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Security and resilience — Emergency management — Guidelines for implementation of a community-based landslide early warning system

Sécurité et résilience — Gestion des urgences — Lignes directrices pour la mise en oeuvre d'un système d'alerte locale immédiat de glissement de terrain

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 292, *Security and resilience*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Landslides are one of the most widespread and commonly occurring natural hazards. Landslides may occur in different types of topographic and geologic settings. The occurrence of landslides may increase significantly due to uncontrolled land use development and human interference into unstable slopes. In many countries, landslides cause substantial socio-economical losses.

Landslide mitigation can be carried out both by structural and non-structural efforts. Structural mitigation includes adjustment of slope geometry, slope reinforcement, and protection and improvement of drainage systems, all of which require a high cost. The alternative option of relocation is not practical for residents living in areas prone to landslides. As a result, the most effective disaster risk reduction can be achieved by non-structural mitigation through improvement of the community's preparedness by implementing an early warning system.

The goal of the development of a community-based early warning system is to empower individuals and communities who are vulnerable to hazards to act in sufficient time and in appropriate ways to reduce the possibility of injury, loss of life and damage to property and the environment. The implementation of a community-based early warning system is consistent with the Sendai Framework for Disaster Risk Reduction of 2015–2030[14]. The fourth priority of the framework emphasizes the improvement of preparedness in order to respond effectively to a disaster, by implementing an early warning system and improving the dissemination of information about early warning of natural disasters at local, national, regional and international levels.

According to UN-ISDR[15], a complete and effective early warning system consists of four interrelated key elements:

a) risk knowledge;

b) monitoring and warning service;

c) dissemination and communication;

d) response capability.

The implementation of a community-based early warning system takes into account the correlation between a strong bond and effective communication channels among all of these elements.

Demographic, social, economic and cultural aspects are most often left out in the implementation of early warning systems, compared to other technical aspects. Early warning system guidelines promote the role of the community and social aspects in general. Efforts to train people to respond to the warnings should be followed up by experts/researchers and by decision-makers at local and national levels.

By referring to the four key elements of community-based early warning system, this document for a landslide early warning system promotes uniformity in the development and implementation of early warning systems and will improve the preparedness of the communities vulnerable to landslides.

Security and resilience — Emergency management — Guidelines for implementation of a community-based landslide early warning system

1 Scope

This document gives guidelines for a landslide early warning system. It provides a definition, aims to improve understanding, describes methods and procedures to be implemented, and gives examples of types of activities.

It is applicable to communities vulnerable to landslides, without taking secondary effects into consideration.

It recognizes population behaviour response planning as a key part of the preparedness.

It takes into account the approach of ISO 22315 and provides additional specifications for landslides.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 22300, *Security and resilience — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 22300 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
mass movement
displacement of materials such as soil, rock, mud, snow or a combination of matter down a slope under the influence of gravity

3.2
landslide
wide variety of processes that result in the downward and outward movement of slope-forming materials including rock, soil, artificial fill or a combination of these

3.3
community vulnerability
characteristics and conditions of individuals, groups or infrastructures that put them at risk for the destructive effects of a hazard

3.4
early warning
provision of information through local networks, allowing affected individuals to take action to avoid or reduce risks and to prepare responses

3.5
community-based early warning system
method to communicate information to the public through established networks

Note 1 to entry: The warning system can consist of risk knowledge, monitoring and warning service, dissemination and communication, and response capability to avoid, reduce risks and prepare responses against disaster.

[SOURCE: ISO 22300:2018, 3.43, modified — "early" has been added to the term and Note 1 to entry has been added.]

3.6
evacuation
organized, phased and supervised removal of people from dangerous or potentially dangerous areas to places of safety

3.7
evacuation command
series of orders to evacuate people

3.8
evacuation drill
activity that practises a particular skill related to *evacuation* (3.7) and often involves repeating the same thing several times

EXAMPLE A drill to practice safely evacuating a neighbourhood or village from a *landslide* (3.2)

[SOURCE: ISO 22300:2018, 3.74, modified — "related to evacuation" in the term has been added and the example has been changed.]

4 Landslide early warning system

4.1 General

The community-based landslide early warning system (LEWS) should comprise seven main sub-systems:

a) risk assessment (4.2);

b) dissemination and communication of knowledge (4.3);

c) establishment of a disaster preparedness team (4.4);

d) development of an evacuation route and map (4.5);

e) development of standard operating procedures (4.6);

f) monitoring, early warning and evacuation drill (4.7);

g) commitment of the local government and community on the operation and maintenance of the whole system (4.8).

4.2 Risk assessment

The risk assessment should be based on ISO 31000 and should consist of technical (geomorphology, geology and geotechnics), institutional and socioeconomic/cultural surveys of vulnerable communities.

ISO 31000 should be adapted to meet the specific requirements of the landslide context including risk identification.

A technical survey for risk identification should be conducted to understand the geological conditions in vulnerable communities, to classify the types of landslide and range of hazard, to assess the potential physical extent of landslide, to collect information regarding the indicators of ground movement, and to determine landslide susceptibility and stable zones. These indicators may include cracks and subsidence, appearance of water springs, fractures of structure and tilting poles and trees. These indicators can be used to determine the placement of the landslide early warning system instruments. Information on lithology types and distribution, slope forming material composition, geological structure types and its orientation distribution, slope crack and slope inclination should also be included when identified during the technical survey.

The purpose of an institutional survey is to understand whether there are established organizations currently responsible for monitoring and mitigating hazards in the disaster-prone areas.

