LandAware workshop 2022

3-5 October, 2022, Zürich/Birmensdorf, Switzerland

Summary report

LandAware is a multi-disciplinary, international network of experts in the development, operation and management of Landslide Early Warning Systems (LEWS) – established in summer 2020. After a series of on-line events and meetings, the LandAware network for the first time organized a first physical meeting to jointly review the first two years of the LandAware network and to discuss recent developments and current challenges in the field of landslide early warning. This two-and-a-half-day workshop was organized and hosted by the Swiss Federal Research Institute WSL, Birmensdorf, Switzerland, and tied in with earlier meetings in Oslo, Norway (2017) and Perugia, Italy (2020).

Introductory presentation of LEWS worldwide (day 1)

Graziella Devoli (Norwegian Water Directorate, Norway) presented two recent examples of contrasting storm events in western Norway with the issued landslide warning: one large-scale storm (Gyda, 12/13 Jan. 2022) that was correctly anticipated several days in advance and helped to take measures to mitigate the impact of the landslides; and a convective small-scale event in June 2022 that was difficult to predict – even at short lead times. These cases illustrated very nicely the daily challenges of the operational warning service.

Nikhil Nedumpallile Vasu (British Geological Survey, United Kingdom) presented the Natural Hazard Partnership, a consortium of 19 public bodies (government departments, agencies and research institutes), that issues all-hazards warnings for UK at lead times of 24 hours- 5 days. He showed a real case from 2015 (storm Desmond) with > 340 mm of precipitation in 24 hours in the region of Cumbria with subsequent landslides (and yellow warning) for several weeks.

Richard Carter (BGC Consulting, Canada) reported on an ongoing work in North America to assess thresholds of regional landslide criticality from an extensive database of in-situ and remote-sensing derived displacement, together with ERA5 hydro-climatic data. They have developed a corresponding visualization tool and generate tailored bulletins for customers.

Silvia Peruccacci (CNR, Italy) informed about the landslide forecast system along the Italian railway infrastructure that is entirely based on precipitation thresholds. This system was validated against 34 rainfall events between August 2018 and December 2019 showing that the number of missed landslide events could be significantly reduced with short lead times (compared to a 24-hour forecast). This nicely demonstrated the value of nowcasting.

Felipe Mandarino (City Information Directorate Rio de Janeiro, Brazil) presented the local LEWS for Rio that is based on NASA's global landslide hazard assessment model and a detailed susceptibility map. The system could be tested during two major storm events in 2019 and demonstrated a high correlation between predictions (at short lead times) and observed landslides. Currently, the team is further developing Rio-LHASA towards a risk-based warning system.

Hiroaki Nakaya (NILIM MLIT, Japan) made some technical remarks related to the Japanese SRD alert system. Some important improvements have been made in recent years with regard to the inclusion of critical snow conditions and the spatial resolution of the warning maps. And it has been investigated whether or not warning thresholds need to be (temporarily) adjusted after earthquakes due to the generally higher susceptibility of the ground to instabilities.

Finally, Andy Subiyantoro (ITC, Univ. of Twente, Indonesia) informed about the regional LEWS for Indonesia that is based on the Delft-FEWS platform. Recent work resulted in slightly more differentiated warning thresholds, and the importance of a community-centered approach has been stressed. Andy also mentioned that local warning systems in the region of Java have been ISO certified and that they plan to develop the system towards impact-based warnings.

Key-messages from the panel discussion:

The panel discussion moderated by Stefano Luigi Gariano (CNR, Italy) was focused on the topic "Warning for natural hazards". Carina Fearnley (UCL Warning Research Center, United Kingdom), Rainer Kaltenberger (MeteoAlarm, ZAMG, Austria), and Atsuhisa Yano (Japan Meteorological Agency) were invited to share their experiences and the main challenges they have faced delivering warnings. Pros and cons of a multi-hazard operational perspective were discussed, and the main sources of uncertainties were highlighted. The discussion was opened to the whole audience in order to share all experiences in balancing qualitative and quantitative approaches for taking the final decision and delivering it to the end users. Finally, the discussion focused on the needs for a standardized communication to citizens, to limit misunderstandings.

