LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Introduction

Nilgiris, Tamil Nadu, India. Credit: © Keystone Foundation.

ABOUT LANDSLIP

Between 2016–2021, the LANDSLIP (LANDSLIde multi-hazard risk assessment, Preparedness and early warning in South Asia: Integrating meteorology, landscape and society) project, consisting of nine partners from India, the UK and Italy, developed a prototype landslide forecasting and early warning system in two regions of India, the Nilgiris and Darjeeling.

Through LANDSLIP (www.landslip.org), experts on landslide processes, meteorological forecasting, social science, data and science-to-practice, came together and collaborated with Indian national and district authorities, and local NGOs, to help build resilience to hydrologically related landslides in vulnerable and hazard-prone areas in India.

A suite of Knowledge Products (KPs) has been developed to capture the knowledge and learning generated by LANDSLIP. The KPs have been designed to be accessible and support practitioners, policy makers and programme managers (amongst others) in the development of current and future landslide forecasting and early warning across and beyond South Asia.

CONTENTS OF KNOWLEDGE PIECE

This KP focuses on data in the context of Landslide Early Warning Systems (LEWS) and contains the following sections:

- Introduction (this page).
- Part A: Improving national landslide inventories.
- Part B: The Landslide Tracker Form.
- Part C: The Landslide Tracker App.
- Part D: Sourcing landslide data through social media—challenges and limitations.
- Conclusions and recommendations.

INTRODUCTION TO THIS KNOWLEDGE PRODUCT

This knowledge product (i) provides an overview of landslide data collection methodologies and the developed tools in the framework of the LANDSLIP project; (ii) describes the importance of consistently and continuously collecting landslide data; (iii) promotes a systematic approach to the collation of relevant landslide information by using different mediums (e.g. proformas, social media, and a mobile application). Each tool is described, along with short explanations as to how they can be used effectively to support data capture.

WHY THIS TOPIC IS IMPORTANT

Landslide data is the backbone of most landslide hazard analyses. One key assumption is that landslides that happened in the past represent regions where landslides are more likely to happen in the future. Therefore, it is important to know, when and where landslides have happened, but also why or how they occurred, to support mitigating future impacts to society.

Landslide models and tools need evaluation as to how accurately they model real-world processes. For this, a substantive and representative inventory of known landslides is essential. Data collection needs to be continuous and systematic. Landslide data collection also needs to involve local communities, and integrate any data captured by these communities into a wider inventory.

Local communities living in landslide-prone regions will likely be more aware of landslide occurrences in their vicinity and can potentially provide information in a timelier manner than officials working elsewhere. This is particularly important for those landslides where their record is erased from the environment in a short amount of time. Such observations, if captured appropriately, can be very useful for the forecasting and warning system.

Natural Environment Research Council

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Foreign, Commonwealth & Development Office

Examples of typical landslides found within the LANDSLIP study areas.

LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Part A: Improving national landslide inventories

A1 OVERVIEW

Landslide inventory data underpins most landslide susceptibility and forecast models. The more representative the inventory of the types and sizes of landslides in both time and space, the more likely these models will accurately reflect real-world conditions. This section (**Part A**) of the Knowledge Product highlights the importance of creating a comprehensive landslide inventory and associated database, to build an understanding of when, why and how landslides occur. We also briefly outline the different data collection tools used in LANDSLIP.

A2 THE IMPORTANCE OF LANDSLIDE DATA

Landslide inventories are the basis for many different landslide models, including landslide susceptibility maps, hazard and risk analyses and forecasting or early warning applications. Key assumptions of many landslide models include:

- The past is the key to the future. Therefore, it is essential to know where, when and under which conditions landslides have occurred, and the impacts of their occurrence.
- Past landslides leave identifiable and characteristic features that can be observed and analysed in the present. These are often morphological features like changes in form or shapes in topography.

Understanding how and why landslides have occurred can help to identify the features and conditions that may make other areas more prone to landslides and slope failure. This understanding can also be used to analyse what might happen if conditioning factors change, for example, because of environmental change. As described in more detail in the Knowledge Product 'Landslide Forecasting', knowing that a specific rainfall intensity over a specific time period had caused several landslides in a particular area can be used as an indicator (threshold) to determine when and where rainfall-induced landslides in this same environmental setting are more likely to occur in the future.

Different techniques exist for collecting landslide information (see this Knowledge Product, **Part B**). Data collection needs to be a continuous and systematic process, but a standard for landslide data collection does not exist. Types of data considered useful include the landslide location, date, trigger and impact.

The nomenclature and wording used when collecting landslide information often follow expert-based classifications, for example, Varnes classification, IAEG Commission on Landslides and UNESCO-WP/WLI. Many classifications use technical language and are aimed at technical engineers. Such classifications can be too comprehensive, and technical and thus not easy for non-technical users to follow. However, non-technical, but trained, local volunteers or response personnel can be a useful resource to provide timely information about landslides simply because they live in or near to the landslide. Therefore, in LANDSLIP, data capture tools were developed to involve non-technical engineers, such as local NGOs and Disaster Management Authority staff in the data collection process.

A3 GENERAL TECHNIQUES FOR COLLECTING LANDSLIDE INFORMATION

Standardised data fields are important for generating a consistent and comprehensive landslides inventory/database. This ensures reproducibility and statistical consistency. Collecting data for a landslide inventory can be carried out using a variety of techniques (see **Fig. A1**), for example:

- field mapping,
- archive studies, literature review and internet research,
- social media (e.g., Twitter, Facebook, Instagram) and newspapers
- interviewing people,
- image interpretation (e.g., satellite images, stereo aerial photographs)
- data from measuring devices

Different examples and descriptions exist outlining what data can be collected and how (e.g., Guzzetti *et al.,* 2012; van Westen *et al.,* 2015).

Figure A1 Examples of four techniques for collection of landslide data. (Photo credits: Upper left photo © Keystone Foundation; All other photos © BGS, UKRI).

A4 LANDSLIDE DATA USAGE IN LANDSLIP

The Geological Survey of India (GSI) provided an extensive landslide inventory and other relevant landslide-related data for the two LANDSLIP study sites, Nilgiris and Darjeeling.

This data enabled the LANDSLIP team to develop, test and evaluate a range of tools and models (see **Fig. A2**). Examples of the use of landslide inventory data in LANDSLIP include:

- T**he short-range forecast**: uses landslide events and corresponding rainfall information from the past to identify when landslides might be more likely in the next two days (see LANDSLIP KP3 for further information).
- **The LANDSLIP forecast bulletin**: a summary interpretation of all available forecasting and landslide tools (see LANDSLIP Knowledge Product 'The Landslide Forecast Bulletin' for further information).

