Science-practice nexus for landslide surveying: technical training for local government units in Indonesia

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Abstract. The Indonesian archipelago is prone to various geological hazards on an almost day to day basis. In order to mitigate disaster risk and reduce losses, the government uses its unique setup of ministerial training institutions. The Centre for Development of Human Resources in Geology, Mineral and Coal offers different levels of technical training to local governments in order to provide them with the necessary means to understand geological hazards, mitigate risks, and hence close the gap between local and national governments. One key factor has been the continuous incorporation of new scientific knowledge into their training curricula. The paper presents benefits and challenges of this science-practice nexus using the standardised landslide survey as one example where mobile technology has been introduced to the training just recently.

1. Introduction

The Indonesian archipelago faces multiple geological hazards and the government needs a comprehensive mechanism to mitigate disaster risks [1,2]. According to the Indonesian disaster statistics of the Centre for Research on the Epidemiology of Disasters (CRED), landslides are the third most frequent disaster, with floods on top, followed by forest fires. Adding up to more than 1,500 events in the year 2016 only (until August) [3]. The hazard specific Global Assessment Report on Disaster Risk Reduction (GAR) on landslide risk in Indonesia [4], states that according to Christanto et al. [5] during the period 1981-2007 the average number of events per year was 49, with the annual distribution closely related to the rainfall variations.

The Hyogo Framework of Action (HFA) with the third Priority for Action on knowledge, innovation, and education includes the following two key elements, which are of particular interest to this paper. First, “Develop training and learning programmes in disaster risk reduction targeted at specific sectors (development planners, emergency managers, local government officials, etc.)” [6]. Second, “Promote the use, application and affordability of recent information, communication and space-based technologies and related services, as well as earth observations, to support disaster risk reduction, particularly for training and for the sharing and dissemination of information among different categories of users” [6].

Based on the biannual HFA progress reports there has been considerable progress in Indonesia on these matters since the formulation of the HFA agenda [7–10]. For example, disaster risk reduction has been included into the national education curriculum and trainings for local governments are
provided regularly. Still, the Indonesian National Disaster Management Authority (BNPB) reports in 2015, that “One of the remaining challenges in this regard [core indicator 2 of priority for action 3] include the need to enhance coordination among relevant agencies from the national down to the local levels. The government needs to advocate further the integration of DRR [Disaster Risk Reduction] and recovery concepts into school education and DM [Disaster Management] training and exercises, particularly at the district/city governments as the actual service providers” [7]. In the “new” Sendai Framework for Disaster Risk Reduction 2015-2030, the issue of government employees as service providers to the wider community has again been raised as an important task [11]. It states now in Priority 1 “Understanding disaster risk”: there is a great need to “Build the knowledge of government officials at all levels, civil society, communities and volunteers, as well as the private sector, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction, including the use of existing training and education mechanisms and peer learning;” [11].

This reflects the ongoing necessity to strengthen the interlinkages, communication channels, and coordination efforts among and between national and local stakeholders including government and non-governmental education institutions in the field of (professional) training to bridge the gap between advanced scientific knowledge on the one hand and implementation on the other hand. In the course of this paper, we refer to this as the science-practice nexus of technical training provision.

Since 2004, the German cooperation project “Mitigation of Georisks”, implemented by the German Federal Institute for Geosciences and Natural Resources (BGR) and subordinated agencies of the Ministry of Energy and Mineral Resources of Republic of Indonesia, strengthens public institutions of disaster management and sub-national authorities in Indonesia to improve their services concerning the mitigation of geological risks [12]. In cooperation with the Ministries Human Resources Development Agency (BPSDM) the project focuses since 2015 on the improvement of selected technical trainings [13]. One major result of the project is the development of the Landslide Survey Data Sheet (LSDS) based on international standards [14] together with the Geological Agency of Indonesia (GAI) and its implementation in current training curricula at the Centre for Development of Human Resources in Geology, Mineral and Coal (PPSDM GEOMINERBA). Using international standards for landslide data collection though the LSDS ensures comparability of data on national and international level and fosters harmonization processes on data acquisition, susceptibility mapping and hazard evaluation. The landslide survey data is stored in the Landslide Inventory Database of Indonesia (LIDIA), also developed during the cooperation project [15] and now maintained by the GAI Centre for Volcanology and Mitigation of Geological Hazards. The parameters stored in the database can be used to further analyse landslide susceptibility on various scales.