Current status and direction of LandAware working groups

In the afternoon of the first day, the eight running working groups of LandAware were presented and discussed (link to YouTube video).

WG1 - Catalog of LEWS – co-chaired by Hiroaki Nakaya (NILIM MLIT, Japan) and Graziella Devoli (NVE, Norway)

WG2 – Communication-Networking – chaired by Stefano Luigi Gariano (CNR IRPI, Italy)

WG3 – Communication with stakeholders – co-chaired by Katy Freeborough (BGS, United Kingdom) and Joanne Robbins (Met Office, United Kingdom)

WG4 – eLearning – chaired by Michele Calvello (University of Salerno, Italy)

WG5 – Innovations – chaired by Manfred Stähli (WSL, Switzerland)

WG6 – LEWS data – chaired by Dalia Kirschbaum (NASA, USA)

WG7 – Operational LEWS – chaired by Graziella Devoli (NVE, Norway)

WG8 – IoT-based methods and analyses – chaired by Luca Piciullo (NGI, Norway)

It was concluded that the WG structure worked more or less well in the first two years of LandAware, with some tangible products (e.g., workshops, glossary, documents) and active discussions on specific topics (e.g. innovations, IoT, worldwide data). It was noticed that the working groups were very heterogeneous with regard to their working approach and compositions. Some specific challenges were faced across all working groups: e.g. the bottom up communication

within each WG and between them, the topical overlap of the working groups and the active involvement of the associates.

Key-information related to the field excursion (day 2)

Staff members of the Swiss Federal Research Institute WSL and the Federal Office of the Environment (FOEN) presented ongoing work and results from a pilot study for a national LEWS for Switzerland. To this end, the workshop group first visited a field site near Wasen in the Emmental region. Here, WSL has carried out extensive soil wetness measurements for four years and related these measurements to the occurrence of landslides in the neighborhood. Based on these observations the following recommendations can be made:

- For the purpose of landslide early warning, soil wetness measurements don't necessarily need to be conducted on the slopes; flat-site measurements can equally well be useful to identify critical situations.
- It is not recommended to use water content from single sensors, but to look at profile saturation (integrating all available sensors) to draw conclusions about critical landslide conditions.
- It is worth measuring both the volumetric water content and the soil water potential together in the profiles; both having their weaknesses and strengths.

In the afternoon, FOEN presented their plan and timeline to set up a new LEWS for Switzerland, integrated in the existing framework of multi-hazard warnings www.natural-hazards.ch. It will include both the survey of the high-alpine areas with regard to ongoing (deep-seated) surface displacement (InSAR) and the day-by-day assessment of the disposition for precipitation-induced spontaneous landslides. For the latter, they can make use of recent studies by Leonarduzzi et al.[1], and Wicki et al.[2]

Finally, Tobias Halter (WSL/ETHZ, Switzerland) presented results from a simulation of three storm events causing numerous landslides in the Emmental region using the hydromechanical model STEP-TRAMM, and Maxime Clarence (Geoprevent, Switzerland) showed two examples of automated local warning and alarm systems in Switzerland: one along a main traffic route at the lake of Lucern (Axenstrasse), and one in a touristic area in the Bernese Oberland (Spitze Stei).

Early career presentation (day 3)

Lisa Luna (University Potsdam, Germany) addressed a very relevant question of many LEWS experts: how to deal with heterogeneous and incomplete landslide inventories that are the backbone of our warning systems. She nicely demonstrated, for the Pacific Northwest, that the seasonality of critical antecedent wetness can be assessed in an integrated manner from a set of different landslide data[3], and in general that landslide inventories do not need to be complete to be useful.