Models developed in LANDSLIP need ground truthing data to evaluate their performance (or model skill), thus continuous collection of landslide data is essential. New landslide data shows how effectively different models work and how useful they are. It also identifies gaps and weaknesses in the tools and models and helps to improve and adapt them to changed conditions or improved understanding.

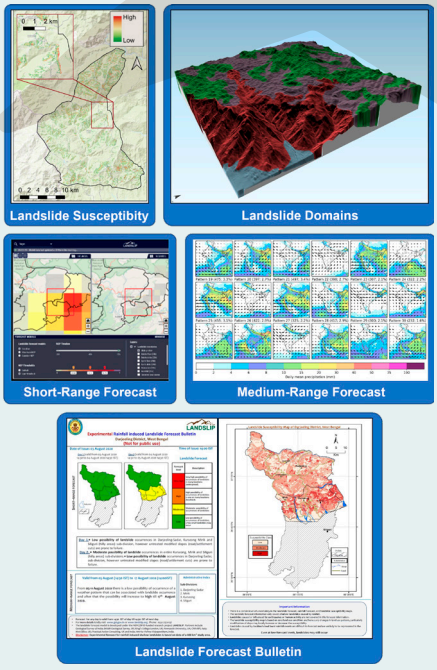


Figure A2 LANDSLIP examples of models and outputs that depend on availability of a representative landslide inventory.

A5 CONSIDERATIONS WHEN SELECTING OBSERVATION DATA

LANDSLIP developed tools to support the collection of landslide information, thus enhancing the normal field survey and mapping campaigns of the GSI. These tools were co-developed and field-tested with colleagues from local NGO partners Keystone Foundation (for Nilgiris) and Save The Hills (for Darjeeling). These two local NGOs followed the training, included personal safety awareness, and used the LANDSLIP tools to collect landslide information to improve the Indian national landslide inventory. These data collection tools were used in the 2020 and 2021 monsoon seasons, during which time timely landslide data was recorded for more than 500 landslides. This data includes landslides in rural areas, thus significantly enhancing the data GSI would otherwise have been able to collect. These tools include:

- **The Landslide Tracker Form**: A paper-based questionnaire that includes questions about the landslide's location, date and time, material and type and subsequent impacts. It includes explanatory notes to help the user to fill it out. This form is aimed at users with little or no technical knowledge of landslide processes. (See this Knowledge Product, **Part B**).
- **Mobile Landslide Tracker App**: Building on the paper form to enhance the content via regular meetings of the LANDSLIP team, project partners Amrita University developed an Android mobile app (freely available, Google Play). The app differentiates between three user groups with different levels of questions: (i) Level 1, untrained users (similar questions to paper form); (ii) Level 2, those with more knowledge of landslides, due to training or their work; (iii) Level 3, the technical experts, e.g., GSI field scientists (technical questions using world-wide accepted landslide terminology). (See this Knowledge Product, **Part C**).
- **Newspapers**: Reports of landslides from local newspapers were collated to enhance the landslide inventories.
- **Social Media**: LANDSLIP colleagues from Amrita and Newcastle Universities explored messaging services (WhatsApp, Twitter) to identify how people communicate about landslide relevant information, before, during and after events. Machine learning algorithms determined different communication patterns that can help in the future to find areas where and when landslides occurred. (See this Knowledge Product, **Part D**).

A6 REFERENCES

Guzzetti, F., Mondini, A.C., Cardinali, M., Fiorucci, F., Santangelo, M. and Chang, K.T. 2012. Landslide inventory maps: New tools for an old problem. *Earth-Science Reviews*, 112, 42–66.

Van Westen, C., Jetten, V., Trigg, M. and Alkema, D. 2015. Report on methodologies for hazard mapping in the Caribbean. *Caribbean Handbook on Risk Information Management* (CHARIM, Version 3).

LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Part B: LANDSLIP Landslide Tracker Form

B1 OVERVIEW

To enhance the Geological Survey of India (GSI) national landslide inventory records, local stakeholder records are essential (see this Knowledge Product Introduction and **Part A**). For local organizations LANDSLIP engaged with, the quality, consistency, usefulness and systematic reporting of their collection of field landslide data varied depending on the knowledge and expertise of the people collecting the information. The variability makes it difficult to compare the data meaningfully, and the usage of this information for landslide analysis can be compromised. Here, we report on a standardised data collection methodology for landslides that LANDSLIP partners developed using a paper-based form. A landslide tracker app (see this Knowledge Product, **Part C**) was also developed, using this methodology as its basis for its first level. Some local users prefer the paper version (e.g., due to internet connectivity).

B2 WHY IS IT IMPORTANT?

The Geological Survey of India (GSI) is the nodal agency for landslides in India. As experts, they do extensive surveying of landslides in India, but are unable to be in all places at all times during periods of the year (e.g., the monsoons) with increased landslide activity. Many landslides disappear in a matter of days or weeks after they occur, because they are very small and quickly removed, or because they are blocking infrastructure and cleared by local teams. Therefore, to aid the modelling of future landslide risk, GSI supplements their existing inventories with stakeholder landslide reports.

B3 DESIGN AND STRUCTURE OF THE FORM

Here, a paper-based form was developed for local users (e.g., students, district officials, NGO volunteers) who might experience landslides regularly in their environment.

The form was developed for local users with limited or no understanding of landslide processes and in such a way that it would be easily understood and filled out.

The development occurred in strong collaboration with UK and Indian partners, benefitting from valuable feedback from local partners (e.g., Save The Hills, Keystone Foundation) whose field-based experience was important to developing and tailoring the document.

The landslide tracker form consists of two double-sided pages (**Fig. B1**), with essential information in the form of tick-box questions on pages 1 and 2 and additional landslide and safety information on pages 3 and 4.

Tick-boxes allow a consistent, fast and easy way for the user to fill out the document, whilst also allowing for comparison of information across multiple landslide entries. For some answers, users have the option to give additional information in a free text box. **Fig. B1** gives a thumbnail overview of the four pages.

Below, we describe each section's content.