In order to successfully conduct landslide surveys and apply the LSDS in remote areas, technical trainings for civil servants across the country are indispensable to support the technical capacity at local level. This further serves the national data availability in the field of geological hazards and strengthens the capacity to do landslide susceptibility analysis at GAI. To support instantaneous transfer of survey data from local surveyors to GAI an Android application has been developed in the course of the development cooperation project [16]. The mobile application replaces the paper-based LSDS and is used in the Landslide Survey training of PPSDM GEOMINERBA. Landslide survey techniques using mobile applications allow to reach out to remote areas for data collection while preserving high data quality. The necessary technical training using such methods needs to enable local government units to survey independently and maintain minimum standards.

2. Purpose
The paper presents benefits and challenges of existing interlinkages between PPSDM GEOMINERBA and GAI for landslide surveying and database utilization through appropriate training setup and teaching techniques. It highlights the importance of technical trainings for local governmental bodies to support disaster mitigation strategies. Transferring scientific and technical knowledge into formal training processes in the field of geological disaster mitigation has been at the centre of the GEORISK project. In the course of this process, various scientific institutions are involved in reviewing and updating the existing training materials. Simultaneously, implementing personnel (= users) are encouraged to provide their valuable insights from the implementation point of view. In this sense, the
Science-practice nexus is strengthened through sharing of experiences and working as a team on improving training curricula.

We illustrate this based on the landslide survey trainings offered at PPSDM GEOMINERBA compromising of a sequence of two trainings (“Landslide Surveying” and “Survey Data Processing and Interpretation”) [17,18]. Therefore the paper first provides insights to the governmental setup of training centres, second the structure of two landslide related trainings is explained using the LSDS and LIDIA as a best-practice example. Third, the rational of introducing mobile technology to further enhance the learning experience and closing in on the science-practice nexus is explained.

3. Institutional Framework of Human Resource Development in Indonesia

In Indonesia, each Ministry has an Agency for Human Resources Development. Its functions encompass all tasks of planning, implementation, monitoring and evaluation of the human resource development activities in their respective working areas. In the case of the Ministry for Energy and Mineral Resources, these working areas are comprised of Geology, Mineral, and Coal; Power, New Energy, Renewable Energy, and Energy Conservation; Oil and Gas. The specific tasks in the geology sector include inter alia provision of training in geological risk mitigation, georisk-sensitive spatial planning and volcanological monitoring.

The training centres are mandated to train Local Government Unit (LGU) personnel. They are eligible to request professional training, which is then performed by the training centres professionals. Often these trainings even take place on the LGUs premises.

The GAI under the same ministry as the Agency for Human Resource Development is mandated among other things to perform research on geological disaster mitigation, mapping of existing hazards, and monitoring of potential geological threats. This includes the assessment of all landslides occurring across the country, providing hazard maps for earthquakes, landslides, and volcanoes, as well as monitoring of volcanic activities. In order to facilitate the surveying and monitoring task of GAI, LGU staff are doing the basic geological survey. If more detailed analysis is necessary, national staff is dispatched to the scene by GAI. Local government employees are therefore often requested to do the initial geological landslide survey. For the purpose of appropriate technical training of these local government employees, GAI also supports PPSDM GEOMINERBA in developing and revising of training curricula and material, as well as during the trainings itself.

While LGU staff needs ready to use methods, the advanced user wants as many details as possible based on the latest scientific achievements. Linking the data user (GAI) with those providing the technical training (PPSDM GEOMINERBA) to the surveyor (LGU) has been of great benefit to the continuous improvement of a practical training setup.

4. Professional Trainings for Local Government Units

The two trainings offered by PPSDM GEOMINERBA in the field of landslide survey and analysis aim to train LGU staff in order to support the government agencies, especially GAI. Learning objectives and training outcomes are defined using a competence-based approach: the Landslide Survey Training uses existing international standards to develop a consistent method for the assessment of landslides in Indonesia. Participants are enabled to perform landslide data acquisition and landslide reporting to the GAI. The second training advances one step further and uses these data, enabling participants to further explore landslide survey data, analyse them according to national regulations, and provide technical recommendations. The following section explains further the layout and content of said trainings and how international surveying methods are incorporated.

The Landslide Survey Training of PPSDM GEOMINERBA is based on a comprehensive and modular landslide assessment workflow that was developed by BGR as a standard operating procedure [19]. In cooperation with the GAI, this standard workflow was adapted to the specific situation and requirements of Indonesia and was implemented by GAI to elaborate and maintain the national landslide inventory of Indonesia. This approach comprises three sub-modules that build upon each other, starting with the “Field Survey Techniques” module that encompasses the knowledge and skills to record and map landslides in the field by using a specific field survey form, called “Landslide Survey Data Sheet (LSDS)” [20]. The second module, the “Digital Landslide Inventory” module,
comprises a corresponding database application that is known as the “Landslide Inventory Database of Indonesia (LIDIA)” [15]. This national inventory database application offers the seamless integration of the recorded analogue field data into the digital workflow. The third module, the “Landslide Susceptibility Assessment” [21] module, facilitates the GAI to assess the spatial hazard and risk potential of landslides and supports sustainable land use planning and implementation of mitigation strategies.

