



**Geology
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Characterizing current opportunities and challenges in education and career development for the professional geohazards community in Guatemala

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Se está preparando una versión en español de este informe.

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Cover Image: Volcan de Fuego (2014)

Foreword

At Geology for Global Development (GfGD), we aim to help build a sustainable future for all by transforming understanding of, access to, and capacity to use the geoscience required to implement the Sustainable Development Goals (SDGs), leaving no one behind. There can be no sustainable development without effective disaster risk reduction. Disasters threaten progress on education and health, destroy livelihoods and separate communities, and divert resources away from activities that support individuals, families, and communities to prosper. Reducing disaster losses is therefore embedded into the SDGs and the primary aim of the Sendai Framework for Disaster Risk Reduction. Delivering this framework requires a greater understanding of risk (including all its components). There is a clear need, therefore, for a thriving geohazards community in countries affected by natural hazards. This is the context that resulted in this report being commissioned.

Guatemala is affected by multiple, interrelated natural hazards, with resulting disasters disproportionately affecting the most vulnerable communities. Guatemala, the wider Central American region, and the world will benefit from a well-resourced and supported professional geohazards community. This work created a space for the voices of Guatemala's hazard scientists to be heard, their challenges understood, and their professional development priorities captured. At GfGD, we will reflect on the report and determine what we can do to help address these priorities and further the recommendations made at the end of this report. Our challenge to all those international organisations and individuals working in Guatemala and with Guatemalan scientists is to carefully consider what they can do to address these needs also.

I'd like to offer my personal thanks to Dr Ailsa Naismith (University of Bristol, UK), lead researcher and lead author of this work, for the hard work and dedication to the people of Guatemala that resulted in such an informative report. This work was also supported by Professor Eliza Calder (University of Edinburgh, UK) and Dr Rüdiger Escobar-Wolf (Michigan Technological University, USA). Individuals, groups of students, and other organisations (particularly the *International Union of Geological Sciences*) have provided the financial support to make this work possible. This output also represents a collaboration with the GCRF-funded *Ixchel* project (NE/T010517/1), of which Eliza, Rüdiger and Ailsa are all involved. Finally, our collective thanks go to all those in Guatemala who generously shared their insights and ideas.

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Executive Summary

Recognising the importance of a well-resourced and supported geohazards community if we are to reduce disaster losses, this report aims to (i) characterize Guatemala's professional geohazards community and (ii) document current training and development opportunities and gaps. To address these aims, we gathered and analysed data including (i) a review of available literature and web resources on the professional geohazards community in Guatemala, (ii) a survey of community members' perspectives of opportunities and challenges in their profession (11 responses), and (iii) qualitative interviews with key community members (10 participants). This report is for both current and future geohazards professionals in Guatemala and for entities (internal and external) seeking to support them.

Results helped to characterise the professional geohazards community in Guatemala, showing a range of organisations working in a set of communities of practice: social studies, development, risk managers, structural engineers, geography, geophysics, climate change, landslides, coastal risks, earthquakes, volcanoes. Results also helped to identify several major challenges for the professional geohazards community in Guatemala. These challenges include insufficient geohazards education, lack of connection between universities and institutions and therefore opportunities to gain experience necessary for professional development, and poor retention of staff within governmental institutions related to employment conditions. Relationships with organizations outside Guatemala appear to be an important source of opportunity for many professionals but are also potentially problematic when that interaction distracts agencies from what should be their proprietary work according to their mission.

Preliminary findings of this report indicate that stronger geohazards education, better inter-institutional collaboration, and greater job security for government staff would greatly improve the situation. This report included responses from a limited number of professionals within the community; further research may confirm or revise first conclusions, as suggested below. The report promotes existing opportunities and helps direct future capacity-building efforts towards filling current gaps.