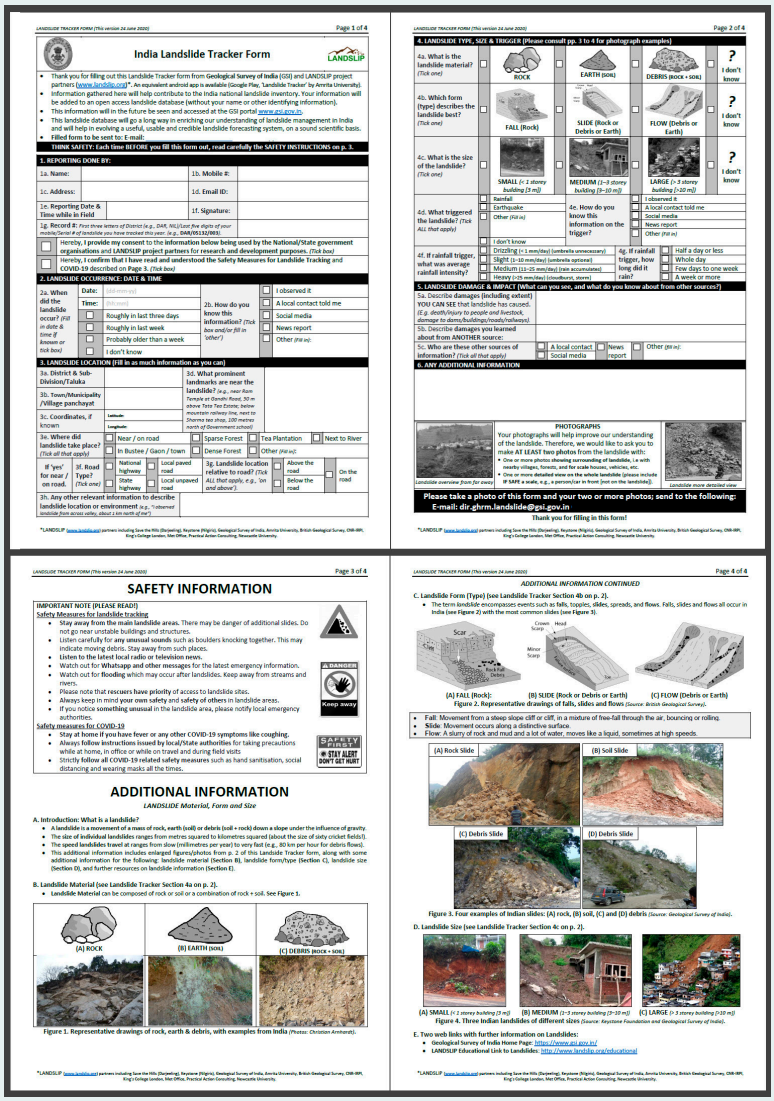


Figure B1 Thumbnail overview of the four-page LANDSLIP Landslide Tracker Form (two pages for recording information, two pages for safety and additional information).

B4 LANDSLIDE TRACKER FORM PAGE 1 (INTRODUCTION AND SECTIONS 1 TO 4)

Introduction and Section 1. User name, contact information and consent. (See **Fig. B2**). This gives those collecting the data context as to the type of user (e.g., a local person who might have a better understanding of local conditions) and in case GSI wants to contact this person for further information. The user gives consent to the use of the data and confirms they have read the safety measures on page 3, as some might not be aware that after a landslide occurs, it might continue to move.

India Landslide Tracker Form

- Thank you for filling out this Landslide Tracker form from **Geological Survey of India** (GSI) and LANDSLIP project partners (www.landslip.org)*. An equivalent android app is available (Google Play, 'Landslide Tracker' by Amrita University).
- Information gathered here will help contribute to the India national landslide inventory. Your information will be added to an open access landslide database (without your name or other identifying information).
- This information will in the future be seen and accessed at the GSI portal www.gsi.gov.in.
- This landslide database will go a long way in enriching our understanding of landslide management in India and will help in evolving a useful, usable and credible landslide forecasting system, on a sound scientific basis.
- **Filled form to be sent to: E-mail: .....**

THINK SAFETY: Each time BEFORE you fill this form out, read carefully the SAFETY INSTRUCTIONS on p. 3.

1. REPORTING DONE BY:			
1a. **Name**:		1b. **Email ID** :	
1c. **Reporting Date & Time while in Field**		1d. **Initials:**	
Record #:			
☐	Hereby, **I provide my consent** to the **information below being used by the National/State government organisations** and **LANDSLIP project partners** for **research and development purposes**. [Note: Depending on your country, you may need to also state where data is stored, and who has access to it]. *(Tick box)*		
☐	Hereby, **I confirm that I have read and understood the Safety Measures for Landslide Tracking** and **COVID-19** described on **Page 3**. *(Tick box)*		

Figure B2 Introduction and Section 1. User name, contact information and consent.

Section 2. Landslide date and time of occurrence. (See **Fig. B3**). Users have the option to record the exact time and date of the landslide, however, it is not often that this is known To account for the uncertainty around timing tick boxes allow the user to estimate the rough date and time as well as an option to say that they do not know. Importantly this captures the uncertainty of the user which is relevant for the future analysis of the data.

2. LANDSLIDE OCCURRENCE: DATE & TIME				
2a. **When did the landslide occur?** *(Fill in date & time **if known** or tick box)*	**Date:**	(dd-mm-yy)	2b. **How do you know this information?** *(Tick box and/or fill in 'other')*	☐ I observed it
	Time:	(hh:mm)		☐ A local contact told me
	☐	Roughly in last three days		☐ Social media
	☐	Roughly in last week		☐ News report
	☐	Probably older than a week		☐ Other *(Fill in)*:
	☐	I don't know		

Figure B3 Section 2. Landslide occurrence information.

Section 3. Landslide location. Within (See **Fig. B4**). Users can give the latitude and longitude of the landslide if known. In addition to this, options are included to describe the landslide location, whether the landslide happened near a road or a forest, the name of the nearest village or a specific landmark. This is helpful if the user does not have any latitude/longitude information. A small box for free text is included where the user can describe the location in his words.

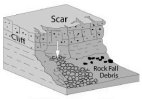
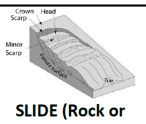
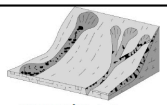
3. LANDSLIDE LOCATION (Fill in as much information as you can)							
3a. **District & Sub-Division/Taluka**				3d. **What prominent landmarks are near the landslide?** *(e.g., near Ram Temple at Gandhi Road, 50 m above Tata Tea Estate; below mountain railway line, next to Sharma tea shop, 100 metres north of Government school)*			
3b. **Town/Municipality /Village panchayat**							
3c. **Coordinates**, if known	**Latitude:**						
	Longitude:						
3e. **Where did landslide take place?** *(Tick all that apply)*	☐ Near / on road	☐ Sparse Forest	☐ Tea Plantation	☐ Next to River			
	☐ In Bustee / Gaon / town	☐ Dense Forest	☐ Other *(Fill in)*:				
If 'yes' for near / on road. 3f. **Road Type?** *(Tick one)*	☐ National highway	☐ Local paved road	3g. **Landslide location relative to road?** *(Tick ALL that apply, e.g., 'on and above').*	☐ Above the road	☐ On the road		
	☐ State highway	☐ Local unpaved road		☐ Below the road			
3h. **Any other relevant information to describe landslide location or environment** *(e.g., "I observed landslide from across valley, about 1 km north of me")*							

Figure B4 Section 3. Landslide Location.

