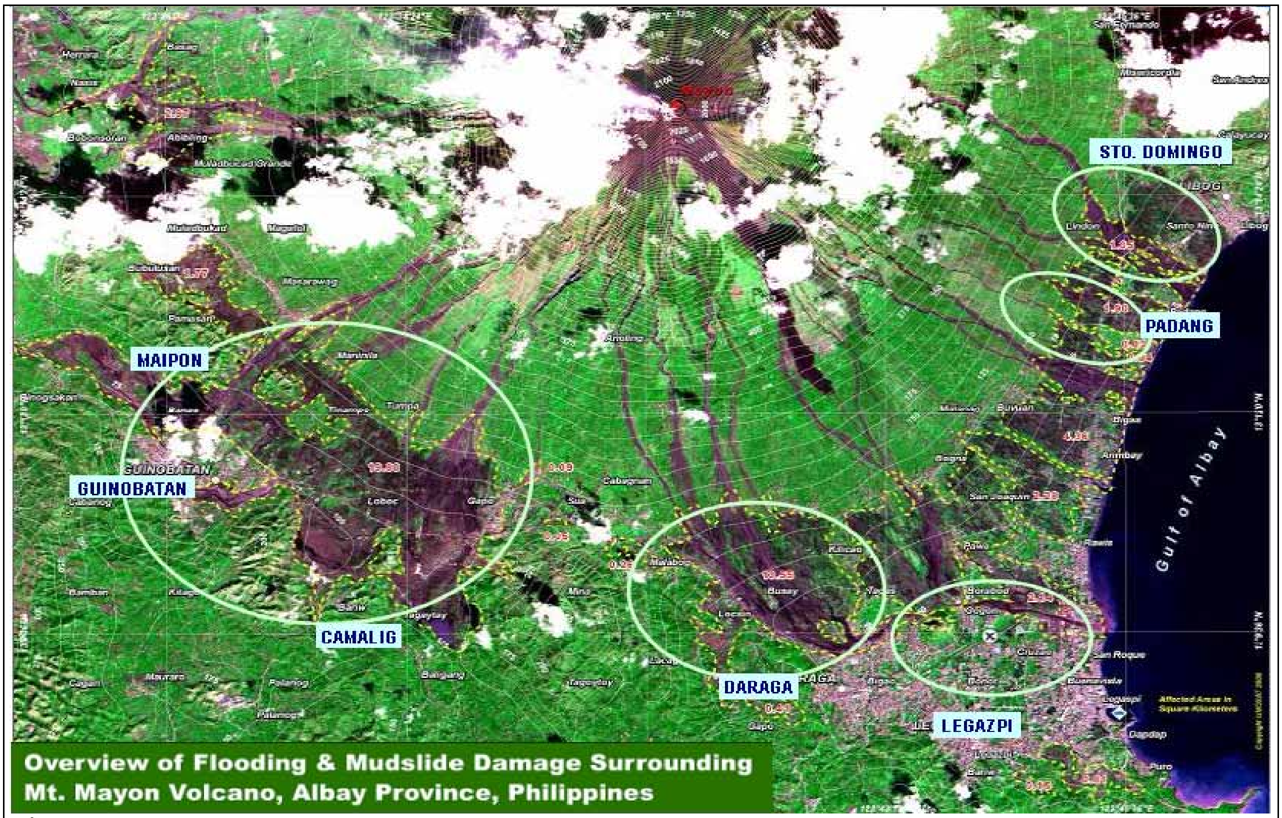

Figure7 Satellite image showing areas affected by flooding and mudslide in the municipalities surrounding Mayon.
Source : UNOSAT / JICA-FCSEC-Japan Survey Team December 2006

6. Mechanism of Disaster

6.1 Mayon Mountain Slope Profile and Riverbed Slopes

The topographical profile of Mayon Volcano has an extraordinary symmetry. Its summit level is 2,462m above sea level and covers an area of 254 km^2 which is divided on the margin of fan landform. The mountain slope has steep gradient (1/2.5) from the summit down to 500m above sea level. From 500m down to 200m above sea level, it becomes little gentle gradient (1/7.8) more than upper reaches. From 200m level down to the sea base, it has gently sloping sides (1/40).

Classification of Slope Gradient on Mayon Volcano

Elevational Classification by Slope Gradient (m)	Displacement of Elevation (m)	Horizontal Distance from Summit (m)	Horizontal Area (km^2)	Slope Gradient
2,469 - 1,000	1,469	2,330	17	1 / 1.6
1,000 - 500	500	4,000	50	1 / 3.3
500 - 200	300	6,330	126	1 / 7.8
200 - 10	490	9,000	254	1 / 12.3
10 - 0	10	10,300	333	1 / 100

Source : Final Report: Study on Comprehensive Disaster Prevention Around Mayon Volcano, Oct. 2000

6.2 Factors that Contributed to Debris Flow

The debris flows at Mayon are generally triggered by intense and prolonged rainfall as a result of monsoon rains or the passage of a typhoon within its vicinity. Eruptive products play a major role in debris flow remobilization and deposition. Main sources of debris include old and recently emplaced pyroclastic flow deposits, ashfall/tephra fall deposits, old and new lahar materials deposited along the catchment areas of various river systems on the volcanic slopes.[8]

Additional debris materials were incorporated during transport by lateral and vertical erosion of confining channels. Generally loose materials resting on slopes in excess of 20 degrees are unstable and are readily susceptible to mobilization.