1. Introduction

1.1. Scope and Aims of Report

Disasters undermine efforts to achieve sustainable development throughout the world. However, disaster risk reduction (DRR) is highly complex, requiring understanding of root causes of risk as well as collaboration between institutions and populations at risk. In recent years, evolving environmental factors including acceleration of climate change highlight an increasingly urgent need for more effective DRR strategies. This urgency is captured in the United Nation's (UN) Sendai Framework for Disaster Risk Reduction (2015 – 2030), created in 2015 for UN Member States to tackle risk in a joined-up approach by "working cross-sectors, between and within institutions, and ensuring harmony from policy through to activity." (UNDRR, 2022). This framework includes the Sustainable Development Goals (SDGs): 17 goals for future peace and prosperity for Earth. The Sendai Framework identifies **geohazards** as an area critical to countries' success in mitigating impacts of disaster and in achieving the SDGs. As there are various definitions of geohazards, this report uses the definition given by the UNDRR:

Geological or geophysical hazards originate from internal earth processes. Examples are earthquakes, volcanic activity ... and related geophysical processes such as mass movements, landslides, rockslides, surface collapses and debris or mud flows. Hydrometeorological factors are important contributors to some of these processes¹.

(UNDRR, 2017)

Geohazards professionals contribute to DRR efforts by understanding disaster risk, by strengthening disaster risk governance, or by enhancing disaster preparedness (J. Gill & Bullough, 2017; J. C. Gill, 2017). To appreciate how geohazards professionals may contribute to DRR within a country, it is essential to understand the circumstances in which these professionals work (Cummins, 2017). This report is commissioned by Geology for Global Development (GfGD), an organization devoted to raising public awareness of geoscience and strengthening the international geoscience community to help deliver the SDGs (GfGD, 2023). GfGD's Research and Analysis department commissioned this report "... to develop our understanding of the professional geohazards community in Guatemala, and their training and development needs, to guide future engagement in the region" (from commission brief). Guatemala was chosen due to funding constraints. This document aims to characterize a country's geohazards community to guide future engagement and could be replicated for other countries. The main objective of this report is to provide an exploratory account of the current professional geohazards community in Guatemala, with a particular focus on current training and development opportunities and gaps. It also considers relationships between organizations within the community. In doing so, the report aims to promote existing opportunities and to direct future capacity-building efforts towards filling current gaps. The summary includes a list of considerations which appropriate

¹ Noting that hydrometeorological processes contribute to geological hazards, this report includes contributions from professionals working in hydrology and hydrometeorology in Guatemala.

groups might take on board to support and build capacity within the community in future. This report is for both current and future geohazards professionals in Guatemala and for entities (internal and external) seeking to support them.

1.2. Guatemala

Vivid, vibrant, and geologically violent: Guatemala spans one of the most dynamic tectonic regions of Earth. The country lies at the intersection between the Caribbean, Cocos, and North American tectonic plates. The complex interplay between these plates generates frequent earthquakes and volcanic eruptions (BGS, 2016; Loughlin, S. C., Sparks, R. S. J., Sparks, S., Brown, S. K., Jenkins, S. F., & Vye-Brown, 2015), with associated hazards such as pyroclastic density currents and lahars (**Figure 1**). Examples of recent disasters include the 1976 earthquake and the devastating eruptions of Volcán Santa María in 1902 and Volcán de Fuego in 2018. Guatemala has both Pacific and Caribbean coastlines and is affected by powerful hurricanes and tropical storms. These have produced disasters like Hurricane Stan in 2005, which generated landslides that buried the town of Panabaj, and Hurricanes Eta and Iota in 2020, which caused extensive damage as they traversed the department of Alta Verapaz. Eta caused eight deaths and 88 disappearances in Quejá, Alta Verapaz (ReliefWeb, 2021). Landslides triggered by heavy rains not associated with storms also present great risk. On 1st October 2015, rains triggered a landslide that buried El Cambray II, a settlement on the outskirts of Guatemala City. An official account records 280 deaths and several hundred people missing (UN, 2015).



Figure 1: Lahar deposits at the base of Volcan de Fuego (2014)

Guatemala is home not only to an ensemble of natural hazards but also to striking inequality and political instability. A violent civil war lasted for 36 years and claimed the lives of 200,000 people (BBC, 2022). Guatemala is the most populous country in Central America, with 17.2 million people in 2019 (UN, 2022). The majority live in areas prone to natural hazards, making the country particularly susceptible to associated losses. An estimated 95% of Guatemala's population live within 100 km of one or more Holocene volcanoes (Loughlin, S. C., Sparks, R. S. J., Sparks, S., Brown, S. K., Jenkins, S. F., & Vye-Brown, 2015), and 83.3% of the country's GDP is generated in areas exposed to multiple natural hazards (GFDRR, 2010).