[1] DOI: 10.5194/nhess-20-2905-2020
[2] DOI: 10.1007/s10346-020-01400-y and DOI: 10.5194/hess-25-4585-2021
[3] DOI: 10.1029/2022GL098506

Interactive session on needs and challenges of LEW services

Graziella Devoli (NVE, Norway; on-site) and Katy Freeborough (BGS, United Kingdom; online) led through an interactive session on the critical issues, challenges, and problems attendees faced in the last 3 years of daily operations. Participants were asked to consider their responses on 5 themes and key challenge areas; Organization, Risk Knowledge, Monitoring, warning model and warning service, Communication, Response capability. Whilst the themes attracting most individual comments were *Monitoring, warning model and warning service*, and *communication*, it was clear from the varied discussions, both in the room and online, that similar challenges were faced by all attendees within each theme and several cross-cutting issues across the themes.

All themes show a reoccurring challenge of funding LEWS. Comments regarding access to supporting funds related to all technical areas including the maintenance, updates and development of models and software, and, also about personnel. Remarks were made on the difficulties in funding resources for staffing daily operations and included comments on the opportunity/ required aspect for development and education of staff. Discussions mentioned the size of units and departments tasked with operations, along with the day-to-day skills set within those sections. There was also a recognized differentiation between staffing roles related to research and operational activities and how this is often a crossover of pool staff rather than supported separately.

Although perhaps not specific to 'the last 3 years' observations also focused on the challenges of missing information and data that would support decision making and evaluation of systems. This is an issue in a research area very rapidly moving from hazard to risk. Attendees focused on key uncertainties in both models, operational warning assessment and underlying risk knowledge. These were based on lack/limits of suitable data (e.g., landslide data for risk analysis and threshold validation, accessing of event information where landslides have occurred but not reported). Risk knowledge appears to be a key aspect of future understanding aiming for a better understanding of dynamics in vulnerability, nuances in local threshold data, and understanding of risk mapping bias and cascading effects. The LandAware network was recognized as an important source of knowledge sharing on LEWs over the last 3 years, and there is a potential for wider knowledge sharing in the area of risk knowledge with collaboration.

Communication is still noted as being a key challenge over the last 3 years. This comprises human challenges (e.g., cell phone service, language barrier, and dissemination issues), stakeholder communication (e.g., uncertainty and conflicting messaging) through to technical communication (e.g., warning level, risk, scale of issue).

Limited contributors were able to comment on the theme of response capability due to their/ their organisations not being part of the chain involved in this. However, key comments were received about communication between the key stakeholders and LEWS operators.

Outlook LandAware

In the final session, led by Michele Calvello (University of Salerno, Italy), the workshop participants discussed how to go forward with the LandAware network after the first two years. It was proposed/discussed /concluded that the LandAware activities should be carried by more shoulders than the current steering board and WP leaders. Identification of early career members and forwarding specific tasks to them could be a sustainable approach. Also, the

exchange/communication within LandAware between researchers and operators could be improved by reducing the number of working groups allowing to focus on interactive/joint initiatives. Another point of discussion was how to better reach (and involve) the operators and stakeholders. Regional meetings, such as those carried out with stakeholders in South America in local languages, could be a useful solution. Speaking of concrete (tangible) outputs, it was proposed that LandAware could try to aim for more products (basics/standards/best practices/professional trainings) specifically designed for / addressed to operators. On another note, it was also suggested that LandAware could help finding financial support to facilitating LandAware members to join (physical) LandAware activities. Finally, it was strongly advocated that LandAware products should be open access to maximize the circle of users. As a general conclusion, we have to define clear and reachable priorities for our next steps (task for the executive committee).