6.2.1 Guinobatan, Albay

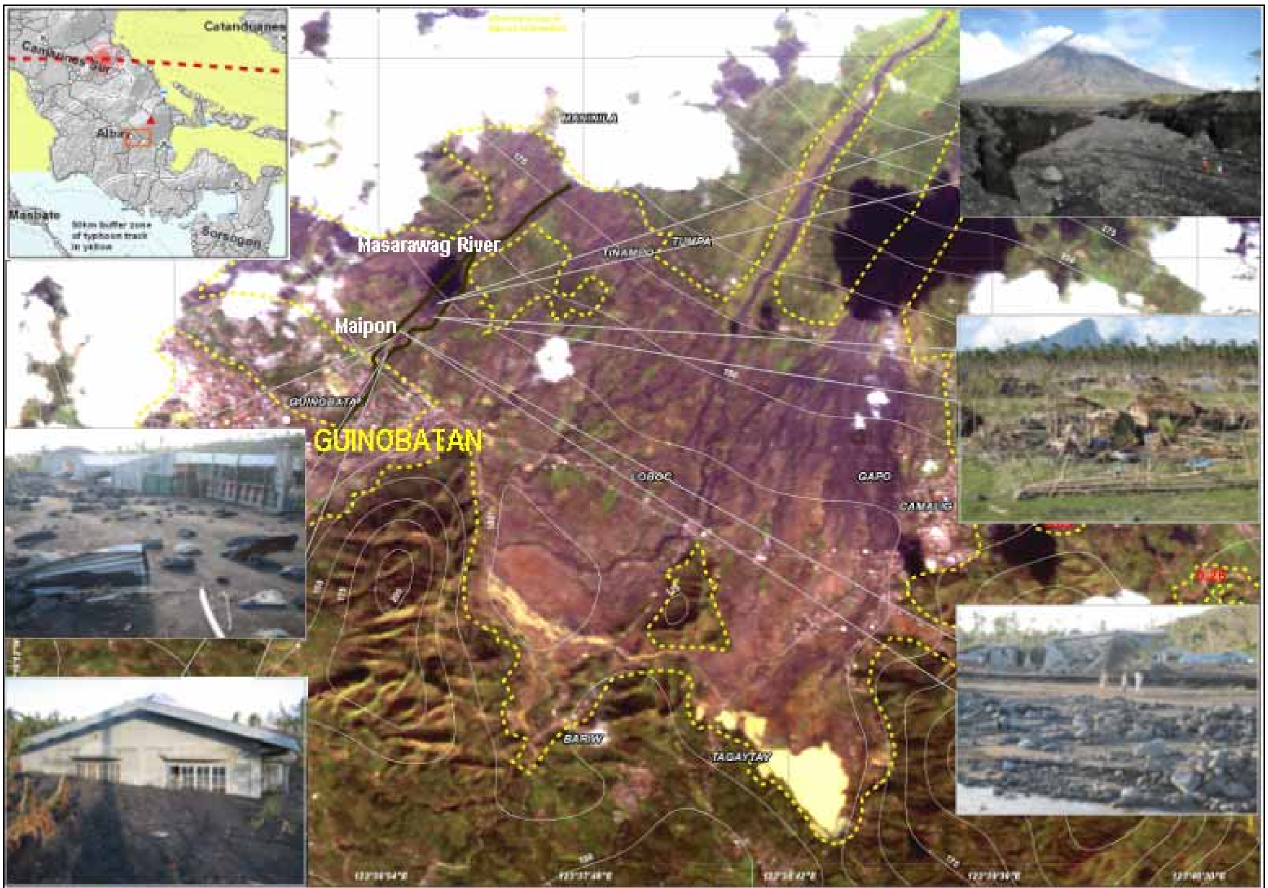

Figure8 Barangays Maipon and Masarawag, Guinobatan, Albay
Source: UNOSAT / JICA-FCSEC-Japan Survey Team December 2006

Guinobatan is a 2nd class municipality in the Province of Albay. When Typhoon Durian bore down on Guinobatan, numerous debris flows occurred and almost 200 people killed and more than 300 are lost. According to the 2000 census, the Municipality of Guinobatan has a population of 71,071 people in 14,154 households. Barangays Maipon and Tandarora, two of the heavily affected communities in Guinobatan are situated at the slope of Mt. Mayon with slope of 4º with boulders and trees surrounding the landscape.

[8] Lahar and Flood Hazard Mapping and Assessment after Super Typhoon Reming and Typhoon Seniang, Phivolcs Report of Investigation, Dec. 2006.

According to the inhabitants of the Barangay Maipon, the morning of 30 November 2006 was marked with slight rainfall. This intensified around 10 a.m. and developed into heavy downpour at 2 p.m. About this time, electricity including communication lines was cut off. Not long enough, creeks with small streams were inundated, with the water quality turning into mudlike. Without warning, the water level rose and inundated the whole of Barangay Maipon, with the torrent of debris flow becoming strong. At 2:30 p.m. the debris flow affected the main streets of the barangay and caught many people unaware. Houses were obliterated and washed away by the intense torrent of debris flow. Some people fled to safety by crossing the strong current towards elevated land, but debris flow hit them with strong impact killing them instantaneously. Some houses were flattened by debris flow to the ground level. While other houses made up of light construction materials (e.g., nipa, bamboo, sawali, etc.) were completely swept by the strong current. Several bodies were found were found 2-3 km downstream near the river mouth.

Figure9 Main roadway was buried by debris flow even public transportations were immobilized.

Figure10 The debris flow surged rapidly down Mayon and deposited in communities situated below, burying communities.

Figure11 Whole of the Brgy. Maipon was buried under debris flow.

Debris flow was deviated to Brgy. Maipon when a 50m wide and 10m deep Masarawag gully was formed during the height of typhoon Reming. The said deep gully acted as channel to the convulsive mixture of volcanic debris caused by lateral and vertical erosion. The amount of sediment transported was massive considering the changes in the gully cross section profiles.

