Review on monitoring and early warning system for debris flow and flash flood

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• Part 2 Review on monitoring and early warming system for landslide
• Part 3 Construction pilot monitoring system, early warning flash floods, landslides in Northern Mountains
  – Legal basis
  – Purpose
  – Content
  – Time and budget for implementation
Part 1
Review on monitoring and early warning for Debris blow
1. Overview

- Vietnam is one of the most vulnerable countries to natural disasters and climate change. The intensity and frequency of disasters are increasing with devastating human and asset losses. In the last 20 years, natural disasters have resulted in about 10,800 people dead or missing and caused an annual loss of 1-1.5% of GDP (VND 20,000 billion). Northern mountainous region: Frequently occurrences of natural disasters such as flash floods, landslides, heavy rainfall, thunderstorms, etc., especially flash floods and landslides caused serious damage and tend to increase.

<table>
<thead>
<tr>
<th>Year</th>
<th>By Flash flood, landslides in Northern mountainous</th>
<th>Whole country</th>
<th>Rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014</td>
<td>19</td>
<td>133</td>
<td>15</td>
</tr>
<tr>
<td>2015</td>
<td>20</td>
<td>154</td>
<td>13</td>
</tr>
<tr>
<td>2016</td>
<td>31</td>
<td>264</td>
<td>12</td>
</tr>
<tr>
<td>2017</td>
<td>95</td>
<td>376</td>
<td>25</td>
</tr>
<tr>
<td>TBNN</td>
<td>47</td>
<td>375</td>
<td>12</td>
</tr>
</tbody>
</table>
## I. CURRENT SITUATION

### 2. Some flash floods, landslides in the last time

<table>
<thead>
<tr>
<th>Year</th>
<th>Flash flood</th>
<th>Dead, missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>2005</td>
<td>Flash floods in Van Chan district – Yen Bai province affected by typhoon No. 7</td>
<td>64</td>
</tr>
<tr>
<td>2009</td>
<td>Landslides in Pac Nam commune, Bac Can province</td>
<td>13</td>
</tr>
<tr>
<td>2013</td>
<td>Flash flood in Ban Khoang, Sa Pa Dists, Lao Cai province</td>
<td>11</td>
</tr>
<tr>
<td>2014</td>
<td>Landslides in Hoang Su Phi Dists, Hà Giang province</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Landslides in Dong Dang town, Cao Lap district, Lang Son province</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Flash floods in Tam Đương Dists, Lai Châu province</td>
<td>5</td>
</tr>
<tr>
<td>2015</td>
<td>Flash floods in Thuận Châu Dists, Sơn La province affected by typhoon No.1</td>
<td>11</td>
</tr>
<tr>
<td>2016</td>
<td>Landslides, flash floods after typhoon No. 2 in Bat Xat, Lao Cai Province</td>
<td>13</td>
</tr>
</tbody>
</table>
I. CURRENT SITUATION

Damages as result of landslides, flash floods in 04 provinces of Son La, Yen Bai, Dien Bien and Lai Chau (02-03/8/2017)

42 people
Dead and missing

236 Houses
collapsed, washed away

398 household
Moving

$1.400 billion VNĐ
(62 million USD)

Flash floods, landslides in Mường La dists, Son La province

Mù Cang Chải district, Yên Bái province
I. CURRENT SITUATION

Damages as result of landslides, flash floods in 03 provinces of Hòa Bình, Yên Bái, Sơn La (10-12/10/2017)

- 70 people Dead and missing
- 239 House collapsed, washed away
- 4.138 Household Moving
- 4.450 billion VND (196 million USD)

Flash flood in Nghĩa Lộ disstrict, Yên Bái

Landslides in Tân Lạc District, Hòa Bình Province
Warning and Constructing Monitoring Solutions

Artificial Vegetation Recovery

Spillway

Retaining wall

Sediment Dredging

Check dam

Sedimentation pond

Flash flood monitoring station

Channel expansion
Flood prevention works

- Sedimentation dam

- Sediment deposit at dam
Flash floods map in the territory of Vietnam

- Flash Floods, landslides most often occur in the mountainous and midland provinces in the territory of Vietnam.
- According to statistics, from 2000 to 2016, occurred more than 250 flash floods and landslides.
- Density of flash floods and landslides tend to be increasing and intense. Especially 2017
  - 02-04/8/2017 in Mường La (Sơn La), Mù Cang Chải (Yên Bái);
  - 10-12/10/2017 in Tân Lạc district, Đà Bắc district, Hòa Bình, Hòa Bình province;
  - 04-05/11/2017 in Bắc Trà My và Nam Trà My, Quảng Nam province.