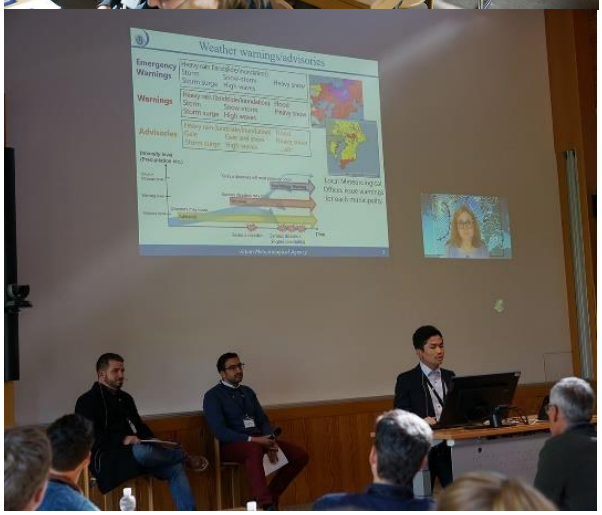
The workshop was then officially closed with the announcement of the upcoming general assembly taking place in December 2022 and with the sincere thanks to the organizers (WSL) and to the participants which made this workshop a very pleasant and interesting exchange.

Outcomes/products from the workshop:

- Recorded presentations and discussions: available as a playlist in LandAware's YouTube channel **https://www.youtube.com/@LandAware** (direct link to Playlist)
- Information and photo documentation: available at www.landaware.org/workshop2022/

Impressions:

First workshop day (Mon, 3 Oct) at the Swiss Federal Research Institute WSL



Panel discussion with Rainer Kaltenberg (ZAMG, Austria), Carina Fearnley (UCL, UK) and Yano Atsuhisa (Japan Meteorological Agency), moderated by Stefano Luigi Gariano (CNR IRPI, Italy)

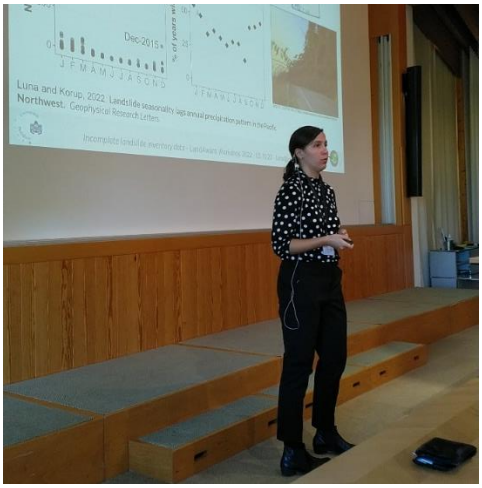
Field excursion (Tue, 4 Oct): The team of WSL and Federal Office of the Env. at the field site in Wasen i.E.

Presentation and discussion of the upcoming Swiss national Landslide Early Warning System.

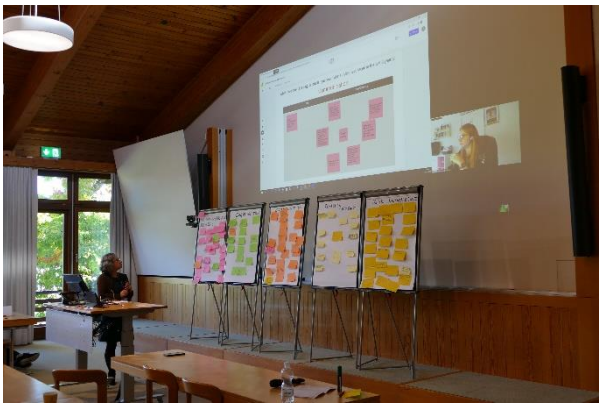
Group foto at Lüderenalp.

Workshop dinner (Tue, 4 Oct):

Online participants day 3 (Wed, 5 Oct)



Final workshop day (Wed, 5 Oct): Invited lecture by Lisa Luna (University of Potsdam, Germany) on the use of incomplete, heterogeneous landslide inventories



Interactive session to assess recent challenges and needs of operational Landslide Earl Warning Services

Final discussion and outlook LandAware network


After dinner:

Detailed workshop program:

Monday 3 October 2022, 08:45-12:30

Intro, panel discussion, invited presentations

Start	End	What
08:45	08:50	**Welcome address** by Manfred Stähli (WSL, Switzerland)
08:50	09:00	**LandAware network** by Michele Calvello (University of Salerno, Italy)
09:00	10:45	**Presentations on LEWS**
	(15')	How to deal with shorth summer convective rainfalls and big storms by Graziella Devoli (NVE, Norway)
	(15')	Assessment of rainfall-induced landslides hazard at regional scale – BGS experience through the Natural Hazards Partnership by Nikhil Nedumpallile Vasu (BGS, UK)
	(15')	Development of data-driven LEW thresholds for slow moving landslides in Western Canada by Richard Carter (BGC Consulting, Canada)
	(15')	Landslide forecasting: an Italian experience along the national railway infrastructure by Silvia Peruccacci (CNR-IRPI, Italy)
	(15')	LHASA Rio: a local LEWS based on NASA's global landslide hazard assessment model by Felipe Mandarino (City of Rio, Brazil)
	(15')	Landslide Early Warning System: Some technical remarks from Japan by Hiroaki Nakaya (NILIM MILIT, Japan)
	(15')	Local LEWS in Indonesia By Andy Subiyantoro (Indonesia)
10:45	11:15	**Coffee break**
11:15	12:30	**PANEL: Warnings for natural hazards**
		Moderated by Stefano Luigi Gariano (CNR, Italy) <u>Invited organizations and panelists</u> • UCL Warning Research Center (UK): Carina Fearnley • MeteoAlarm: Rainer Kaltenberger • Japan Meteorological Agency: Yano Atsuhisa

Monday 3 October 2022, 12:30-14:00

LUNCH

Monday 3 October 2022, 14:00-17:00

Activities of Working Groups

Start	End	What
14:00	15:30	**LandAware WGs (part 1)** chaired by Luca Piciullo (NGI, Norway)
	(30')	WG1: Glossary and catalog of LEWS (Graziella Devoli, NVE, Norway and Hiroaki Nakaya, NILIM, Japan)
	(10')	WG2: Communication-Networking (Stefano Luigi Gariano, CNR IRPI, Italy)
	(15')	WG3: Communication with stakeholders (Katy Freeborough, BGS; and Joanne Robbins, Met Office, UK)
	(20')	WG4: Single slide fact-sheets, online educational resources (Michele Calvello, University of Salerno, Italy)
	(15')	WG5: Innovations in LEWS (Manfred Stähli, WSL)
15:30	15:45	**Coffee break**
15:45	17:00	**LandAware WGs (part 2)** chaired by Stefano Luigi Gariano (CNR IRPI, Italy)
	(15')	WG6: LEWS data (Dalia Kirschbaum, NASA, USA)
	(15')	WG7: Operational LEWS (Graziella Devoli, NVE, Norway)
	(15')	WG8: IoT-based monitoring and warning (Luca Piciullo, NGI, Norway)
	(30')	Final discussion
17:00		**Closure of first workshop day**

Monday 3 October 2022, evening

Individual program (self-organized by participants)

Tuesday 4 October 2022, all day

Excursion to Napf-region (Emmental)

Start	End	What
07:45		**Departure from Hotel Neufeld (Zürich Goldbrunnenplatz)**
07:50		**Departure from WSL Birmensdorf (Main entrance)**
09:15	09:45	Arrival at Wasen i E. (Field site), Coffee and croissants
09:45	10:45	**Presentation of in-situ soil moisture measurements for LEWS**
		Three groups à ~15 persons (a) Intro to the topic and site [Manfred Stähli, WSL, Switzerland]; (b) measurement set-up and operation [Armin Dachauer, WSL; Tobias Halter, ETHZ/WSL, Switzerland], (c) findings/results from 4 years of measurement [Adrian Wicki, WSL/Federal Office of the Environment, Switzerland]
10:45	11:15	Transfer to Restaurant Lüderenalp (Bärnsicht)
11:15	12:00	**Intro to the upcoming Swiss National LEWS**
		Background; organizational embedding; planning and development of the new LEWS; major challenges; time line; anticipated products [Hugo Raetzo, Adrian Wicki, Federal Office of the Environment FOEN, Switzerland)
12:00	14:00	Lunch and walk with opportunity for informal discussions
14:00	14:40	**Presentations:** Pilot-Study Napf for Swiss National LEWS (Tobias Halter, ETHZ/WSL, Switzerland; Adrian Wicki, FOEN, Switzerland)
14:40	15:30	Examples of local LEWS in Switzerland (M. Carrel, S. Stähely, Geoprevent, Switzerland)
16:00	18:00	Departure and travel back to Zürich-Uitikon [workshop dinner location]