DPWH, in association with JICA, conducted feasibility studies related to sediment disaster prevention and flood control facilities in Mayon, these include:

a. Study on Mayon Volcano Sabo and Flood Control Project (1978-1981)
b. Study on Comprehensive Disaster Prevention Around Mayon Volcano (1998-2000)

Based on 1981 Study, P2.1 Billion for a period of 10 years should be earmarked for construction of sabo structures around Mayon. However, only P200 Million fund was actually released by the Philippine Government over a period of 10 years. Implementation schedule was even deferred due to slow release of budget. After the eruption of Mayon in 1984, construction of sabo projects commenced.

Figure12 Debris flow between the municipal boundary of Camalig and Guinobatan

Figure13 Extensive gully formed from a small creek during the typhoon. Residents observed that this is where large debris cascaded.

Figure14 Training dike constructed by DPWH Regional Office on October 1989 trapped debris flow from affecting adjacent barangays.

After the disaster, the DPWH - Regional Office V undertook rehabilitation plan of the damaged flood control and sabo structures. River systems have now become heavily silted with sediments affecting communities (e.g., Padang River which is now totally filled-up with sediments, Debris flow burying the barangays of Tandarora and Maipon, etc.).

The DPWH Regional Office has also to contend in finding safe and appropriate relocation sites for the displaced families after the disaster and those still living near high risk areas. This is compounded due to the problem of procuring land for evacuation centers due to the absence of counterpart fund from the local government. An example is the flooding/bank scouring problem in Barangay Binitayan, where many persons were killed especially those living near the river bank.

Moreover, the dredging works that is, clearing of existing channels with spoils placed as earthdike embankment, done by the DPWH District Engineering Office in the Masarawag River acted as a barrier that protected the communities (Brgys. Maninila and Masarawag) against debris flow. However, in the case of Brgy. Maipon – where dredging has yet to be undertaken, many people died considering that the river channel is heavily silted resulting to incapacity of the waterways to convey floodwater/debris flow subsequently overtopping of the natural banks, which resulted to widespread flashflood.

6.2.2 Daraga, Albay

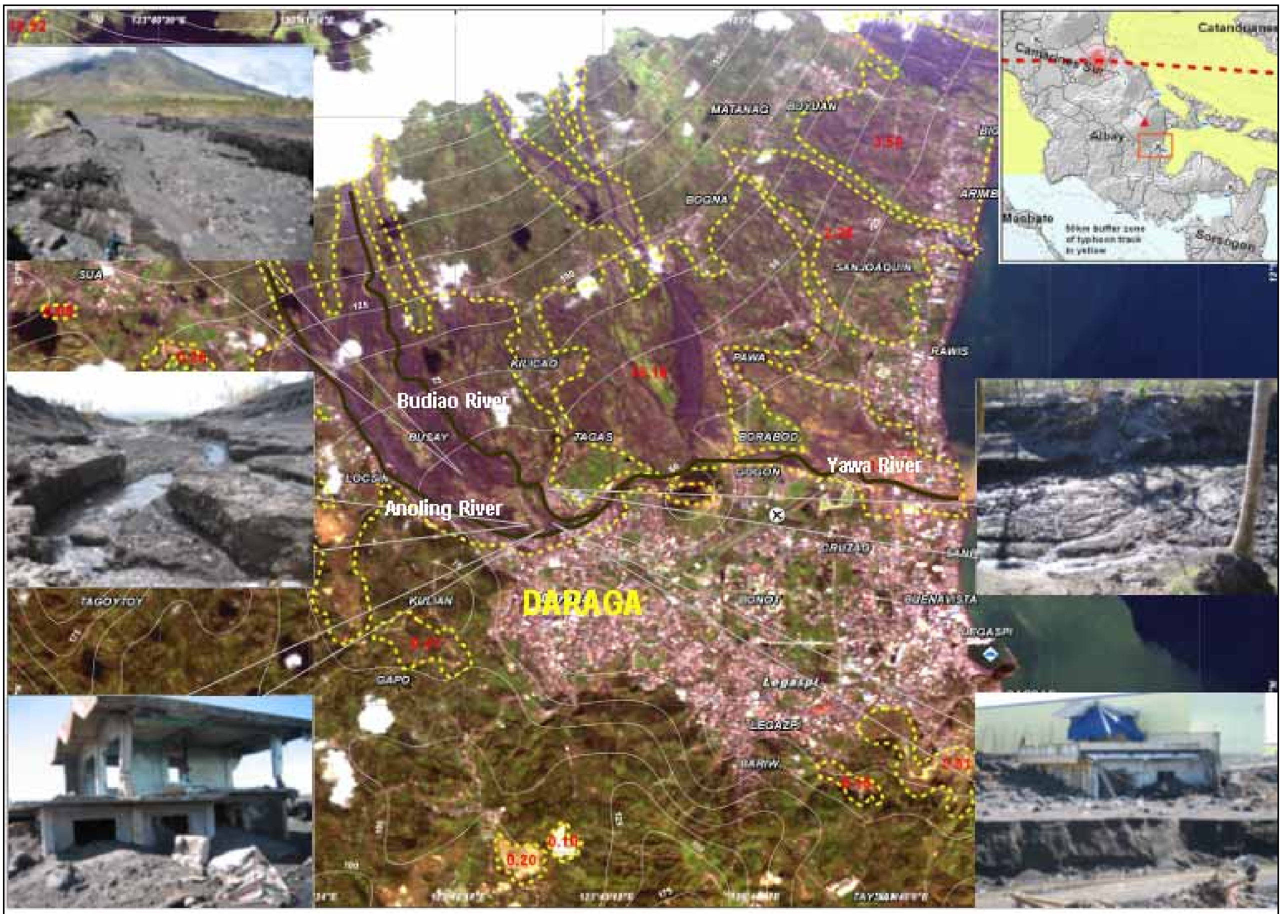

Figure15 Barangays Busay, Salvacion, Budiao and Vanadero, Daraga, Albay
Source: UNOSAT / JICA-FCSEC-Japan Survey Team December 2006

Daraga is a 1st class municipality in the Province of Albay with population of 101,031 people in 20,082 households (2000 census). Busay, a barangay in Daragay, Albay where the famous Cagsawa ruins can be found, is one of the most devastated places in Bicol, with homes and families buried alive or swept away to the sea several kilometers away.