B5 LANDSLIDE TRACKER FORM PAGE 2 (SECTIONS 4 TO 6 AND PHOTOGRAPHS)

Section 4. Landslide Type, Size & Trigger. (See Fig. B5). A series of pictures and pictograms, based on internationally recognised definitions (see Varnes, 1978; Canadian Geotechnical Society and UNESCO, 1993), were developed for this section to help the user understand the definition and to aid their decisions. Landslide triggers can be varied but the options were tailored to the pilot area with a focus on rainfall and earthquakes, with further questions about rainfall intensity and duration. A free-text box is available to provide additional trigger information.

4. LANDSLIDE TYPE, SIZE & TRIGGER (Please consult pp. 3 to 4 for photograph examples)

4a. **What is the landslide material?** *(Tick one)*	☐	 **ROCK**	☐	 **EARTH** (SOIL)	☐	 **DEBRIS** (ROCK + SOIL)	☐	**?** I don't know
4b. **Which form (type) describes the landslide best?** *(Tick one)*	☐	 **FALL (Rock)**	☐	 **SLIDE (Rock or Debris or Earth)**	☐	 **FLOW (Debris or Earth)**	☐	**?** I don't know
4c. **What is the size of the landslide?** *(Tick one)*	☐	 **SMALL** *(< 1 storey building [3 m])*	☐	 **MEDIUM** *(1–3 storey building [3–10 m])*	☐	 **LARGE** *(> 3 storey building [>10 m])*	☐	**?** I don't know

4d. **What triggered the landslide?** *(Tick ALL that apply)*	☐ Rainfall ☐ Earthquake ☐ Other *(Fill in)* ☐ I don't know	4e. **How do you know this information on the trigger?**	☐ I observed it ☐ A local contact told me ☐ Social media ☐ News report ☐ Other *(Fill in)*	
4f. **If rainfall trigger, what was average rainfall intensity?**	☐ Drizzling (< 1 mm/day) (umbrella unnecessary) ☐ Slight (1–10 mm/day) (umbrella optional) ☐ Medium (11–25 mm/day) (rain accumulates) ☐ Heavy (>25 mm/day) (cloudburst, storm)	4g. **If rainfall trigger, how long did it rain?**	☐ Half a day or less ☐ Whole day ☐ Few days to one week ☐ A week or more	

Figure B5 Section 4, landslide type, size and trigger.

Section 5. Landslide damage & impact. (See Fig. B6). A free-text box is included to provide information about damages and the impact of the landslide, including how they know this information.

5. LANDSLIDE DAMAGE & IMPACT (What can you see, and what do you know about from other sources?)

5a. Describe **damages (including extent) YOU CAN SEE** that landslide has caused. *(E.g. death/injury to people and livestock, damage to dams/buildings/roads/railways).*						
5b. Describe **damages you learned about from ANOTHER source:**						
5c. **Who are these other sources of information?** *(Tick all that apply)*	☐ A local contact ☐ Social media	☐ News report	☐ Other *(fill in)*:			

Figure B6 Section 5, information about damage and impact.

Section 6. Any additional information. (See Fig. B7). Additional information not covered in previous sections can be added in another free-text box.

6. ANY ADDITIONAL INFORMATION

Figure B7 Section 6, additional information.

Photographs. (See Fig. B8). Request for at least two photographs. Allows analyst (e.g., GSI) a better understanding of the landslide itself, its processes, size (if a scale in the photograph) and to capture any further information potentially missed by the original user. The section gives guidance on the use of scale within the pictures and how the pictures should be taken.

Landslide overview from far away

PHOTOGRAPHS

Your photographs will help improve our understanding of the landslide. Therefore, we would like to ask you to make **AT LEAST two photos** from the landslide with:

- One or more photos **showing surrounding of landslide**, i.e with nearby villages, forests, and **for scale** houses, vehicles, etc.
- One or more **detailed view on the whole landslide** (please include **IF SAFE a scale**, e.g., a person/car in front [not on the landslide]).