18:00	Workshop dinner at Bistro Spilhöfler (Uitikon)
	Afterwards: Individual return by public transport to Hotels in Zurich

Wednesday 5 October 2022, 9:15-12:15

Opening invited lecture, LEWS issues and future of LandAware

Start	End	What
09:15	09:45	**Opening invited lecture by early career scientist**
		Incomplete landslide inventory data: When is it a problem and what can we do with it? by Lisa Luna (University of Potsdam, Germany)
09:45	10:45	**Open discussion: Critical issues, challenges, and problems in daily operations**
		Moderated by Graziella Devoli (NVE, Norway) and Katy Freeborough (BGS, UK) Interactive session
10:45	11:00	**Coffee break**
11:00	12:00	**Open discussion**: Outlook: LandAware 2023+
		Moderated by Michele Calvello (University of Salerno, Italy) Future milestones, way forward, organizational issues, feedback from the participants
12:00	12:15	**Closure** by Manfred Stähli (WSL, Switzerland)
12:30		(optional) Lunch at WSL restaurant

Detailed responses of the workshop participants (both on-site and online) during the interactive session of day 3

Overarching question: What have been the biggest challenges you/your service have faced in the last 3 years?

Organization

You:

Your service:

- Financing improvements and developments - funds are often in place for initial development but not always future developments and upkeep.
- Time to learn/ educate researchers better on subjects/ publish work.
- Proper funding for time (staff) resources.
- Government department - (non-research) GIS/ data hub department so therefore sometimes. struggle with the science.
- Undermanned - (low staff numbers - big country) but same challenge to issue warnings.
- Organizing sufficient holiday cover for duty staff at certain times of the year can be difficult.
- Effective capturing of user need (routinely and consistently) and feeding this back into modelling and operational development.
- Putting our LEWS model into full operational use has been challenging due to lack of "on the ground" resources (small Civil Defense team, big city, etc.).

Not specified:

- Too much responsibility on one organization: lack of manpower/staff; lack of knowledge in Civil defense.
- Small group of landslide experts/researcher who can work on our EWS (Validation, improvement).
- Lack of specific competences.
- Lack of people in Civil Defense who understand the messages.
- Small group to work with LEWS.
- Difficult hiring and retaining experts - especially is a problem as many people in our program are approaching retirement.
- Turn overrate too high, seniors retire in a massive scale, liquefaction of organization (Hiro).
- Less funds, not updated equipment (e.g., software, hardware), problematic cooperation with the other relative departments.
- Difficulty to combine research& operation (few people that work with research).
- As a national organization: legal restriction, cooperate capital office and local office, cooperation with other ministries or private company.
- For new LEWS: battle between two governmental agencies to have the lead.
- How should the private company make a role for the disaster alert system?
- Involve local agents in LEWS.
- Engagement (effective) of different stakeholders receiving the warnings.

Risk Knowledge

You:

- **Your service:**
- Stakeholder led reactions rather than model driven outputs (summer drought led to extra cracks and followed by localized convective heavy rain > stakeholders began tweeting about landslide hazard and infrastructure > resulted in raised assessment at national level due to realistic stakeholder concerns rather than local model outputs).
- Hazard assessments in selected towns -not full overview - is this leading to a bias in warning levels?
- Highest risk areas have better risk maps, susceptibility maps covering whole areas/regions/country; gaps in risk mapping.
- 'Real' Impact modelling.
- Cascade hazards? How does this link to the impact?
- Collecting impact data to help attribute hazards with their societal impacts.