In Barangay Purok IV, Busay, Daraga, 50 people died and 20 houses were destroyed around 4pm on November 30, 2006, when debris flow coming from the Busay River engulfed the whole village.

Figure16 Barangay Purok IV, Busay where 50 people died and more than 20 houses where obliterated by boulders and debris flow.

The upstream of the Busay River is the Busay gully, a deep channel running from the slopes of Mt. Mayon, which was easily scoured due to the runoff caused by excess rainfall. Using a Garmin 60 Global Positioning System (GPS), a Nikon Laser Distance Measurement Device and survey rods, the debris flow in the affected the area was measured to be 2.0 m deep, 307m wide and 314 m long. The volume of deposited debris can be calculated as 193,000 cu.m.

The slope of the Busay River was measured using an inclinometer to be 2º. The debris flow, with average diameter of 1.0mø primarily moved as a coherent slump consisting of volcanic materials and boulders. A fast flowing debris velocity was also suggested by eyewitnesses who stated that most residents were unlucky not to outrun the advancing flow. Similarly, the mode of debris flow movement formed as a result of rising ground water levels after deep infiltration of antecedent rainfall.

Figure17 Boulders averaging 1.0m in diameter rampage down Busay River and killed people and destroyed properties along its path.

Figure18 Debris flow deposits combined with overtopping of riverbanks buried communities.

Figure19 Damage in Budiao, Daraga
Source : Aerial Photo of JICA-FCSEC-Japan Survey Team December 2006

The Municipality of Daraga was heavily affected by debris flow that was routed through the Yawa River. According to Daraga Mayor Gerry R. Jaucian, most of the 149 bodies recovered ended up in Yawa River. He also expressed fears that another major storm event would easily bury Daraga considering that the Yawa River is heavily silted by debris. Before the disaster, Yawa River has a channel width of 50-70m from bank to bank. This has since widened to 300 – 500m wide with indistinct channel banks. Adjacent communities were heavily affected, with 3-storey houses easily buried by debris flow. Moreover, downstream of Yawa River is Legazpi City which is easily threatened by inundation.

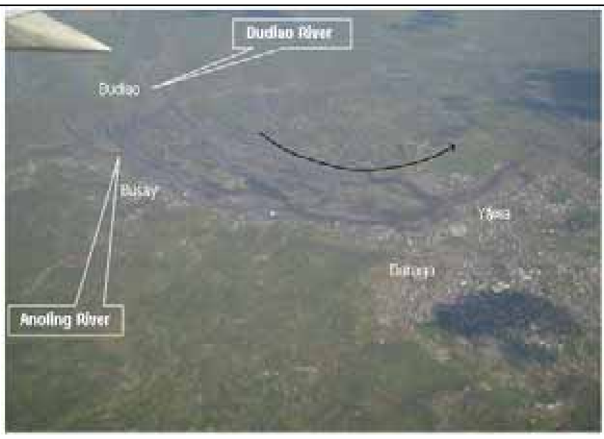

Figure20 Debris flow originating from Budiao and Anoling Rivers affecting the Municipality of Daraga and Yawa

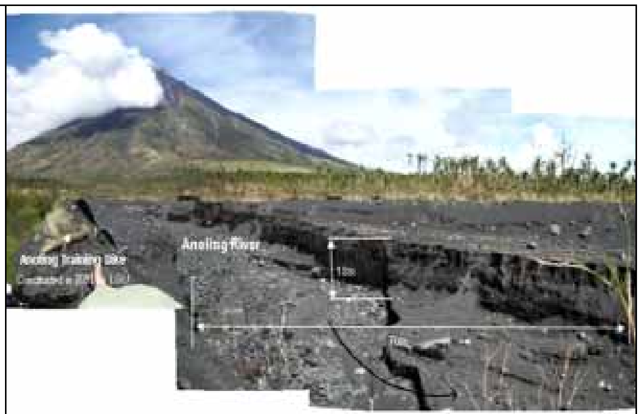

Figure21 An 18m deep gully was formed in the Anoling River where debris flow surged rapidly down Mayon

Figure22 Wide photo of Budiao River where numerous houses were once located. Debris deposited is estimated to be 600m x 245m with boulders averaging 1.0ø in diameter.

At the upstream of Anoling River, where a 50m training dike was constructed by the Daraga Municipal Government in 2001 (Location: N13.1998º, E123.63686º, Elev. 290m) a 70m wide and 18m deep gully was formed. The debris flow concentrated in these gully, redirecting away from Brgy. Anoling but acted as funnel and buried Brgys. Salvacion and Miisi. Using an inclinometer, the slope of the Anoling River is measured to be 4º.

Downstream of Anoling River is Budiao River that traverses Barangay Salvacion. According to a resident on November 30, 2006 at 2:00pm heavy debris flows destroyed around 30 houses and killed 50 persons. Before that fateful day, Budiao River is just a small stream where people wash clothes and farm animals drink water. The debris deposited was estimated to be 600m x 245m with boulders averaging 1.0m in diameter. Interestingly, there are still houses buried by debris flow that happened 15 years ago (see picture below). This add credence to the fact that the area is highly susceptible to debris flow. According to local accounts the debris flow lasted from 1:00pm to 4:00pm on November 30, 2006. Most of the bodies of victims were transported several kilometers downstream and some were even found in Legazpi.

Figure23 Section of the Budiao River in Brgy . Salvacion shows scouring depth of the riverbed and difference in lava layers as a result of volcanic activities.