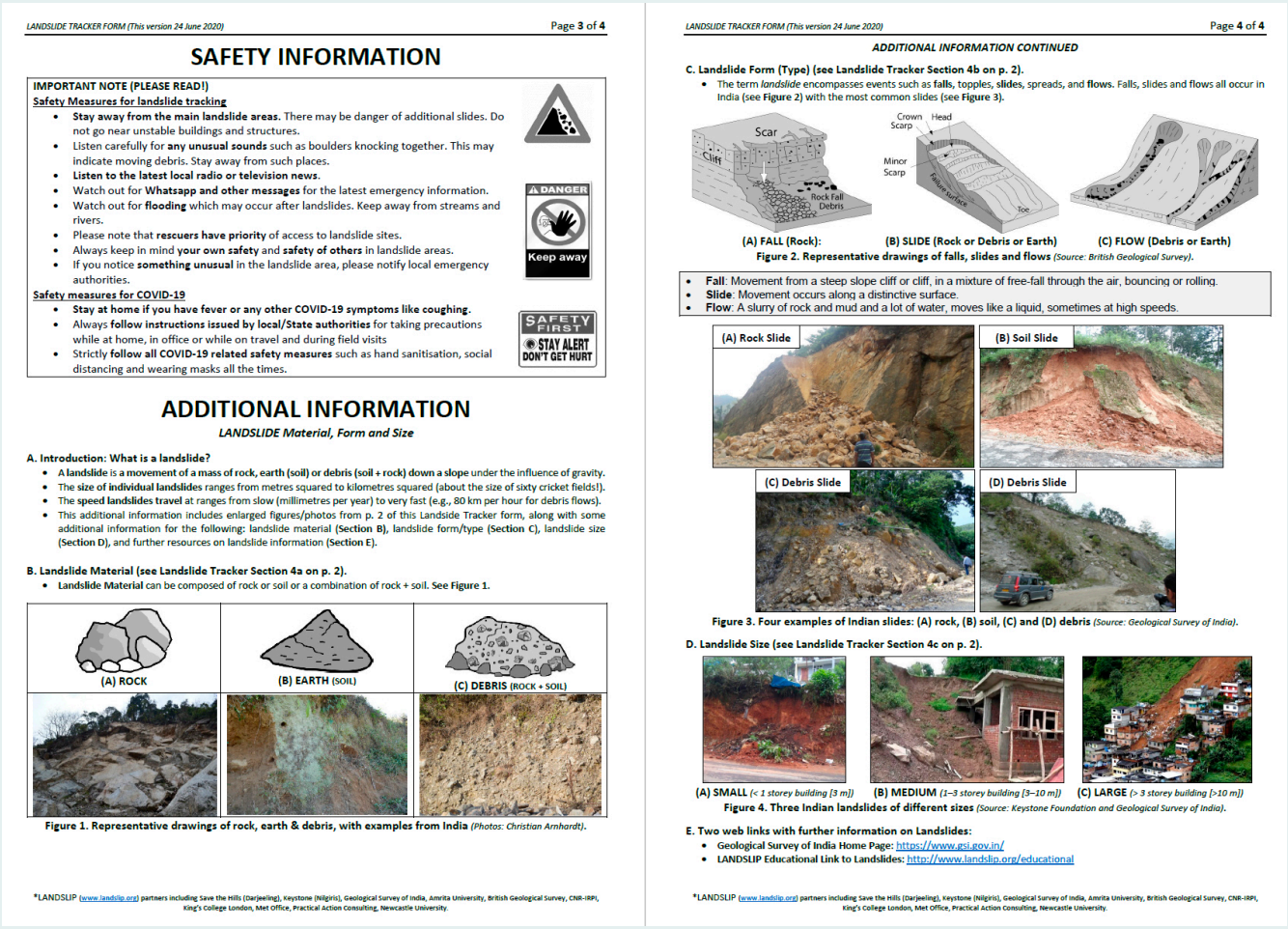
Landslide more detailed view

Figure B8 Photographs.

B6 LANDSLIDE TRACKER FORM PAGES 3 TO 4 (SAFETY AND ADDITIONAL INFORMATION)

Safety Information. On Page 3 of the Landslide Tracker Form the user can find some general safety information (see **Fig. B9**). detailing a list of what to do and not to do around potentially unstable ground. A brief section on COVID-19 safety is also included.

Additional Information. On Pages 3 to 4 of the Landslide Tracker Form, the user can find additional information (see **Fig. B9**) on landslides using graphics and text to illustrate different landslide types.



LANDSLIDE TRACKER FORM (This version 24 June 2020) Page 3 of 4

SAFETY INFORMATION

IMPORTANT NOTE (PLEASE READ!)

Safety Measures for landslide tracking

- **Stay away from the main landslide areas.** There may be danger of additional slides. Do not go near unstable buildings and structures.
- Listen carefully for **any unusual sounds** such as boulders knocking together. This may indicate moving debris. Stay away from such places.
- **Listen to the latest local radio or television news.**
- Watch out for **Whatsapp and other messages** for the latest emergency information.
- Watch out for **flooding** which may occur after landslides. Keep away from streams and rivers.
- Please note that **rescuers have priority** of access to landslide sites.
- Always keep in mind **your own safety** and **safety of others** in landslide areas.
- If you notice **something unusual** in the landslide area, please notify local emergency authorities.

Safety measures for COVID-19

- **Stay at home if you have fever or any other COVID-19 symptoms like coughing.**
- Always **follow instructions issued by local/State authorities** for taking precautions while at home, in office or while on travel and during field visits
- Strictly **follow all COVID-19 related safety measures** such as hand sanitisation, social distancing and wearing masks all the times.

DANGER Keep away

SAFETY FIRST STAY ALERT DON'T GET HURT

ADDITIONAL INFORMATION

LANDSLIDE Material, Form and Size

A. Introduction: What is a landslide?

- **A landslide** is a **movement of a mass of rock, earth (soil) or debris (soil + rock) down a slope** under the influence of gravity.
- The **size of individual landslides** ranges from metres squared to kilometres squared (about the size of sixty cricket fields!).
- The **speed landslides travel** at ranges from slow (millimetres per year) to very fast (e.g., 80 km per hour for debris flows).
- This additional information includes enlarged figures/photos from p. 2 of this Landside Tracker form, along with some additional information for the following: landslide material (**Section B**), landslide form/type (**Section C**), landslide size (**Section D**), and further resources on landslide information (**Section E**).

B. Landslide Material (see Landslide Tracker Section 4a on p. 2).

- **Landslide Material** can be composed of rock or soil or a combination of rock + soil. **See Figure 1.**

(A) ROCK (B) EARTH (SOIL) (C) DEBRIS (ROCK + SOIL)

Figure 1. Representative drawings of rock, earth & debris, with examples from India *(Photos: Christian Arnhardt).*

*LANDSLIP (www.landslip.org) partners including Save the Hills (Darjeeling), Keystone (Nilgiris), Geological Survey of India, Amrita University, British Geological Survey, CNR-IRPI, King's College London, Met Office, Practical Action Consulting, Newcastle University.

LANDSLIDE TRACKER FORM (This version 24 June 2020) Page 4 of 4

ADDITIONAL INFORMATION CONTINUED

C. Landslide Form (Type) (see Landslide Tracker Section 4b on p. 2).

- The term *landslide* encompasses events such as **falls**, topples, **slides**, spreads, and **flows**. Falls, slides and flows all occur in India (see **Figure 2**) with the most common slides (see **Figure 3**).

Scar Cliff Rock Fall Debris Crown Head Scarp Minor Scarp Failure surface Toe

(A) FALL (Rock): (B) SLIDE (Rock or Debris or Earth) (C) FLOW (Debris or Earth)

Figure 2. Representative drawings of falls, slides and flows *(Source: British Geological Survey).*

- **Fall**: Movement from a steep slope cliff or cliff, in a mixture of free-fall through the air, bouncing or rolling.
- **Slide**: Movement occurs along a distinctive surface.
- **Flow**: A slurry of rock and mud and a lot of water, moves like a liquid, sometimes at high speeds.

(A) Rock Slide (B) Soil Slide (C) Debris Slide (D) Debris Slide

Figure 3. Four examples of Indian slides: (A) rock, (B) soil, (C) and (D) debris *(Source: Geological Survey of India).*

D. Landslide Size (see Landslide Tracker Section 4c on p. 2).

(A) SMALL *(< 1 storey building [3 m])* (B) MEDIUM *(1–3 storey building [3–10 m])* (C) LARGE *(> 3 storey building [>10 m])*

Figure 4. Three Indian landslides of different sizes *(Source: Keystone Foundation and Geological Survey of India).*

E. Two web links with further information on Landslides:

- **Geological Survey of India Home Page:** https://www.gsi.gov.in/
- **LANDSLIP Educational Link to Landslides:** http://www.landslip.org/educational

*LANDSLIP (www.landslip.org) partners including Save the Hills (Darjeeling), Keystone (Nilgiris), Geological Survey of India, Amrita University, British Geological Survey, CNR-IRPI, King's College London, Met Office, Practical Action Consulting, Newcastle University.

Figure B9 Landslide Tracker Form safety and additional information.

B7 SUMMARY

The landslide tracker form developed by the LANDSLIP team has helped to collect landslide information, date and time, location, landslide type and material, trigger and impact in a standardised but uncomplicated way that enables -users who are not technical specialists to fill it out. First tests with this form (and the landslide tracker app, see this Knowledge Product **Part C**) in the monsoon season 2020 in two test sites in India (Darjeeling and Nilgiris) helped to collect in total more than 500 landslides. Discussions with users after the monsoon season showed that the form was easy to understand and all in all quickly to use in the field.