Not specified:

- (Risk knowledge) Or risk awareness?
- Lack of landslide data to perform risk analysis.
- Lack of landslide data for threshold validation.
- How do you think about yourself, myself.
- Lack of interdisciplinary expertise (e.g., social scientists).
- Not well-informed database regarding hazard and risk mapping; not updated information concerning the statistical issues of elements of risks.
- Lack of reliable dataset for thresholds.
- Dealing with lack of (historical) data.
- Shortage of risk knowledge in rural areas.
- Different impacts generated by landslide events triggered by different rainfall critical conditions.
- How to include local risk knowledge in LEWS at regional scale?
- Better understanding of the dynamics of vulnerability.
- Lack of vulnerability data.
- Learn more about natural hazards in school, improve people's own risk knowledge.
- People are not informed (or they do not want to listen to warnings) and they do not have correct behaviors in critical conditions.
- Mix of terminology is confusing for stakeholders (hazard, vulnerability, exposure, damage, risk).
- Business risk occupies people's minds too much. Natural & long-term risk to their own lives are pure in the shelves (to enjoy life perhaps) Cognitive suppression all the time.
- Need to communicate with the same standards.
- Risk knowledge implies to know vulnerability, exposure for large areas this could be challenging.
- Lack of vulnerability mapping.
- Ideas: work together with staff of social welfare – subject lack of risk knowledge among elderly people; facing issues of difficult of evacuation of elderly people.
- Source areas not the same as runout areas, identification of element € at risk; vulnerability analysis is challenging; sometimes frequency analysis of landslides is difficult (susceptibility /not hazard).
- Possible cascading effects.

Monitoring, warning model and warning service

You:

- Borderline decisions: raising the assessment from green-yellow in situations where confidence is low.
- When to lower the assessment - the slope is still saturated, but rain has stopped.
- Conveying the severity of the event (either compared to 'normal' or in-terms of the user capacity to act).

Your service:

- Warnings from multiple sources which may convey different information across hazards.
- Model/ software problems - Failure of external data transfers within the window of model automated scripts.
- Validation of databases - just because landslides are not reported it does not mean there have not been landslides. Can't visit everywhere.
- How do you capture local nuances in rainfall in a national/ regional model? (large radar areas - local saturation models).
- Moving to Impact Based Forecasting (IbF). Currently the output is based on perceived understanding of potential impacts to the infrastructure network but missing a lot of local information.
- Bias in reporting - more likely to hear about events if there has been impacts.
- Small number of weather stations.
- Resolution of models.
- Resolution of warning/ assessments.
- Difference between automated tools and non-automated decisions. Delivery of warning is subjective... Is there a push for fully automated systems?

Not specified:

- Frequent regional scale change detection to identify where events have happened.
- Which type of landslide events are monitored; what will be the future impact of climate change scenarios?
- Necessity to develop low-cost hydrological sensors in order to implement a regional LEWS.
- Insufficient station density to capture small spatial scale convective rainfall.
- The warning models need improvement for local areas.
- Small or no budget for maintenance of local monitoring systems or national EWS.
- Limits in models, data availability and choice of appropriate parameters.
- Threshold models not updated.
- Lack of information when I have to design a monitoring system (where is the slip surface? What is the monitoring purpose?); Budget; The tenders sometimes split instrumentation supply and data management service.
- Which resolution is suitable and effective and capable for the municipality and resident?
- Lack of capable crew to keep monitoring network running. We need more mid-level skill training than PhD researchers.
- Not updated software regarding monitoring systems; insufficient service.
- Landslide clusters and LEWS in remote areas are difficult to maintain; maintenance reduces time for science.
- Interruption of instrumental data input chains.
- Limited landslide data available (5 landslide days in 20 Years?).
- How to deal with incomplete landslide inventories?
- Difficulties with predictions of storms in summer; budget for service maintenance.
- Advantages, disadvantages, use AI model in the system.