Figure24 Brgy. Salvacion, Daraga is susceptible to debris flow, as what happened 15 years ago (1990 Debris flow) when it buried many houses.

In Brgy. Vanadero, a right bank 2-km training dike was constructed by the DPWH District Engineering Office in 1986-1989. Approximately 80m of the said training dike was overtopped by debris flow (Location: N13.10971º, E123.41.981º, Elev. 138m).

6.2.3 Padang, Sto. Domingo, Albay

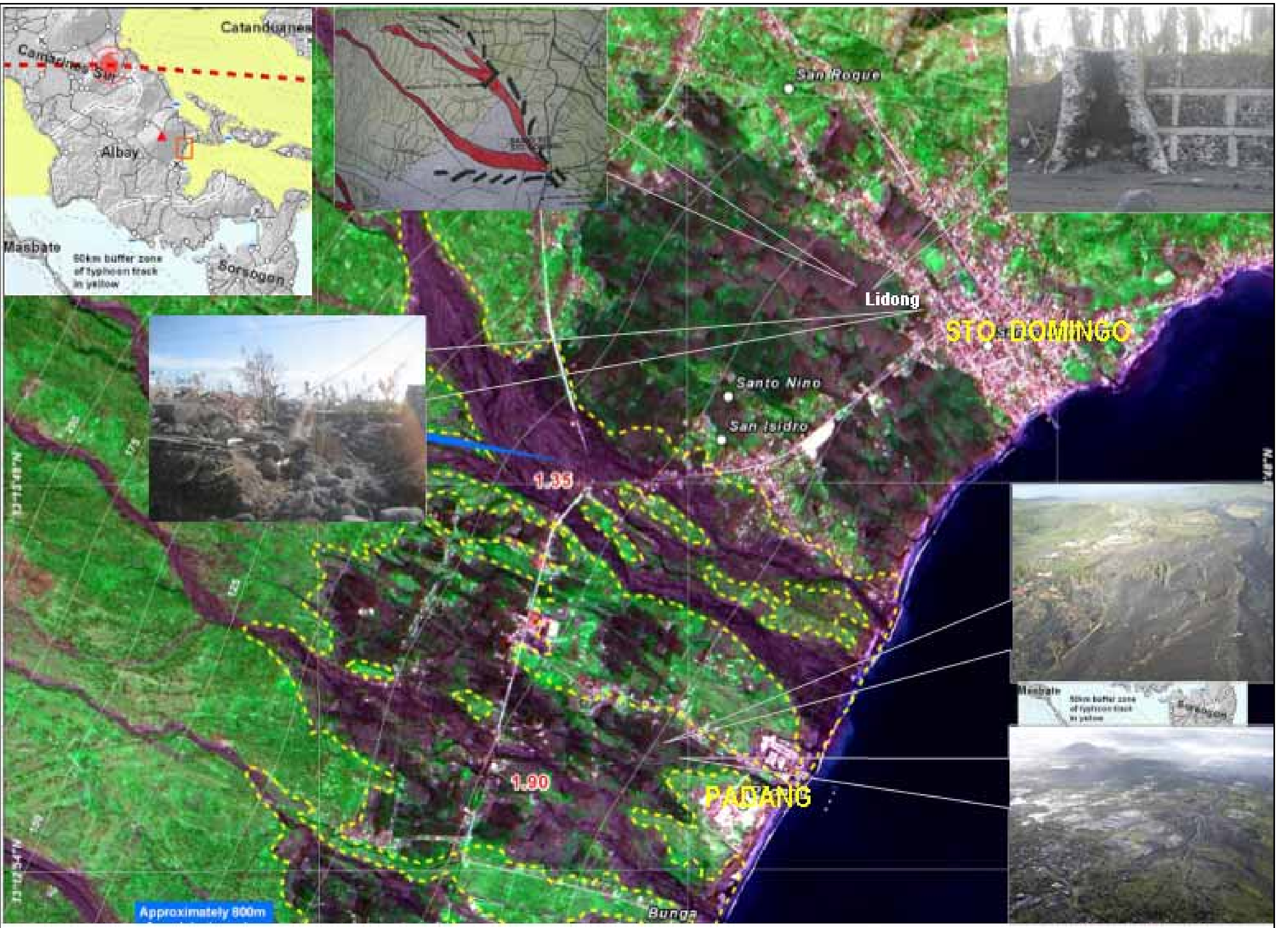

Figure25 Padang and Sto. Domingo, Albay
Source: UNOSAT / JICA-FCSEC-Japan Survey Team December 2006

In Yawa River in Sto. Domingo, Albay, the mechanism of debris and debris flow were observed to have passed unimpeded through the breached Yawa Irrigation Dam (Width=150m), which was damaged during Typhoon Xangsane (Milenyo). The said irrigation dam is located in the southern sector of Mayon. These also affected the towns of Lidong, Sto. Niño and San Isidro.

