

Technical Note: Experiences from Site-Specific Landslide Early Warning Systems

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The following questionnaire has been sent in June 2011 to more than hundred institutions in charge of landslides monitoring and/or early warning centers in Asia, Europe and North-America. The results of the present paper are based on answers that we received till autumn 2011.



Oslo and Lausanne, the 23rd of June 2011.

Subject: Invitation to participate to a screening survey about landslides Early Warning Systems

To whom it may concern,

The large, integrating project SafeLand, funded by the European Commission in the 7th Framework Programme, is intended to develop generic risk management tools and strategies for landslides. SafeLand is a collaborative project between 27 partners from 12 countries and coordinated by the International Centre for Geohazards (ICG) in Oslo, Norway. One of the main objectives of the SafeLand project is to merge experience and expert judgment and therefore to create synergies on EC-level and to make these results available to end users and local stakeholders. More information on this project is available at www.safeland-fp7.eu.

As part of this study, we are **gathering information about the responsible organizations for landslide early warning system and risk management in selected countries**. You have been identified on internet or by colleagues as an organization in charge of one or several Early Warning System(s). Thus, we would very appreciate that you fill the attached form. **This short (four-page) questionnaire aims to compile information about the state of the art technologies and existing strategies**. The intention of this screening study is **to provide guidelines that will facilitate the establishment of new Early Warning Systems**. Additional information could be sent as attached documents. As our project is limited in time, we would very much appreciate if you **return this form before the 15th of September 2011** to safeland@igar.org.

Do not hesitate to spread this questionnaire to other people involved in Early Warning Systems. Of course, if you have any additional question, do not hesitate to contact us. We look forward to receiving your information.

Sincerely yours,

Sara Bazin for SafeLand Project Coordinator, Norway
Clément Michoud and Prof. Michel Jaboyedoff, for University of Lausanne, Switzerland
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Questionnaire

on landslide early warning systems

1. GENERAL INFORMATION ON THE UNIT IN CHARGE OF THE EWS

Name of the operational unit			
Country		Location	
Person in charge of the operational unit	Name		
	Email address		
Level of operational unit	<input type="checkbox"/> National <input type="checkbox"/> Regional <input type="checkbox"/> Local <input type="checkbox"/> Private		
Source of funding			Yearly cost of unit
Are there any codes for EWS in your country?	<input type="checkbox"/> Yes <input type="checkbox"/> No	Are there any guidelines for EWS in your country?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Is the unit also responsible for monitoring other than landslides?	<input type="checkbox"/> Yes <input type="checkbox"/> No If yes, specify <input type="checkbox"/> volcanoes <input type="checkbox"/> earthquakes <input type="checkbox"/> tsunamis <input type="checkbox"/> weather <input type="checkbox"/> other (specify):	Number of monitored landslides with implemented EWS?	
		Number of monitored landslides without EWS?	
Scale of landslide	<input type="checkbox"/> Single slide <input type="checkbox"/> Multiple slide <input type="checkbox"/> Regional slide		
Are the warning systems in operation?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If not, is it: <input type="checkbox"/> planned <input type="checkbox"/> under construction <input type="checkbox"/> damaged <input type="checkbox"/> stopped	
Number of persons employed at the unit	A person is present on duty 24/7 <input type="checkbox"/> Yes <input type="checkbox"/> No A person is on call 24/7 <input type="checkbox"/> Yes <input type="checkbox"/> No		
Confidentiality/ Access to data	<input type="checkbox"/> Public (full access of general data (e.g. Topography, geology, structural, borehole, hazard/risk etc.), detailed monitoring data accessible on request) <input type="checkbox"/> Not Public (specify whether authorization is already available/requested):		
Web site			

2. MONITORED LANDSLIDES

Please fill this table for each landslide that you monitor

Name of the site:			
Slide has occurred yet?	<input type="checkbox"/> Yes <input type="checkbox"/> No (slide prone)	If yes, potential for future sliding?	<input type="checkbox"/> Yes <input type="checkbox"/> No
Type of landslide	<input type="checkbox"/> rock <input type="checkbox"/> debris <input type="checkbox"/> earth <input type="checkbox"/> other (specify):	Type of slope	<input type="checkbox"/> natural cliff <input type="checkbox"/> quarry or mine <input type="checkbox"/> redesigned slope <input type="checkbox"/> other (specify):
Triggering mechanism	<input type="checkbox"/> rainfall <input type="checkbox"/> earthquake <input type="checkbox"/> erosion <input type="checkbox"/> human activity <input type="checkbox"/> other (specify):	Volume of landslide	
Elements at risk, specify and quantify for each case	<input type="checkbox"/> buildings (private, public...) <input type="checkbox"/> infrastructure (railways, roads, bridges, power lines...) <input type="checkbox"/> people (inhabitants, workers, tourists...) <input type="checkbox"/> indirect risk (tsunami, flooding...) <input type="checkbox"/> other (specify):		
Human losses (death and injuries) due to previous events	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, quantify:	
Economic loss due to previous events	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, quantify in €:	
Social consequences due to previous events	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify:	
Mitigation (already performed or envisaged)	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, describe (structural/non-structural):	
Land planning already established for the case	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify:	

3. PRE-INVESTIGATIONS USED TO DESIGN THE EWS

Was geology or geomorphology a design criterion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify:
Were geophysical data a design criterion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify (technique, profiles, scale etc.):
Was hydrogeology a design criterion?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify (piezometers, suction etc.):
Were geotechnical data used to design the EWS?	In situ data: <input type="checkbox"/> Yes <input type="checkbox"/> No Lab data: <input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify (type of test, drilling depth, location, maps availability etc.): If yes, specify (type and number of tests, material tested):
Were surface movement data used to design the EWS?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify type (technique), scale and date:
Was modeling used to design the EWS?	<input type="checkbox"/> Yes <input type="checkbox"/> No	If yes, specify type (technique):