(*) Theo Viện Khí tượng thủy văn và Biến đổi khí hậu
### Method, model of flash flood warning system (1)

<table>
<thead>
<tr>
<th>Warning system</th>
<th>Countries</th>
<th>Input data</th>
<th>Method, model of flash flood warning system</th>
<th>Range</th>
<th>Forecast Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>ALERT</td>
<td>Australia</td>
<td>Rainfall and Real-time Stage Hydrograph</td>
<td>Flood peak and food time</td>
<td>By basin research</td>
<td>now-cast</td>
</tr>
<tr>
<td>Gridded Flash flood Guidance (GFFG)</td>
<td>North America</td>
<td>NEXRAD radar, Rainfall Station, rainfall value Forecast</td>
<td>soil moisture distribution model, floodplain discharge</td>
<td>100-300 km² Basin</td>
<td>3-24h</td>
</tr>
<tr>
<td>FFG system Central America</td>
<td>Belize, Costa Rica, El Salvador, Guatemala, Honduras</td>
<td>Observed rainfall, satellite rainfall data (GHE)</td>
<td>Based on soil moisture saturation</td>
<td>100-300 km² Basin</td>
<td>3-6h</td>
</tr>
<tr>
<td>CB flash floods system in Austria</td>
<td>Austria</td>
<td>Observed rainfall and runoff, rainfall radar, rainfall value Forecast</td>
<td>Mesh model of soil moisture content</td>
<td>1 km² grid</td>
<td>48h</td>
</tr>
<tr>
<td>Warning system</td>
<td>Countries</td>
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<td>Method, model of flash flood warning system</td>
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<td>-----------------------------------------</td>
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<tr>
<td>European Flood Forecasting System (EFFS)</td>
<td>European</td>
<td>Real-time rainfall, rainfall radar, GCM downscaling</td>
<td>Heavy rain modeling LISFLOOD-FF: Hydraulic mode LISFLOOD-FP</td>
<td>Grid hydrological model 1km² Grid hydraulic model 10-100 m</td>
<td>72-120h</td>
</tr>
<tr>
<td>Framework for decision support - flash flood warning of Thailand</td>
<td>ThaiLand</td>
<td>Rainfall, air temperature, humidity, radiation, wind, rainfall value forecast</td>
<td>Use ANN artificial neural network to forecast flood. Compared with historical flash floods in the system</td>
<td>By basin research</td>
<td>24h</td>
</tr>
<tr>
<td>Flood Forecasting System in Ayalon lake.</td>
<td>Israel</td>
<td>Real-time rainfall and Runoff</td>
<td>The system includes modules: auto-regression at upstream tributaries; Rainfall distribution and runoff regression module at the station to be calculated.</td>
<td>By basin research</td>
<td>30- 3.5h</td>
</tr>
<tr>
<td>Debris flow warning system</td>
<td>Japan</td>
<td>Radar rain estimated at the real-time rainfall (rainfall accumulation 1h)</td>
<td>Using cumulative rainfall in 1h to calculate short period rainfall (TANK Model); Using artificial neural network to calculate flash flood threshold</td>
<td>calculation grid 5x5km²</td>
<td>1 - 3h</td>
</tr>
</tbody>
</table>
# Methods, models of flash flood warning system (3)

<table>
<thead>
<tr>
<th>Warning system</th>
<th>Countries</th>
<th>Input data</th>
<th>Method, model of flash flood warning system</th>
<th>Scope</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>The flash flood warning system in Caribbean and Central America</td>
<td>Caribe area</td>
<td>Auto-rain gauge system</td>
<td>Automatic warning system by 3-level</td>
<td>At station</td>
<td>now-cast</td>
</tr>
<tr>
<td>Flood monitoring system, flash floods and landslides in mountainous districts, Thanh Hoa province(*)</td>
<td>Viet Nam</td>
<td>Auto-rain gauge system</td>
<td>Automatic warning system by 3-level</td>
<td>At station</td>
<td>now-cast</td>
</tr>
<tr>
<td>Flash flood warning system for Peng river basin- Bat Xat district, Lao Cai province</td>
<td>Viet Nam</td>
<td>Auto-rain gauge system, water level</td>
<td>Automatic warning system by 1-level</td>
<td>At station</td>
<td>now-cast</td>
</tr>
</tbody>
</table>
Types of flood monitoring sensors (1)