7 ANALYSIS

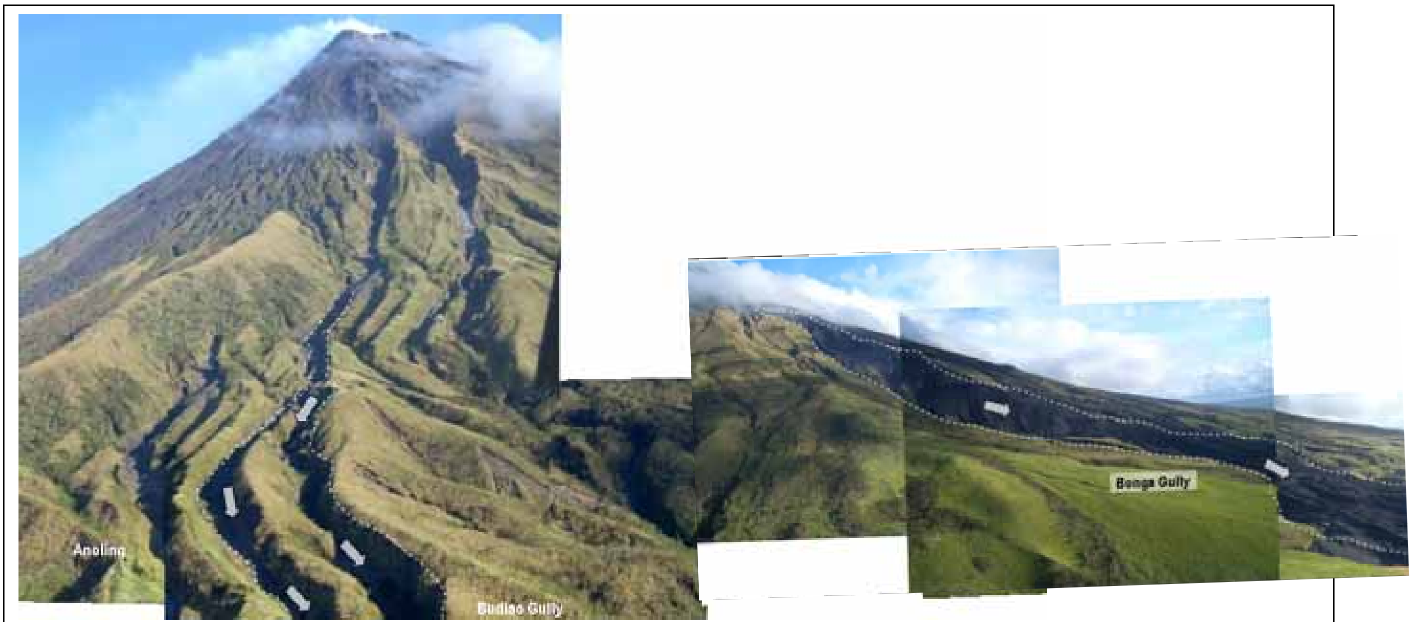

Figure26 Wide photo showing major gullies in the southeastern (SE) quadrant of Mayon where debris flow occurred, caused by high rainfall.
Source: Aerial Survey of JICA-FCSEC-Japan Survey Team December 2006

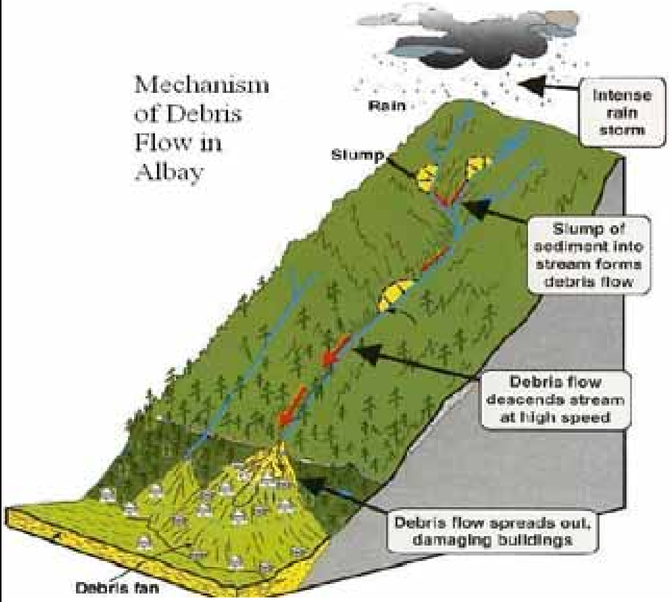

Figure27 Schematic diagram of mechanism of debris flow that affected many municipalities in Bicol
Source : JICA-FCSEC-Japan Survey Team December 2006

Generally, debris flows in Mayon are generally triggered by intense and prolonged rainfall as a result of the passage of a tropical cyclone in its vicinity. Typhoon Durian after making landfall over Bicol in November 2006 has brought extreme amount of rainfall that supersaturated the thick volcanic soil and highly weathered and sheared bedrocks in on the steep slopes of Mayon. This resulted to the failure of the soil and rock materials that make up the hill slope of Mayon and consequently driven down by gravity.

Such phenomena caused the mass wasting or down slope movement of loosened unconsolidated materials (e.g., weathered rock and thick volcanic soils). High concentration of runoff also added weight to the instability of loose masses of rocks and soil triggering them to slide down steep slopes.

The debris flow occurred due to the weakening of the soil structure caused by near continuous and heavy rainfall on the 30th of November 2006.

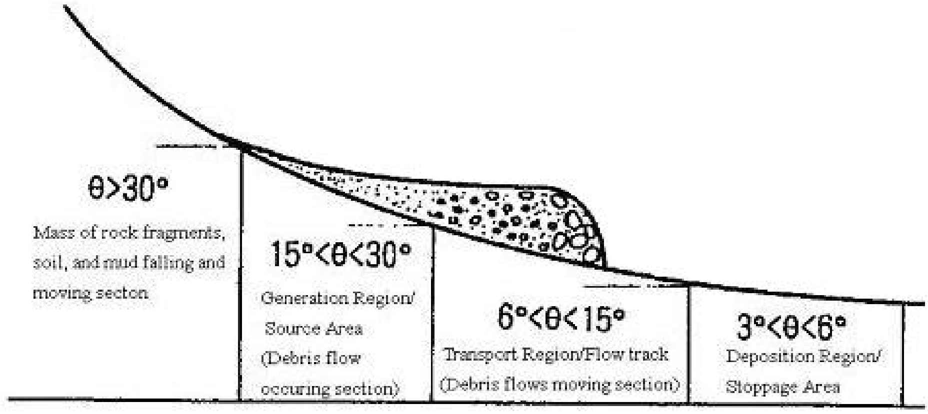

Figure28 Critical slope gradients that define different mechanism of debris flow regions
Source : Landslide Control Manual

High concentration runoff, transformed from debris slides to debris flows, considering the fluidized movement of volcanic debris (boulders, logs, etc) that flowed in relatively rapid velocity because of lower cohesion due to higher water content. The debris flow have slump blocks at the head, and the cascading debris mass breaks up into smaller and smaller parts as it advances towards the foot, the movement is usually dissipated.