2. Methodology

We used a three-step approach to structure this work and to gather results:

- 1 **Initial scoping work**, involving a literature review on geohazards communities globally and identification of organizations within the Guatemalan geohazards community,
- 2 **Three areas of data gathering** comprising: (i) a review of available literature and web resources on the professional geohazards community in Guatemala, (ii) a survey of community members' perspectives of opportunities and challenges in their profession, and (iii) qualitative interviews with key community members.
- 3 **Data analysis**, including synthesis of literature, survey analysis, interview transcription, and selection of salient quotations to illustrate findings.

Standard ethical considerations were applied for collecting interview data. All interview participants were >18 years old, had the study explained to them before participating, and were assured that they were able to withdraw at any time and that interview results would be presented anonymously. Interview participants were selected by purposive sampling.

3. Characterization of the professional geohazards community in Guatemala

3.1. Literature Review

3.1.1. Geohazards Higher Education in Guatemala

This report considers "pregrado" (undergraduate) and "posgrado" (postgraduate) courses. There is only one undergraduate geology degree in Guatemala. This is Geological Engineering, offered by Guatemala's national public university, Universidad de San Carlos (USAC), at the CUNOR campus in Cobán. Initially dedicated to oil and mineral exploration, the geology school has expanded its focus to include taught modules in hydrogeology, volcanology, disaster prevention and environmental geology (USAC, 2020). Geological Engineering students undertake independent investigation at the end of their degree, and several alumni have pursued geohazards-relevant research after graduating, for example in INSIVUMEH's Volcanology department. USAC's campus in Quetzaltenango offers an undergraduate degree in Engineering and Local Environmental Management, which includes modules in GIS and cartography.

Beyond these degrees, most higher education degrees in Guatemala that include geohazards are engineering degrees. USAC's Faculty of Engineering in Guatemala City includes the Centre for Superior Studies of Energy and Mines (CESEM), which offers undergraduate engineering degrees with various geology-relevant modules (including structural geology, applied

geophysics, and disaster risk management). Excepting three courses that are obligatory for the Environmental Engineering undergraduate degree (Disaster Management (course code 305), Geology (450), and Climatology (879)), most geohazards-relevant courses in CESEM's undergraduate engineering degrees are elective courses (USAC, 2021)². However, students wishing to pursue graduate engineering degrees specialized towards geology must choose some of these modules. CESEM offers several postgraduate master's degrees in engineering; among these, the Master's in Geotechnical Engineering with specialization in geology offers most geohazards-relevant content, with modules in evaluation of geological risks and environmental impacts, GIS, and applied geophysics (CESEM, 2023). On several occasions, CESEM has developed specialization courses in geohazards-relevant themes including disaster risk, mining, and energy. These are aimed mainly at engineers who wish to update or specialize their skillset. The longevity of these specialized courses varies as courses are designed and offered subject to Guatemala's economic needs or at the request of a particular institution.

USAC offers some geohazards education opportunities outside the Faculty of Engineering. In 1994, USAC formed a University Commission on Disasters (as an internal body) to promote academic contributions to disaster mitigation, including the development of educational courses related to disasters (USAC, n.d.). Following Hurricane Mitch in 1998, concerns were raised regarding USAC's role in risk management and post-disaster recovery; the university participated in various voluntary activities for years before founding the Centre of Studies of Secure Development and Disasters (CEDESUD) in 2008 (CEDESUD-USAC, 2010). CEDESUD advises on and carries out disaster prevention and awareness projects. Recent publications highlight the previous and potential contributions of these departments towards DRR (e.g., recognizing USAC's previous work on risk management (Ávila Arbizú, 2018); or urging universities to develop available courses relevant to geohazards (PRIDCA, 2018)). USAC's School of Physical Sciences and Mathematics (ECFM) offer Geophysics and Seismology modules to undergraduate students of physics. The school also has both master's and PhD in Physics programs, which allow a focus on geophysics (Wiki, 2023). Faculty express interest in building a full geophysics research group over the longer term (B. Cosenza, pers. comm.).