1. Rainfall Station integrated warning system
2. Rain gage warming system in place
3. Wire sensor
4. Soil moisture sensor
5. Camera video
6. Pore pressure
7. Soil pressure
Types of flood monitoring sensors (2)

**Wire sensor**

- Functions:
  - Warning for debris flow;
  - Debris flow height measurement;
  - Simple, effective, popular.

- Widely used in Japan, Italy, USA, Taiwan
Types of flood monitoring sensor (3)

**Ultrasonic sensor**

Function:
- Debris flow height measurement
- Measuring water level;
- Measuring speed of Debris Flow;
Types of flood monitoring sensor(4)

**Sound waves/ seismic sensors**

- Floods make vibration, noise, streambed vibration and two banks;
- Measuring of vibration velocity and flood forecasting
- Installed sound waves sensors in bank, safety and
### Types of flood monitoring sensors(5)

<table>
<thead>
<tr>
<th>Sensors</th>
<th>Function</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrasonic sensor (ultrasonic), rađa, laser</td>
<td>Measuring of debris flow</td>
<td>Easy to set warning threshold</td>
<td>Ultrasonic sensors to hang above the stream; Installation difficulty if unstable stream banks</td>
</tr>
<tr>
<td>(geophones) and (seismometers)</td>
<td>Background vibration measurements are made by flash floods.</td>
<td>Easy and safe installation because the sensor buried in stable place on stream bank.</td>
<td>Determining the threshold is very complex. Risk of false alarms because of other seismic such as cars, falling rocks,... The seismic signal filtering increases the level of complexity of the warning system.</td>
</tr>
<tr>
<td>(wire sensors)</td>
<td>Detecting debris flow the wires</td>
<td>Simple equipment</td>
<td>Need to recover after floods. Risk of false alarms in the case of animals running through, fallen tree...</td>
</tr>
<tr>
<td>(photocell), (infrared photobeam)</td>
<td>Detecting debris flows</td>
<td>Indirect measurement is not direct contact with debris flow. Not recovered after</td>
<td>Must be installed carefully to avoid contact with debris flow.</td>
</tr>
</tbody>
</table>
Some monitoring and early warning system for debris blow(1)
Some monitoring and early warning system for debris blow(2)

Taiwan

Station monitoring, early warning system for debris blow Shen-Mu Village, Nantou, Taiwan
Some monitoring and early warning system for debris blow (3)

Italia
Italia

- Flood identification: after rain, sudden increase or over threshold of:
  - Pore pressure;
  - Soil pressure;
  - Frequency sound waves;
Application:

Set up three (03) measuring stations

**Station 1: Flood Creation Region**
- Rain gauge stations
- Soil moisture sensors
- Wire sensors
- Pore water pressure

**Station 2: Flood Transition Region**
- Pore water pressure
- Measuring soil pressure
- Ultrasonic sensors
- Sound sensors
- Camera
- Water level measurement

**Station 3: Influence Region**
- Rain gauge
- Camera
- Ultrasonic sensors
Part 2

Review on monitoring and early warming system for landslide
Landslides
Solution for Landslide Stability

- Drainage system
- Anti-slide pile
- Retaining walls, anchor
- VTC Geotechnical Research center VTC has invented large diameter wells, drainage and anti-slip

Drainage wells
Ex: Landslides Provincial Assisi street, Perugia province, Italy
Ex: Landslides: Provincial Assisi street, Perugia province, Italy
Part 3

Construction pilot monitoring system, early warning flash floods, landslides in Northern Mountains

1. Legal basis
2. Purpose
3. Content

1. Time and budget for implementation
3.4 Rain gauge system at Hát Lừu Commune, Trạm Tấu district, Yên Bái Province.

- Rain gauge system:
  - Rain drain;
  - Barometer in door;
  - Warning device according to rainfall threshold using whistle;
  - Low cost, can equip many households living in the area.
3. Content: ông Tượng Hill area, Hoa Binh City

3.5. Landslide monitoring system at ông Tượng Hill, Hòa Bình, Hòa Bình Province.