The numerous debris flows that occurred around Mayon happened in rapid progressive failures, and the whole mass coming from steep slopes flowed in rapid velocity - after liquefying due to super saturation - finding its way to stream channels and gullies. This is what observed in several stream channels like those in Brgys. Maipon and Busay. Unsuspecting streams suddenly bulked to debris consistency and buried communities.

Mudflow, also classified as debris flow, is composed of earth materials – at least 50 percent sand, silt and clay sized particles that is saturated enough to flow rapidly like what happened in Guinobatan, Daraga and Sto.Domingo. The numerous debris flows that occurred around Mayon happened in rapid progressive failures, and the whole mass coming from steep slopes flowed in rapid velocity - after liquefying due to super saturation - finding its way to stream channels and gullies. This is what was observed in several stream channels like those in Brgys. Maipon and Busay. Unsuspecting streams suddenly bulked to debris flow consistency and buried communities.

Once the debris flow in a channel ways (rivers and streams) occur, the mixture now attains a transporting power that is disproportionate to its size, and as more debris material (bank collapse, trees, boulders, etc.) is added the size of debris head becomes larger and its power increase. [9]

8. RECOMMENDATIONS (By the Survey Team)

The Japanese Survey Team from the Ministry of Land, Infrastructure and Transport (MLIT), together with the Japan International Cooperation Agency (JICA) Experts and staff from the Department of Public Works and Highways - Flood Control and Sabo Engineering Office (DPWH-FCSEC), submitted the following recommendations to the DPWH Secretary in December 2006:

[9] Landslide Control Manual, pp. 11-12, Volcanic Sabo Technical Center, 1984.

8.1. Strengthening the Organizations for Disaster Prevention

Related agencies such as DPWH, PAGASA, PHIVOLCS, RDCC have to make their data and role sharing clearly and stay in close coordination and cooperation with each other during normal condition and at times of disasters. Especially in a time of emergency and after the disaster, more close contact and cooperative framework must be established.

8.1.1 Updating the Hazard Map

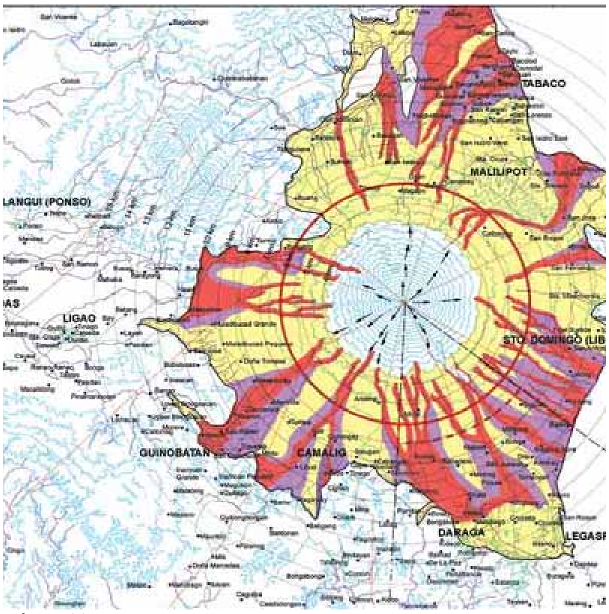

Figure29 Hazard maps are produced to identify areas susceptible to lahar flow / debris flow
Source : Phivolcs

Although PHIVOLCS made a hazard map of lahar flow around Mt. Mayon, major changes of streams and/or newly formed streams are observed. Therefore, based on detailed survey of affected areas by the debris flow due to Typhoon Reming with changes of topography, it is necessary to update the existing hazard map taking engineering knowledge into account.

At the same time, it is necessary to disseminate how to utilize the hazard map to the people and the characteristics of debris flow.

8.1.2 Collection and Utilization of the Meteorological and Hydrological Data

To predict the occurrences of debris and establish warning and evacuation system, getting real time hourly rainfall data is necessary. Although there were two (2) real time telemeter rainfall gauge stations donated by JICA, only one (1) station worked and even the data was not utilized during this disaster.

Therefore, it is required to rehabilitate the existing facilities and to place some additional telemeter rainfall gauging stations, and technology transfer for the effective utilization of the data. Especially, it is effective to establish a system in which simple rain gauges are set and people evacuate independently based on the observed data. Finally, those data will be used in coming up with a more appropriate Sabo plan.

8.2 Emergency Countermeasures

Emergency countermeasures mentioned below are recommended to prevent the occurrence of similar disasters.

8.2.1. Construction of Training Dike

Training dikes at just upper reaches and vicinity of barangays should be constructed for the protection of lives and properties. Soil cement is generally recommended as material for training dike as it is stronger than soil.

8.2.2 Elevating of Possible Evacuation Sites

Embankment / Heightening of previously affected areas to serve as evacuation sites shall be done.

8.2.3 Arrangement of Evacuation Areas

If the existing evacuation area is identified to be unsafe, it is necessary to construct sabo facilities for securing the place. As emergency countermeasures, it is one of the methods to construct reinforced two-storied structures, which can endure against impact force of debris flow. It is also recommended to establish similar measures for the safety of significant facilities such as hospitals, city halls and so on.

8.3 Updating of Sabo Plan

In Masarawag, where the damage to a village was greatly mitigated by the training dike, the effect of the existing training dikes was confirmed. However, as the rate of completed facilities is only 15% in terms of total budget, it is not sufficient to protect lives and properties completely. On the other hand, the condition of the area has changed severely as several catchment captures occurred. Therefore major updating of the plan is necessary based on the lessons from this disaster.