In this perspective, the first training course of PPSDM GEOMINERBA enables the participants to record and map landslides in the field, using the LSDS, and transfer the analogue information into the digital LIDIA application.

The LSDS is based on the suggested methods and terminology of the UNESCO Working Party on World Landslide Inventory [14,22,23], serves as a checklist for the documentation and investigation of landslides in the field and aims to achieve a standardized institutional nomenclature. It is organized in three information levels. The first information level is compulsory and contains the minimum required information about the mass movement, namely location, general geological and environmental setting and the date of occurrence. The second information level comprises descriptive information on landslide typology, causes and triggers, and the third information level on damages, losses and casualties [20,24]. The recorded information therefore meets all requirements for a reliable inventory dataset but requires trained personnel with a basic understanding of landslides.

Therefore, the training incorporates a thorough introduction of the theoretical background of landslide mapping and the necessary information to be recorded in the field. This is supplemented by practical exercises in the field, during which the participants apply the imparted knowledge and map different landslides in the surroundings of the training locality. In that way they gather first experiences and are able to discuss results and challenges with the teaching staff. Mixing exercise elements at the landslide location with theoretical classroom sessions provide the basis for a mutual learning environment. In a second step, the participants are introduced to the digital database application LIDIA that is used to store the field data. After that, the participants conduct practical exercises with the landslide database, as they transfer the acquired field data of their “personal” landslide surveys into the LIDIA. Again, using the application in practice deepens the understanding and handling of the database.

The second training course of PPSDM GEOMINERBA on Survey Data Processing and Interpretation provides a more sophisticated approach to analyse data from the LIDIA that currently holds more than 5,900 landslide datasets. State of the art techniques for slope stability analysis and statistical analysis methods, as well as the integration of data to Geographic Information Systems (GIS) are part of the training. The BGR section on Engineering Geological Hazard Assessment also provided recommendations on this training curriculum.

5. Mobile Applications to Enhance Learning Experience

Mobile applications have entered our lives in no time. Smartphones and tablets are becoming more and more central elements of our day-to-day (working) activities, offering a huge variety of connections to information, data, and people. This connectivity has transformed more and more into a bi-directional communication thread, allowing users not just to search for and collect information, but also to share (new) information.

In the field of Disaster Risk Management (DRM) for example the timely information people in affected areas can provide is crucial and has modified the way we deal with disasters, especially if it comes to post-disaster measures. The International Association for Information Systems for Crisis Response and Management (ISCRAM) is a lively community, that shares the primary mission to foster “a community dedicated to promoting research and development, exchange of knowledge and deployment of information systems for crisis management” [25]. Their annual conference is a good example for the continuous effort by researchers and practitioners in developing the highest usable outcome from the Information and Communication Technology (ICT) for DRM.

Recent technological applications allow users to actively engage in the way information and data is collected, for example through providing flood-level data [26], damage state information, or requesting help in the aftermath of a disastrous event. A list of such applications offering two-way-
information sharing can be found on the fulcrumapp.com site [27]. The future prospect is that the massive amount of distributed “human sensors” might allow for intelligent data mining leading for example to more accurate flood predictions, better estimations of losses, and improved rescue services.

In order to successfully conduct landslide surveys and apply the LSDS in remote areas of Indonesia, technical trainings for civil servants across the country are indispensable to support the technical capacity at local level. One challenge has always been the huge spatial extent of landslide occurrence and timely surveying of these incidents across the peninsula. To support instantaneous transfer of survey data from local surveyors to GAI an Android application has been developed [11]. The mobile application replaces the paper-based LSDS (booklet and paper-format) and is nowadays used in the Landslide Survey training of PPSDM GEOMINERBA (Figure 1). The mobile application allows for a reliable and comprehensive data collection and reduces the risk of human errors during transfer of the data to GAI.

![Figure 1](image1.png)

**Figure 1.** Analogue to Digital Transformation by applying the Android Application.

Most of the current technological developments in the field of mobile technology aims to make work more effective and efficient. The mobile LSDS applications is based on the Android system, was developed with the Java programming language and designed using EXtensible Mark-up Language (XML). The compilation of the program uses Android Studio version 2.1.2. The application is approximately 6 megabyte large and is distributed during the trainings using the exchange android application package (.apk). Figure 2 provides three screen samples of the final product.