Private universities in Guatemala also offer engineering degrees with geology-relevant modules. Universidad Mariano Gálvez offers an undergraduate degree in Civil Engineering which includes compulsory modules in geology, soil mechanics, and hydrology. This university may soon (within a few years) offer a postgraduate master's course in Volcanology through its Institute of Investigations in Engineering, Mathematics, and Physical Sciences (in3) (Members of SSG, pers. comm.). Universidad del Valle de Guatemala (UVG) does not have a geology-specific course but offers an undergraduate course in Civil Environmental Engineering that includes hydrology (UVG, 2023). Universidad San Pablo Guatemala offers a master's level degree in Comprehensive Risk Management (with a focus on health and occupational safety). This does not include specific

² CESEM does offer a wide variety of elective courses in their undergraduate engineering degrees that are geohazards-relevant, including Disaster Management (335), Geography (030), Geology (450), Geophysics (538), and Structural Geology (687).

modules on geohazards but does cover risk and disaster management (Universidad San Pablo, 2023).

There are no doctoral (PhD) programs in geology in Guatemala. Several Guatemalan geohazards professionals have obtained a PhD in a relevant discipline outside Guatemala. It is difficult to find information on this number, on the funding sources for the PhDs, or on the proportion of this number of people that currently work in Guatemala. However, the National Secretariat for Science and Technology (SENACYT) host a national directory of Guatemalan investigators (both resident in Guatemala and abroad) which can be sorted by scientific grade and academic area. The directory currently holds 3,643 investigators (SENACYT, 2023). Many highly educated Guatemalans relocate abroad to seek greater opportunity (the "brain drain" phenomenon). Recent studies document this diaspora and consider how interactions between the diaspora and in-country partners may influence Guatemala positively (Bonilla, Arrechea, & Velásquez Pérez, 2022; Bonilla, Romero-Oliva, et al., 2022). Academic knowledge of geohazards outside of the SENACYT directory is large and dispersed and includes the theses that all undergraduate students are required to complete for graduation. There is a long list of thesis projects related to geohazards, risk and disasters by students of CESEM and other university departments, which is significant particularly when it comes to published work in that area. These projects are not always publicly available but may be obtained by contacting the relevant university departments.

3.1.2. Professional Geohazards Sectors in Guatemala

Guatemala's professional geohazards community can be organized into "**communities of practice**" (CoP), i.e., groups of people who "share ... a common interest in a topic and who come together to fulfil both individual and group goals" (Edmonton Regional Learning Consortium, 2016). This is an efficient way to visualize the many organizations involved in various aspects of geohazards in Guatemala. **Figure 2** (adapted from (Geohazard Community of Practice, 2016)) shows CoP within the Guatemalan geohazards community and organizations within each CoP. Organizations within a CoP may work in various aspects of geohazards, including research, monitoring, and DRR. Further information appears in this report's Appendices.

Table 1 lists organizations in **Figure 2** by CoP. **Table 2** gives the full name of each organization and its relevant CoP(s). This report's Appendices include a glossary of these organizations and a more comprehensive table of information, including the organization's work sector, date formed, theme(s) of focus, and a link to the official website.