- Poor accessibility to data; too many data formats.
- We want to adopt snowmelt processes for LEWS in Japan. Not only rainfall, but also snowmelt water for snowmelt triggered slow landslides.
- How can we consider SWC monitored data to develop physically based thresholds?
- Computational limitations related to modelling, technological advances and availability of high performance computers will help.
- Warning model results “against” (to help) decision supporting tools.
- Warning model should be validated (performance analysis).
- How to effectively convert theoretical models into practical tools.

Communication

You:

- Local languages? Is this a real problem.
- Need to better work with stakeholders: some like 1-1 , some prefer official channels. We need to better understand preferences... is it the 'right' person - bespoke information not always possible.
- Understanding of wording and uncertainty.
- Borderline decisions; raising the assessment from green-yellow in situations where confidence is low.

Your service:

- Borderline decisions: raising the assessment from green-yellow in situations where confidence is low.
- Fake news – media reporting and interpretation leading to incorrect communication before events (e.g. media using a storm name before the Meteorological Office, reporting an event as a landslide before investigation)
- Standard concept of landslides - what is the level that is an issue (community understanding).
- Cellphone service for warnings in remote communities.
- Different warning systems based on different sources cannot give conflicting information to end users and the general public.

Not specified:

- Attention deficit everywhere with noisy advertisement & runners; our brain gets to its limit information saturation.
- Communication must be coded in order to be understandable.
- Translation of materials is a challenge. It is easy to do, in our organization, for long-terms products and webpages. However, this is not the case for responding to events. This is a problem when significant portion of the population in landslide prone area does not speak English.
- Converting probabilities into warning actions.
- Conflicting messages coming from different actors, also including private ones (e.g., meteo apps).
- Simplifying knowledge base for common people; what does LEWS add to the life of common man? Risk means… rehabilitation?
- System reliability; not enough personality for communication.
- After warning we don’t receive good feedback about the number of landslide (location, date).
- Notification service to residents related to the rising risk level; collaboration of push (notification) service and pull information (ex. real time risk map).

- Contradictory or deviating warning levels for “rainfall” and landslides at the same time.
- Idea: “Town walking” with experts to check dangerous points. Subjects: lack of communication between residents and experts on risk knowledge. Enhancing of well-known on dangerous point of my town through town walking.
- Finding the most appropriate way to disseminate information, in order to make them clear and understandable for everyone.
- Multiple stakeholders involved in LEWS with different understanding of goals of LEWS.
- Lack of platforms to communicate with public especially immigrants and tourists.
- Encourage more regular conversation between end-user and researchers.
- Who should we be communicating to and how to tailor specific communication for the different audience? How much do we say/share to the media?
- Better well-organized communication with different stakeholders; better access with social media.
- Communicating accuracy to non-specialists. What does landslides mean for the public, landslide = everything?
- Type of messages for different LEWS end-users.
- The messages should be easier to understand for the public.
- Communicating uncertainties to end-users.
- Lack of structured/standard communication protocols.

Response capability

You:

Your service:

- Putting our LEWS model into full operational use has been challenging due to lack of "on the ground" resources (small Civil Defense team, big city, etc.).
- Not applicable to our service.

Not specified:

- What is expected from people when regional warnings are issued?
- Sometimes actions are not taken in time.
- I had some critical alerts from my sensors and no-one read my email and sms and/or called me from the authorities.
- Still difficult for local authorities to implement actions when a yellow level is sent.
- Messages difficult to be interpreted, more simplicity is needed; Lack of a response framework.
- Used up by Health Covid 19; Emergency; People are more on their own now than pre-covid 19.
- Lack of “dedicated” employees to respond to events.
- Lack of resources to follow-up on warnings issued by LEWS; unclear distribution of roles.
- Who is responsible to implement LEWS measures like evacuation of a certain area?
- Better informed decisions.
- Increase personal responsibility.
- How to verify the actual resources available to face specific events?
- Input data timely and correctly collected.