Figure31 The existing Mayon Sabo plan should be updated to address the ever-increasing trends of sediment related disasters in Albay.
Source : DPWH Regional Office V

In conclusion, not only maintenance but also implementation of additional Sabo facilities according to the updated plan is essential. On the above-mentioned recommendations, this study team proposes that Republic of the Philippines and Japan, both of which are investigating and studying countermeasures against sediment related disasters around active volcanoes, collaborate to mitigate these disasters.

Based on this investigation, we come to have following recognition. For the protection of lives and properties, not only structural measure, but also evacuation based on the forecast and warning is very important specially in these prone area for disasters like around Mayon. And for smooth evacuation, improvement of disaster prevention consciousness of local residents and local government unit are indispensable.

PAGASA has the responsibility for the warning on the typhoon related disasters. According to them, they announce the danger of sediment related disaster this time. But the residents we interviewed did not know the warning. It become clear that there are many matters that have to be improved, such as how to warn, how to relay and how to catch the importance of the information

Based on the Technical Standards and Guidelines for Flood Control (Specific Discharge Curve, Rainfall Intensity Duration Curve, Isohyet of Probable Rainfall) developed by DPWH / JICA in March 2003, under the Project for Enhancement of Capabilities in Flood Control and Sabo Engineering of the DPWH, the rainfall on November 30, 2006 was more than that of 1/100 years. It rained concentrated within very short time (4 hours). So you can see it is very difficult to make warning using snake line method (see Fig. 32), because the time is very tight.

The Snake Line Method is one of the way of warning for landslide, debris flow. This method was extensively used in Japan in forewarning communities and helping reduce casualties. It is based in terms of relationship between effective rainfall (total rainfall) vs 1-hr. rainfall or rainfall intensity. Through constant rainfall observation over years, an ample amount of data can be generated. This, in turn can be used to plot on the graph the rainfall-triggered disasters (dangerous zone) vis a vis non-occurrence of disasters (safety zone). A critical rainfall line and evacuation line is then drawn to separate the values and can be referred to by disaster coordinating units as limit for both systematic warning and evacuation systems, before the occurrence of disasters.

In the case of Snake Line for Legazpi as shown below, we draw critical line based on the interview that the debris flow happened about 2pm. We also draw evacuation line based on the idea that if it rains heavily, people can have an a lead time of at least one (1) hour to evacuate. Data gathering is necessary to establish a more effective warning system.

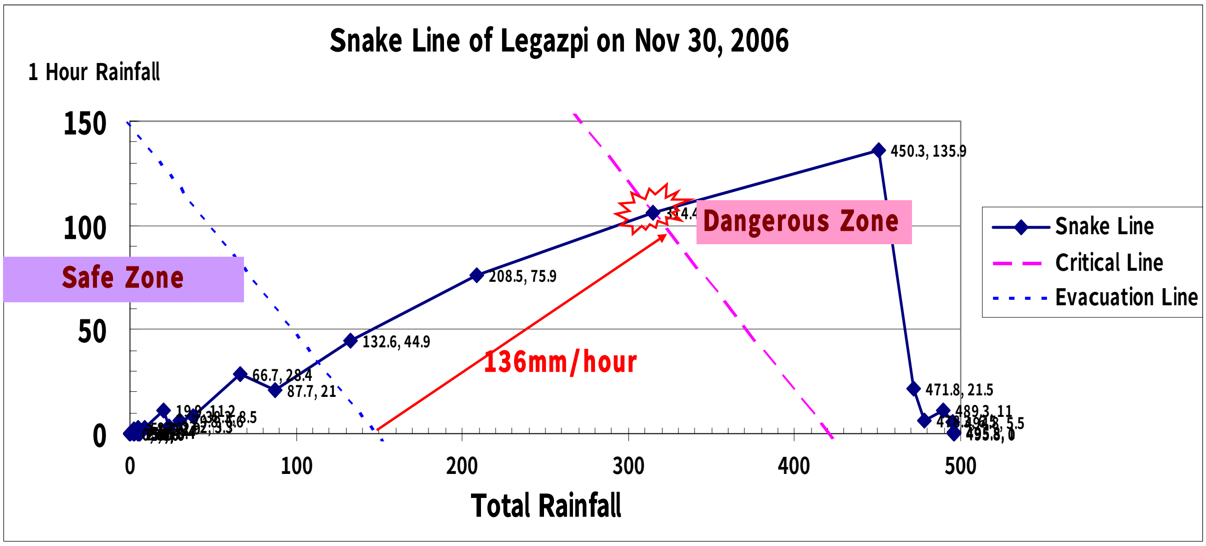

Figure32 Proposed snake-line for Legazpi that will define critical rainfall criteria for warning and evacuation from sediment related disasters.

About structural measure, we need more detail survey, and up date the plan. Anyway it is very difficult to implement all structures at once, we need to prioritize each structures and also carry out with the structures related with non-structural measures such as evacuation center.

Every agency have to recognize the importance of short time rainfall data, importance of stock the data and the necessity of thinking how to keep smooth relay of information and warning, especially mobile hone is out of order. We heard from many residents who lived in Maipon where debris flow gave big damages that they did not expect to suffered from debris flow because their house was far from river but suddenly debris flow attacked the barangay.

We could see this time that at some streams the river course changed and also catchment areas changed in the downstream of those streams.

Local government unit and local residents have to know sometimes stream could change its course and sometimes discharge volume also have big change. And also volcanic deposit is easily eroded and debris flow has characteristics to go straight ahead. So even if there house is a little far from a river, some area can be suffered from it. Those things should be trained by some seminars so that they will get appropriate knowledge for preparation for disasters.

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