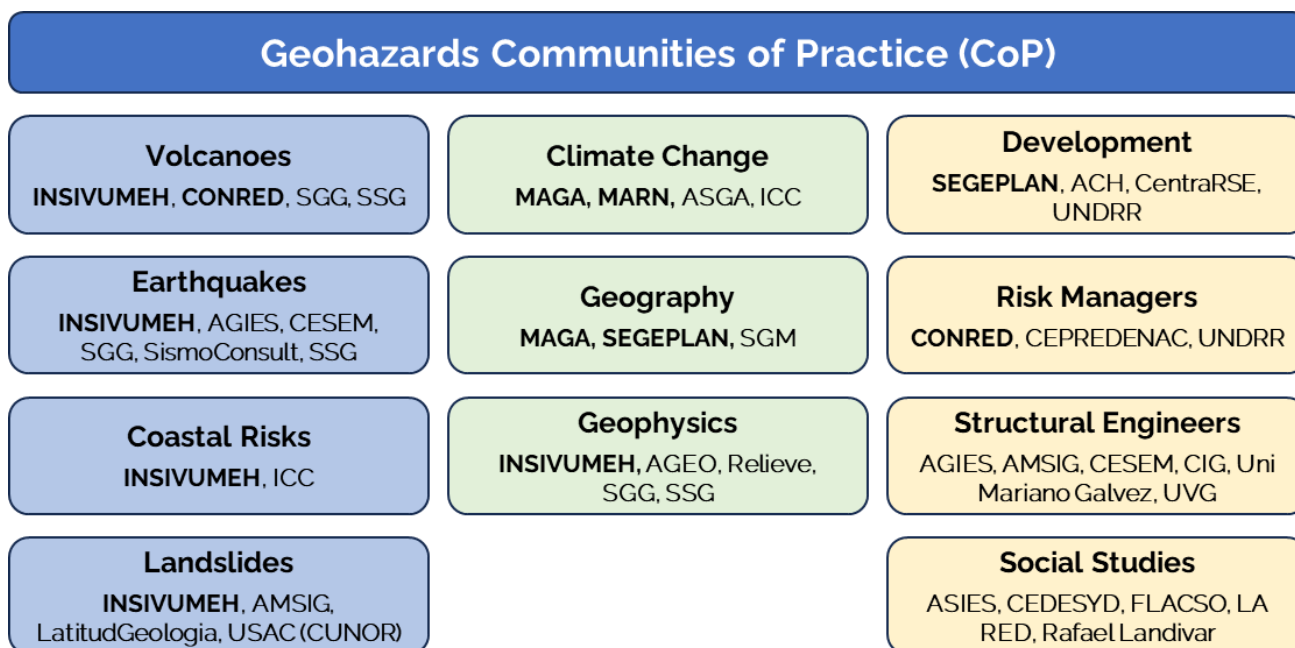


Figure 2: The current professional geohazards community in Guatemala, organized by communities of practice (CoP) bubbles within which are listed the organizations related to that CoP. Adapted from Geohazards Community of Practice (2016). Bubble colours represent different areas of study, and list related organizations underneath. Blue bubbles represent individual geohazards (e.g., volcanoes); green represents areas associated with multiple geohazards; yellow represents areas of societal application of geohazards knowledge.

Table 1: Professional geohazards communities of practice in Guatemala. CoPs same as in **Figure 2**. Mention of specific NGOs and private companies is for example only and does not indicate endorsement.

Communities of Practice (CoP)	Institution in Guatemala (those in bold are governmental)
Social Studies	ASIES, CEDESYD, FLACSO, LA RED, Uni. Rafael Landívar
Development	SEGEPLAN , various NGOs (e.g., ACH), various private companies (e.g., CentraRSE), UNDRR
Risk Managers	CONRED , CEPREDENAC, UNDRR
Structural Engineers	AGIES, AMSIG, CESEM, CIG, Uni. Mariano Gálvez, UVG
Geography	MAGA , SEGEPLAN , SGM
Geophysics	INSIVUMEH , SSG, various private companies (e.g., AGEO, Relieve)
Climate Change	MAGA , MARN , ASGA, ICC
Landslides	INSIVUMEH , AMSIG, various private companies (e.g., Latitud Geología), USAC (CUNOR)
Coastal Risks	INSIVUMEH , ICC
Earthquakes	INSIVUMEH , AGIES, CESEM, SGG, various private companies (e.g., SismoConsult), SSG
Volcanoes	INSIVUMEH , CONRED , SGG, SSG

Table 2: List of all institutions that appear in Figure 2 with names and CoP.