B8 REFERENCES

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LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Part C: The Landslide Tracker App

C1 OVERVIEW

During the Indian monsoons, tracking each landslide event, developing early warning thresholds, understanding triggers, and initiating disaster rescue and relief efforts are complex for researchers and administration. LANDSLIP designed and developed a dedicated crowdsourced mobile application, for systematic collection, validation, summarisation, and dissemination of landslide data in real-time. The app's purpose was to encourage the easy local collection of landslide information via local NGOs and district officials, to supplement the work of GSI (Geological Survey of India) experts, who might not be able to get to landslides in time to record them. This innovative mobile app uses a scalable real-time data collection methodology, tracking landslide events through citizen science. The app is available at the Google Play Store for free and at http://landslides.amrita.edu, with software conceived and developed by Amrita University in the context of the LANDSLIP research project and content developed through a joint effort of LANDSLIP partners. The Landslide tracker app was released during the 2020 and 2021 monsoon seasons, and between it and the Landslide Tracker Form (see this Knowledge Product, **Part B**) more than 500 landslides were recorded.

C2 DESIGN AND STRUCTURE OF THE APP

The app (**Fig. C1**) has been developed to be intuitive and quick to record landslides. Based on experience with local partners, it takes less than 3 minutes to record one landslide. The 'Landslide Tracker' mobile app allows users to record landslide details such as GPS location, date & time of occurrence, images, type, material, size, impact, area, geology, geomorphology, and comments. The Tracker was developed with three user levels to reflect this variation in landslide expertise, with each level including a privacy policy, safety instructions, and an option for the user to be contacted for further information or to be anonymous.

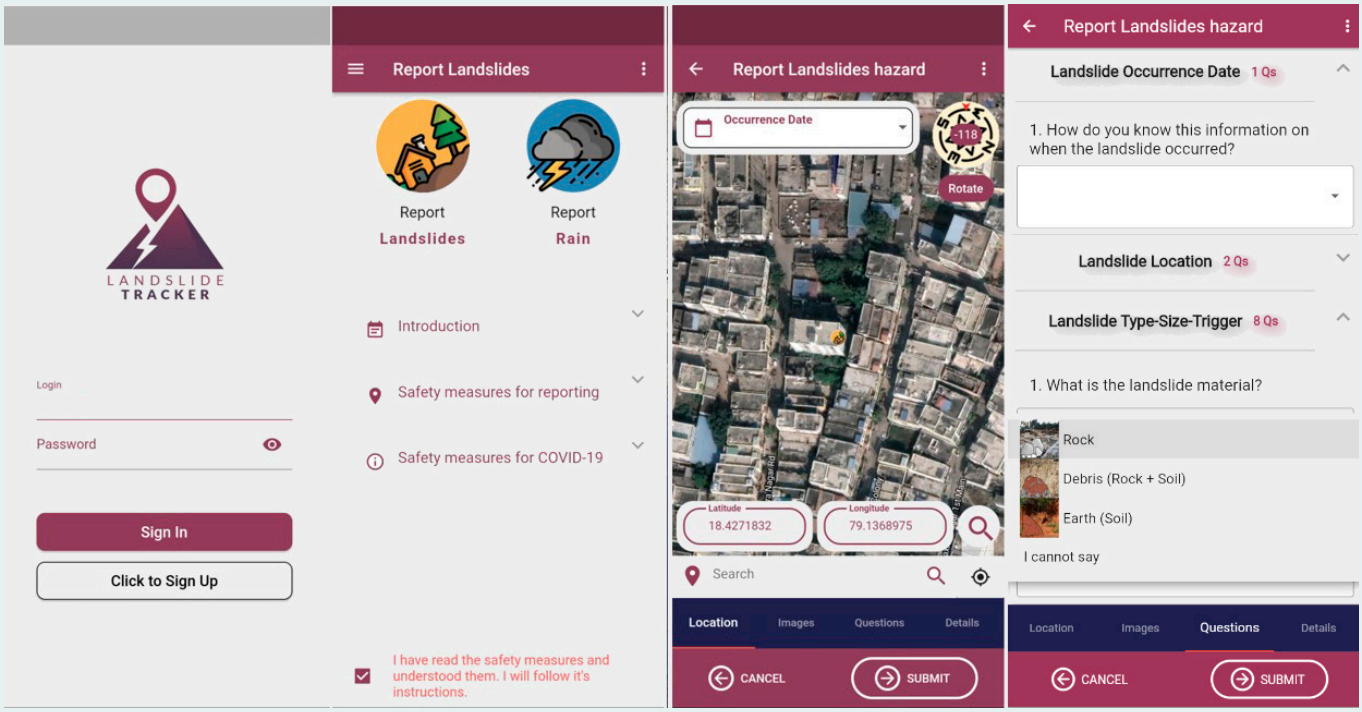

Figure C1 Four example landslide recording screens from the LANDSLIP Landslide Tracker App.

Level 1 represents users with limited expertise and records the most basic landslide information. These non-specialists represent the majority of people capturing data within each study area. Information submitted by this user group, due to the limited understanding of landslides in a geological context, might have the highest uncertainty. Questions for this level use a simplified lexicon: (i) location, date, time, (i) pictures of landslide material, (iii) landslide type, (iv) generalised impact information. Level 1 questions were slightly refined from the Landslide Tracker form (see this Knowledge Product **Part B**).

Level 2 represents more specialist users with a higher advanced understanding of landslides from their background training/proficiency or users that have undergone training. In general, these people are asked the same questions as in Level 1, but using more technical vocabulary and more detailed information is requested, such as landslide size.

Level 3 is for trained landslide experts. They are asked a wide range of landslide questions, reflecting internationally recognised landslide glossaries and definitions, and based on the current methodology used by the GSI.