A socioeconomic or culture survey collects information on community demographics, such as population, by age, education and financial situation, the number of households, vehicles and livestock, and cultural considerations. It also provides information on the community's knowledge concerning landslide hazards. This information provides insight into the community's perception on landslide risk and landslide disaster risk reduction means (technology, population preparedness, etc.) that can be used to improve the successful introduction of the early warning system and to gain an understanding of the community's vulnerabilities and complexities.

NOTE 1 Information on potential vulnerable inhabitants and infrastructure due to landslide is important to determine the level of community vulnerability.

NOTE 2 The community's eagerness and motivation to actively participate is relevant to design strategies for disaster risk reduction programmes that are suitable for the local social conditions.

Training and education programmes should be conducted in order to prepare and increase people awareness.

NOTE 3 The programmes can give knowledge and increase people's capacity to be able to decide what needs to be done in order to prevent and protect themselves from landslides.

4.3 Dissemination and communication of knowledge

Dissemination and communication of knowledge provides the community with comprehension and understanding with respect to potential for a landslide disaster. Methods and materials of the dissemination and communication should be developed based on the preliminary data of the disaster risk assessments.

The community should be provided with information on the types of landslide disasters, how and why they occur, the factors that control and trigger the event, and the structural and non-structural strategies to mitigate the consequences, including an early warning system, warning levels and signage.

The dissemination and communication of knowledge should use clear language, provide useful information, identify the authoritative agency and provide multiple communication methods to ensure the maximum number of people is reached.

Effective dissemination provides for better understanding about landslides and how to minimize risks once the early warning systems are in place.

The dissemination of information may lead to the identification of key people with an interest in participating in a disaster preparedness team.

4.4 Establishment of a disaster preparedness team

Disaster preparedness team members should be selected based on their knowledge and abilities in landslide preparedness, prevention, mitigation and post-disaster management.

Annex A gives an example of a proposed community disaster preparedness team.

The disaster preparedness team should have expertise, including knowledge of the area, data and information management, early warning and mass evacuation systems, first aid, logistics and security. The additional expertise required on the disaster preparedness team should be determined according to the needs of the community.

The disaster preparedness team should conduct preparedness activities, including

a) determining landslide risk zones and evacuation routes,

b) leading, preparing and training the community, and

c) organizing the design-installation-operation-maintenance of the technical system.

NOTE Points a) to c) can lead to the appropriate reaction mentioned in the standard operating procedure (see 4.6).

4.5 Development of an evacuation map and routes

The evacuation map and routes should be developed as operational guidelines for the disaster preparedness team and the community to leave the risk zone, following a predetermined route and to gather in an assembly point.

An evacuation map should be developed based on the identification of landslide risk zones. The evacuation map should provide specific detail on secure locations to be used as assembly point and the evacuation routes to be followed.

The landslide risk zones should be determined by members of the disaster preparedness team, which should then be verified by the local authority or institution officials or experts.

The evacuation map can include information on

a) high-risk and low-risk (safe) zones,

b) residences, including the estimation of the number of residents in each,

c) community facilities: school, place of worship, community health centre, offices, market and landmarks,

d) streets and alleys,

e) locations of early warning system installation point,

f) alert post,

g) assembly point(s),

h) evacuation route(s), and

i) location of shelters.

Annex B gives an example of the layout of the evacuation map and route.

Annex C gives an example of the evacuation map and route. However, the map maybe more simple, depending on the needs of the community.

Annex D gives an example of symbols in the evacuation map and route.

4.6 Development of standard operating procedures

Standard operating procedures (SOPs) should contain the procedures and guidelines for the disaster preparedness team, the individuals and the local authority responsible for responding to the alert issued by the landslide early warning instrument.

SOPs should be prepared based on the discussions and agreements of each division in the disaster preparedness team under the direction of relevant stakeholders and the local authority to follow the flow of warning information, delivery mechanism and evacuation commands.

EXAMPLE The SOP may contain alert levels, such as

— Level 1 (CAUTION: landslide possible),

— Level 2 (WARNING: landslide likely), and

— Level 3 (EVACUATE: landslide occurrence imminent).

These SOP levels may not apply in all communities.

Annex E gives an example of the scheme of a community-based LEWS.

Annex F gives an example of the flow of warning information and evacuation command.

Annex G gives an example of an evacuation SOP.

4.7 Monitoring, early warning and evacuation drill

Early detection devices should be placed in areas that have the highest risk and the largest number of people affected. Determination of the locations should be based on the identification of landslide risk zones.

Installation of the equipment should be coordinated with the community, with the aim to increase the sense of ownership and responsibility for the equipment's condition to guarantee safety.

The type of early detection and alert level should be appropriate to the geological conditions and the scale of landslide.

The monitoring devices installed to support early warning systems should include

a) **rain gauges** to measure the intensity of rainfall within a certain period, and

b) **surface deformation meters** to identify the deformation on the land surface in a certain period. The common devices used are extensometer (monitoring the relative distance between two points on the crack) and tiltmeter (the gauge for changes in the inclination of the land surface).

Additional tools can be used to improve measurement accuracy, such as

— **underground deformation meters** to measure the deformation underground through the movement of the sliding plane within a certain period of time (inclinometer, pipe strain gauge, multi-layer movement meter),

— **groundwater level meters** to measure changes in groundwater level in the landslide zones, mounted inside the borehole,

— **pore water pressure sensors** to measure changes in pore water pressure on the landslide mass, installed in the borehole,

— **soil moisture sensors** to measure the changes of water level in the landslide mass, and

— **survey stakes** to monitor mass movement in a horizontal direction of motion (wooden, bamboo or other stake materials).

This landslide monitoring and early warning system should be based on ISO 22322.

To implement a community-based landslide early warning system, the monitoring and early detection devices should use appropriate technology.