Institution	Name	Name (English)	CoP
ACH	<i>Acción Contra el Hambre</i>	Action Against Hunger	Development
AGEO	<i>Ambiente y Geología</i>	Environment and Geology	Geophysics
AGIES	<i>Asociación Guatemalteca de Ingeniería Estructural y Sísmica</i>	Guatemalan Association for Seismic and Structural Engineering	Structural Engineers
AMSIG	<i>Asociación Guatemalteca de Mecánica de Suelos y Ingeniería Geotécnica</i>	Guatemalan Association of Soil Mechanics and Geotechnical Engineering	Structural Engineers
ASGA	<i>Asociación Guatemalteca de Geociencias Ambientales</i>	Guatemalan Association of Environmental Geosciences	Climate Change
ASIES	<i>Asociación de Investigación e Estudios Sociales</i>	Association of Social Studies and Investigation	Social Studies
CentraRSE	<i>Centro para la Acción de la Responsabilidad Social Empresarial en Guatemala</i>	Centre for Action on Corporate Social Responsibility in Guatemala	Development
CEDESYD	<i>Centro de Estudios de Desarrollo Seguro y Desastres</i>	Centre for Studies in Sustainable Development and Disasters	Social Studies, Development
CEPREDENAC	<i>Centro de Coordinación para la Prevención de los Desastres en América Central y República Dominicana</i>	Centre of Coordination for Disaster Prevention in Central America and the Dominican Republic	Risk Managers
CESEM	<i>Centro de Estudios Superiores de Energía y Minas</i>	Centre for Further Studies of Energy and Mines	Structural Engineers, Earthquakes
CIG	<i>Colegio de Ingenieros de Guatemala</i>	College of Engineers of Guatemala	Structural Engineers
CONRED	<i>Coordinadora Nacional para la Reducción de Desastres</i>	National Coordinator for Disaster Reduction	Risk Managers
CUNOR	<i>Centro Universitario del Norte</i>	Northern University Centre	Landslides
ICC	<i>Instituto Privado de Investigación sobre Cambio Climático</i>	Private Institute for Investigation into Climate Change	Climate Change
INSIVUMEH	<i>Instituto Nacional de Sismología, Vulcanología, Meteorología e Hidrología</i>	National Institute of Seismology, Volcanology, Meteorology and Hydrology	Geophysics, Landslides, Coastal Risks, Earthquakes, Volcanoes
FLACSO	<i>Facultad Latinoamericana de Ciencias Sociales</i>	Latin American Faculty of Social Sciences	Social Studies
LA RED	<i>La Red de Estudios Sociales en Prevención de Desastres en América Latina</i>	Network of Social Studies in Disaster Prevention in Latin America	Social Studies
Latitud Geología	N/A	Latitude Geology	Landslides
MAGA	<i>Ministerio de Agricultura Ganadería y Alimentación.</i>	Ministry of Agriculture, Animal Husbandry, and Nutrition	Geography
MARN	<i>Ministerio de Agricultura y Recursos Naturales</i>	Ministry of Agriculture and Natural Resources	Climate Change
Relieve	N/A	Relief	Geophysics
SEGEPLAN	<i>Secretaría General de Planificación y Programación de la Presidencia</i>	General Secretariat for Planning and Programming of the Presidency	Development
SismoConsult	N/A	N/A	Earthquakes

Institution	Name	Name (English)	CoP
SGG	<i>Sociedad Geológica de Guatemala</i>	Geological Society of Guatemala	Geophysics, Earthquakes, Volcanoes
SGM	<i>Servicio Geográfico Militar</i>	Military Geological Service	Geography
SSG	<i>Servicio Sismológico de Guatemala</i>	Guatemalan Geological Service	Geophysics, Earthquakes, Volcanoes
UNDRR	<i>N/A</i>	United Nations Office for Disaster Risk Reduction	Development, Risk Managers
Uni. Mariano Gálvez	<i>Universidad de Mariano Gálvez</i>	Institute of Investigations in Engineering, Mathematics, and Physical Sciences - University Mariano Gálvez	Structural Engineering
Uni. Rafael Landívar	<i>Universidad de Rafael Landívar</i>	Rafael Landívar University	Social Studies
USAC	<i>Universidad de San Carlos</i>	San Carlos University	Structural Engineers, Earthquakes (CESEM), Landslides (CUNOR)
UVG	<i>Universidad del Valle de Guatemala</i>	University of the Valley in Guatemala	Structural Engineers

It is difficult to define the number of geohazards professionals in Guatemala: many organizations do not provide this information. However, some larger institutions do provide a professional directory on their website, including CONRED (CONRED, 2015); ICC (ICC, 2023); and INSIVUMEH (INSIVUMEH, 2023).

3.2. Survey Data

Eleven geohazards professionals accepted the invitation to participate in a survey on their experiences of professional training and development in both current and former roles. Selected survey results appear below.

In your current job, were/are there opportunities to work with other institutions or people working in similar areas?	
Within Guatemala:	91% Yes, 9% No (n=11)
Outside Guatemala:	82% Yes, 9% No, 9% Not Sure (n=11)

In your current job, have you had any of the following opportunities? (number of positive responses)	
Consultancy	1
Academic Conferences	6
Technical Sessions	2
Institutional Visits	3
Exchange	0
Soft Skills Courses (Virtual)	2
Soft Skills Courses (In Person)	0
Technical Training (Virtual)	8
Technical Training (In Person)	6
Mentoring	1
Continued Professional Development (CPD)	5

In your current job, what training or development does not exist that you would like to see?