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4. MONITORING PARAMETERS, THRESHOLDS AND SENSORS EVALUATION

Please provide for each landslide or selected landslides, a map as attached file and a description of the monitoring system using the following table:

Monitoring parameter	Threshold level	Sensor type	Sensors number	Sensor reliability	Active	Duration	Frequency	MM indicator	EW parameter

Explanations:

Monitoring parameter	phenomenon or factor related to slope/area of interest, which could be quantified and monitored in time
Threshold level	a warning is issued when the monitoring parameter reaches this critical value
Sensor type	specify type of technology (e.g. 3C broad-band seismometer)
Sensor reliability	evaluate the instrument dependability based on time frequency of measurements and down time with values from 1 to 10 (maximum)
Active	is the monitoring still in use? (tick = yes)
Duration	duration of monitoring in years
Frequency	frequency of reading per day (D), month (M) or year (Y), for example 6xD
Mass-movement (MM) indicator	monitoring parameter characterizing directly or indirectly the dynamic state of mass-movement processes. Evaluate the parameter with values from 1 to 10 (maximum)
Early warning (EW) parameter	mass-movement indicator allowing to detect an impending or existing critical activation or acceleration of the landslide(s) by its threshold. Evaluate the parameter as an EW parameter with values from 1 to 10 (maximum)

List of eventual monitoring parameters related to landslides:

Displacement (Cumulative, Differential, Acceleration, Velocity, Settlement), **Microseismicity** (also microcracks/strain), **Rockfall event frequency**, **Macrocracks and surface fissures**, **Stress** (direct measurements), **Mass loss/increment balance** (areal 3D deformation at individual slopes-based e.g. on TLS or GB-INSAR), **Precipitation**, **Snow cover**, **Wind velocity**, **Solar radiation**, **Air temperature**, **Ground Water Level**, **Pore-Water Pressure**, **Soil Suction**, **Discharge**, **Ground/superficial water quality** (chem. composition, el. conductivity, pH, etc.), **Electrical ground resistivity**, **Electrical self-potential**, **Density**, **Seismic velocity**, **Temperature** (air, water, substrate), **IP effect**, **Dielectric permittivity** (GPR repeated measurements for monitoring), **Soil humidity**, **Radon emanation**, **Factor of Safety** (monitoring parameter derived from triggering factors), **Regional precipitation** (weather forecast for e.g. hurricanes, etc.), **Volcanic activity**, **Regional seismicity** (activity/shaking/acceleration).

Advantages and limitations of your monitoring system	
How could it be improved?	

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5. WARNINGS, COMMUNICATION, AND DECISION MAKING PROCESS

How is operated the data monitoring?	<input type="checkbox"/> automatic, then specify by <input type="checkbox"/> SMS, <input type="checkbox"/> voice message, <input type="checkbox"/> e-mail, <input type="checkbox"/> other <input type="checkbox"/> manual, then specify the frequency of data check and operator:		
Are the warning based on thresholds set on?	<input type="checkbox"/> single sensors <input type="checkbox"/> multiple sensors	Are thresholds based on minimum resolution and noise level?	<input type="checkbox"/> yes <input type="checkbox"/> no
Are there any power supply back-ups?	<input type="checkbox"/> for the sensors <input type="checkbox"/> for the operational center <input type="checkbox"/> for the communication		
Are there any back-ups for communication?	<input type="checkbox"/> for the data transfer <input type="checkbox"/> for the operational center communication (internet, phone, radio...)		
Type of software and integrated systems?			
Who designed the alarm chain?	<input type="checkbox"/> responsible of operational unit <input type="checkbox"/> local authorities <input type="checkbox"/> governmental/regional institutions <input type="checkbox"/> other, specify		
Are there several levels of warning?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Envisaged If yes, specify how it works :		
Do you have different thresholds for different scenarios?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Envisaged If yes, specify how it works :		
Can you perform direct field observations in case of a warning?	<input type="checkbox"/> Yes <input type="checkbox"/> No	Is there a procedure to cancel the warning once issued?	<input type="checkbox"/> Yes <input type="checkbox"/> No If yes, describe:
Procedure in case of a warning?			
Evacuation time after a warning?			
How is issued the warning to the population?	<input type="checkbox"/> siren <input type="checkbox"/> SMS <input type="checkbox"/> TV <input type="checkbox"/> radio <input type="checkbox"/> other, specify		
Do you have review procedures?	<input type="checkbox"/> operational check list <input type="checkbox"/> report to review group <input type="checkbox"/> other, specify:		
How do you communicate with the public?	<input type="checkbox"/> public reports specifying status of the landslide, if yes specify frequency: <input type="checkbox"/> public meetings, if yes specify frequency: <input type="checkbox"/> public website <input type="checkbox"/> newspaper <input type="checkbox"/> other, specify:		
Tests and evacuation exercises performed?	<input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> Envisaged If yes, specify extent and frequency:		
What are your practical challenges for the EWS?	<input type="checkbox"/> installation and maintenance of the sensors <input type="checkbox"/> installation and maintenance of the operational unit <input type="checkbox"/> weather conditions <input type="checkbox"/> site conditions <input type="checkbox"/> human resources <input type="checkbox"/> funding <input type="checkbox"/> population response <input type="checkbox"/> other, please specify:		
How could the actual EWS be improved?			