C3 LANDSLIDE VIEWING SCREENS

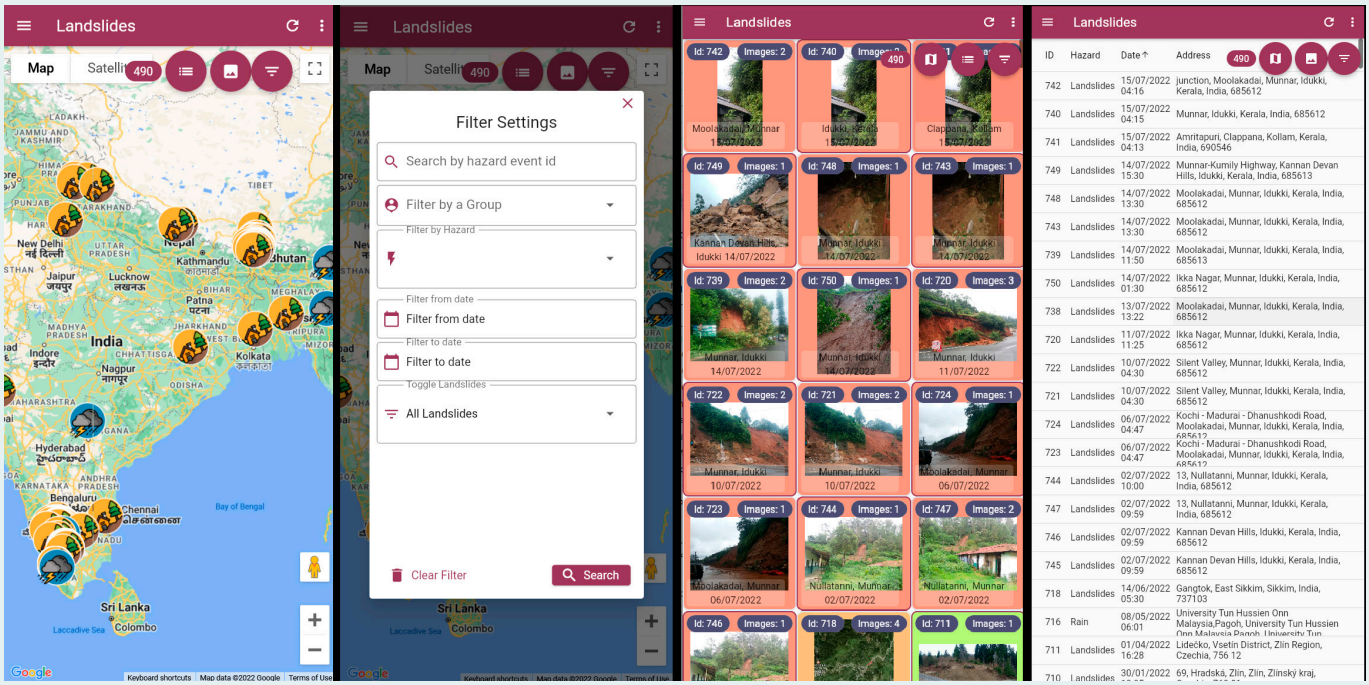

Figure C2 Four example landslide viewing screens from the LANDSLIP Landslide Tracker App.

The user can view the landslides submitted by everyone in real-time using the View Landslides menu using interactive screens (**Fig. C2**). The map viewer shows all landslides by location in a geographic region. The filter viewer allows one to select landslides by ID, group, date, and type of landslide. The picture viewer shows the landslides along with the location and landslide occurrence date (which one can then zoom into). The list interface shows the landslide occurrence date and address. The user can view their own landslides through the View My Landslides menu. The user can update and edit landslide information and other details. Additional images can be uploaded or updated.

C4 LANDSLIDE TRACKER APP STRENGTHS AND ITEMS TO CONSIDER

The Landslide tracker app (see also Landslide Tracker Form, this Knowledge Product **Part B**) was released during the 2020 and 2021 monsoon seasons, and more than 500 landslides were recorded. Strengths we found included (i) detailed enhancement of the GSI's national landslide inventory with data sourced by local actors, (ii) immediate upload of data to the cloud, (iii) collection of a large amount of landslide-related data in a systematic and structured way, (iv) a methodology designed in joint cooperation between national government agencies, NGOs and academic institutions, (v) near real-time collection of data that might otherwise be erased from the record. When developing an app such as this, items to consider include the following: (i) who will pay for and maintain the app once it is operational, (ii) branding of the app, (iii) quality control of the data, (iv) platform deployment with respect to user access, (v) where data is stored and who has access to it both before, during and after any quality control, (vi) how the data will be used (e.g., combining with other types of landslide data and incorporating into landslide modelling). See Paul et al. (2021), who in the context of the SHEAR (Science for Humanitarian Emergencies and Resilience) FCDO/NERC programme, provide a further discussion of items to consider when developing mobile apps.

C5 REFERENCES

Amrita University and the LANDSLIP consortium. 2022. Landslide Tracker App [Online] [Last accessed 1 July 2022].

Paul, J.D., Bee, E. and Budimir, M. 2021. Mobile phone technologies for disaster risk reduction. *Climate Risk Management*, 32, 100296.

LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Part D: Sourcing landslide data through social media: challenges and limitations

D1 OVERVIEW

Social media is increasingly used to acquire information to support disaster management. It provides a potentially useful source of real-time data during the disaster management cycle: (i) pre-hazard preparedness, (ii) emerging hazard response and (iii) post-disaster recovery. Whilst a benefit of social media is data volume, this can also be a limitation along with associated noise and difficulties in extracting useful information in a timely fashion often across multiple platforms. LANDSLIP explored two systems to enable the automated collection of relevant historical and real-time data from social media and online news to support the data gathering and decision-making processes within its prototype regional Landslide Early Warning System (LEWS).

D2 SOCIAL MEDIA IN DISASTER MANAGEMENT

Social media covers the broad range of internet-based applications, websites and messaging apps that allow users to create and share content (photographs, text, videos, audio files), send messages or take part in social networking.

The emergence of social media and crowdsourcing has created opportunities for more human-centric approaches to disaster-related data and information acquisition. These can be used alongside traditional methods of data acquisition to support and enhance the effectiveness of disaster management. Data and information collected through social media is essential during all stages of the disaster management cycle (see **Fig. D1** to right).

Despite the wide range of potentially positive benefits, using social media in disaster management also poses many challenges which need to be managed accordingly. For example, there may be constraints associated with data access, reliability and completeness/representativeness but also in the ability to analyse and process such data. Depending on the application or approach, protocols to ensure privacy and security of information may also need to be established.

Figure D1 Three stages of the disaster management cycle (before, during, after) and the purpose of data and information collection.

See Bee and Budmir (2019) for further reading about using social media in natural hazard early warning systems.

D3 EXPLORING TWITTER AS A DATA SOURCE

The volume, velocity, and variety of social media data make it increasingly difficult for disaster managers to extract relevant and timely information from such data. Tools and systems which can automatically classify this data and turn it into meaningful information are crucial for realising its benefits.

Twitter's Application Programming Interface (API) is more open and accessible than many other social media platforms making it easier for researchers to build tools that utilise its data. Twitter data are comprised of several types of information, including account IDs, timestamps, user tweets (e.g., texts, images, videos), coordinates, retweets etc. This means it is also a relatively rich platform for testing research tools and methods relating to 'unstructured' data.