![Figure 2](image2.png)

**Figure 2.** Mock-Up of some pages/screens of the LSDS Android Application.

In general the implementation of the overall Android application is divided into three different menu sections: “Survey Data Form”, “Upload Photo or Sketch” and “Send Data”. See Table 1 for a detailed explanation of the menu sections.
Table 1. LSDS Android Application Menu.

| Application Menu         | Description                                                                 |
|--------------------------|-----------------------------------------------------------------------------|
| Survey Data Form         | To display the survey sheet that needs to be filled out by the surveyor (12 “pages/screens”). |
| Upload Photo or Sketch   | Function to upload a photos and a sketch of the field conditions. Users can also use stored photos from their hand phone’s gallery. They are attached to the survey data. |
| Send Data                | Button to send all survey data and attachments via email to the administration of GAI for quality check. |

The application needs access to GPS functionalities in order to determine the exact coordinates which are directly stored to the data field. This is considered a major benefit compared to the manual format, where many errors occurred if people had to collect GPS points using additional (handheld-) devices and making notes up to the last digit. In general, the application has been designed to differentiate between mandatory and optional fields for data entry. Hence, submitting incomplete datasets is impossible, as the application forces its users -using colour highlighting- to fill out at least all mandatory data entry fields. These had already been defined in the digital LIDIA, but as enforcement through the paper-based formats is difficult, another main source of errors could be eliminated. Other benefits of the full-digital version are for example in automated field calculations: The survey for instance requires the calculation of the landslide volume utilizing the main dimensions of the landslide area, which is now automated. Additionally, various fields are per se single-option fields. Despite a sophisticated layout of the previous paper-based LSDS, common errors occur if users provide multiple answers instead of single-options. Within the Android App, radio buttons (single option) and check-boxes (multiple choice) have been used in order to account for this and minimize errors.

6. Results
The German Technical Cooperation project “Mitigation of Georisks”, supports PPSDM GEOMINERBA to develop trainings for governmental employees in the field of landslide survey using appropriate techniques [5]. During that process 1) eLearning was introduced to allow participants to interact with training experts in geology remotely; 2) an Android application for landslide surveying was developed, which allows to automatically transfer data from the field to the national landslide database LIDIA [3].

This case study of positive collaboration between PPSDM GEOMINERBA and the GAI shows how applied methodologies can support the generation of reliable data in a decentralized way. The use of modern technology allows bridging the gap between data quality and coverage of landslide events given limited resources and their vast spatial distribution in Indonesia.

The ability of LGUs to access these data and do their own analysis introduces a great moment of enhanced (data) ownership. Surveying landslides within their area of responsibility -which allows them to also assess local risks- improves the uplink from local to national level agencies.

A logically structured training setup that makes use of modern eLearning techniques shrinks the distance between so-far distant training and education experts at the national training centre and the remote data collectors. Nevertheless, the practical part of the training including field exercises, group sessions and reporting is an important element, which allows participants to intensively discuss among each other, build relationships and exchange on problems faced and lessons learned during the assessment of landslide events. This methodological mixture between field training and classroom sessions improves the learning experience.

One remaining challenge has been the constant further education of trainers as the training schedule does not allow for time consuming side activities. Therefore, one important additional activity within
the German-Indonesian development cooperation has been the provision of Training of Trainers (ToT) to advance the level of expertise within the training institution itself, in order to enable them to provide trainings on the highest possible level.

7. Conclusion
Transferring of scientific and technical knowledge to local government units in order to mitigate geological risks is a challenging task and needs close collaboration among various stakeholders. The Indonesian setup of subordinated ministerial training centres has a huge potential providing a unique interlinked learning environment. It offers top-down and bottom-up ways of learning and teaching by integrating local experiences of landslide risk into the field training, but also the incorporation of the latest scientific innovations.

Technical training for landslide surveying in Indonesia improves local capacities and national efforts to mitigate landslide disaster risk. The need for technical support to perform landslide survey at local level is evident, thus local government units need to receive capacity development through the national training centres using suitable methodologies. Dissemination and upscaling of existing trainings offered in the geological sector is mandatory to further understand geological hazards and mitigate risks in Indonesia.

The use of mobile technology to further enhance data quality and user-friendliness offers great potential to further close the gap between professional training staff and local experts implementing the landslide survey. Nevertheless to close the gap within the science-practice nexus requires commitment and a strong culture of collaborative learning, which is always a challenging task.

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