LANDSLIP has developed new methodologies to demonstrate how meaningful data about landslides can be automatically collected from 'semi-structured data' using Twitter. Challenges of Twitter as a data source in India, and thus the applicability of research tools developed, relate to platform use (according to Statista.com, 23.6 million users in India in January 2022, compared with 460 million active internet users) and multiple spoken languages (e.g. Hindi, Malayalam, Tamil, Bengali and English). Nonetheless, the research developed advanced methodological approaches for semi-structured data, irrespective of platform.

D4 WEB CRAWLER CAPTURING DATA FROM SOCIAL AND ONLINE MEDIA APPROACH

LANDSLIP researchers at Amrita University have developed a conceptual tool to collect and use historical and real-time social media data (e.g., Twitter, online news), to gain landslide-related information (see Gopal et al., 2021). This tool consists of three modules: a data collecting module for Twitter, a data collection module for online news, and an event detection module. The Twitter data collection module collects data from Twitter on landslide hazards based on ontology keywords (e.g., landslide, landslip, rockfall, rainfall, cloudburst). It collects tweets in Hindi, Malayalam, Tamil, and Bengali, which necessitates the creation of a language translation and transliteration submodule. Using a keyword ontology, the online news data collection module employs a web crawler to collect hazard articles. Using Natural language processing techniques, local media news reports are able to be captured where they might not be reported in the mainstream media.

D5 TWITTER DATA CLASSIFICATION AND DIALOGUE APPROACH

LANDSLIP researchers at Newcastle University and Amrita University (Phengsuwan et al., 2021) have developed a methodological framework that contextualizes relevant information about landslides from Twitter and then attempts to retrieve additional information that could support pre-event detection. Most social media data processing and/or acquisition methods are based on Machine Learning (ML) and Natural Language Processing (NLP) classifiers which lack the capacity to fully engage with the users who are contributing the data and may miss pre-failure indicators.

The research tool demonstrates a two-way flow of information from the user and a novel ontology to extract knowledge from landslide experts showing the relations among landslides, landslide warning signs, and other potential occurrences of hazards. The approach has the potential for enhancing data acquisition by automatically establishing a dialogue with those that have posted potentially relevant tweets.

Amrita University has further developed a platform for social media mining for multi-hazard event detection (see **Fig. D2**), using tweets and online news related to hazardous events based on keyword mapping.

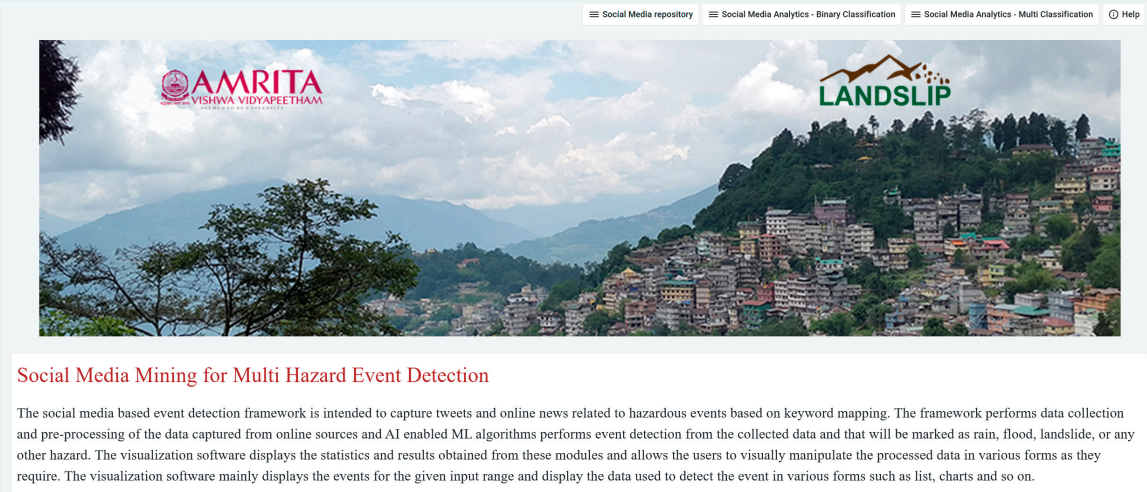

Figure D2 Amrita University social media mining for multi-hazard event detection. Image © Amrita University.

D6 REFERENCES

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LANDSLIP KNOWLEDGE PRODUCT: Landslide Data

Conclusion and recommendations

SUMMARY

Records of the region's past landslides and their impact are key for developing landslide forecasting models and tools and for a better understanding of potential future impact. In this knowledge product we have (i) provided an overview of landslide data collection methodologies and the developed tools in the framework of the LANDSLIP project; (ii) described a landslide tracker form and mobile app co-developed within LANDSLIP for the systematic local collection of landslide records; (iii) described alternative methods (newspapers, crowdsourcing of Twitter feeds) for the collection of landslide records. For any local data collection methods to be successful, they require close co-development between a range of actors, ranging from local actors (NGOs, local officials), national (e.g., Geological Survey of India), and for LANDSLIP, the government, academic, and NGO co-partners.

KEY LEARNINGS

- A representative sampling of landslides in a region, including when, where, size, and impact, is key to creating effective landslide forecasting tools and mitigation efforts.
- A record of landslides for a region includes (i) not just large landslides, but also those that are medium and small; (ii) landslides that occur farther away from roads; (iii) different types of landslides (e.g., deep-seated, shallow).
- Standardised data fields are important for generating a consistent and comprehensive landslides inventory/database.
- Local communities are essential to complement efforts at the national level in creating representative landslide inventories.

RECOMMENDATIONS

- For developing landslide forecasting tools in a region, a detailed inventory of existing quality, quantity and representative completeness of landslides should be done.
- Existing landslide inventories created by national agency experts should be supplemented by local-collected data (e.g., landslide tracker mobile app), and potentially also by newspapers and Twitter.

LIMITATIONS AND OUTSTANDING CHALLENGES

- Local collection methods for landslide inventories require (sometimes extensive) post-processing of the data with regards to duplicates, errors, and representativeness of the region (e.g., are local actors only collecting landslides close to roads).
- Although some local NGOs were willing to use local collection methods developed as part of LANDSLIP, barriers included the ability for local officials to fit the recording of landslide records into their daily time schedules and their approval process. Any local collection method developed should be created such that it is useable, used, and useful for the local actors.
- The legacy of the mobile landslide tracker app developed as part of LANDSLIP is dependent on the willingness of national actors to use/maintain it and promote its use at district (local) levels.
- A challenge of collecting local landslide data—either records via the landslide tracker app, landslide tracker form, or via Twitter and newspapers—is how the data will be combined with other types of 'expert' collected landslide data and incorporated into landslide modelling.

FURTHER READING

- Amrita University and the LANDSLIP consortium. 2022. Landslide Tracker App [Online] Available at Google Play and at https://landslides.amrita.edu [Last accessed 1 July 2022].
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CITATION

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