Meteorology: there is no academic training in the country
Strengthen the monitoring network and strengthen personal capacity
Environmental restoration in disturbed places
[Graduates] in geology focussed on environment or risk management
Exchange with other institutions and universities
Continuous education and mentoring
Advanced GIS, in-person master's course with the right to return to my current job
Master's/PhD in geosciences

The survey template and full anonymised results are in the Appendices.

3.3. Interview Data

To complement survey results, qualitative interviews with 10 individuals working in 6 geohazards organizations provided their views on the availability of, as well as gaps in, professional development and training opportunities.

Many participants agreed that Guatemala provides a uniquely rich environment for geohazards training, with one respondent calling Guatemala's volcanoes "natural laboratories in which we can learn many things". However, others stated that while education in geohazards in Guatemala is improving, opportunities for professional work after graduating are scarce:

Interviewee 1 (CESEM): "If there are Volcanology Masters [graduates], where are they going to work? It's that we don't have anywhere. Apart from us, and ... SSG, who are beginning to offer. ... That's why I stop, because if I have twenty master's students ... and then? What do they do with that? They will hang their certificate on the wall, and it will serve for nothing."

Several respondents stated their pride in being self-taught on themes related to geohazards. However, some stated that this was motivated by insufficient training from their institution:

Interviewee 2 (CONRED): "In general, it's a question of being self-taught. Obviously, experience teaches you many things, but ... Unfortunately, I think that the trainings we receive at the institutional level are quite basic ... deeper questions, on each of the hazards, unfortunately we don't have more than what we can learn by teaching ourselves."

Several acknowledged that DRR in Guatemala is still a very young discipline:

Interviewee 3 (Consultant): "Before [Hurricane] Mitch, the history of disasters was very scarce. [Disasters] are things that historically are left behind. Transmission from generation to generation is almost not done."

When reflecting on their professional trajectories, some people shared positive experiences of working together across multiple geohazards organizations. However, they also acknowledged that this collaboration is often fraught with difficulty:

Interviewee 4 (SSG): “[The 2021 Pacaya eruption] ... we met with CONRED and INSIVUMEH and we made maps. That was very good ... I think this type of activity is what we will need for other crises. Because in previous years, INSIVUMEH were on their side, CONRED on theirs ... so they did not agree, there was not much communication, and now, in this crisis, we could see that a team of people came together to work, and the results were good.”

In parallel, others called for more interdisciplinary work and greater integration between scientific/technical and social sectors in producing more effective DRR efforts:

Interviewee 5 (Uni. Rafael Landívar): “If we make a scientific study, in volcanology, or seismology ... we could think how to integrate this specialist effort with other studies that could be complementary. ... it is very complex [but] I think it would be much more effective.”

Another interviewee (who is involved in the Ixchel research project) urged inclusion of multiple worldviews in DRR, including Maya cosmovision (the worldview of Guatemala's indigenous Maya people, grounded in the natural world):

Interviewee 4: “There are people who have different, very interesting points of view, not only of the scientific part [of hazards] but of the social ... approaching communities has helped me understand their view, of cosmovision, of how they see the volcano ... to strengthen these decision-making networks we also have to include communities.”

On professional challenges, several spoke of job precarity:

Interviewee 6 (INSIVUMEH): “What you are really is a business that lends your services to INSIVUMEH ... you have to sign a contract. Right now, we sign for two months. So there's no stability. Another thing is that since we aren't employees, we don't have any benefits. You don't have social security, you don't have Bonus 14³, you don't have any right to holiday.”

While another talked about general shortcomings in institutions:

Survey respondent: “One of the fundamental problems related to disaster risk management is the institutional scarcity, the little support for technical themes and the scarce opportunity for professional growth. There is no [civil service career] relevant to the theme. The rotation of people in management also reduces the possibility for processes to continue.”

These quotes illustrate several points that are summarized in **Section 4**.

³ *Bono 14* is an annual bonus that employers must pay their employees during the first 15 days of July (Aroche, 2023).

3.4. Integration and Interpretation of Data

3.4.1. Formal and Informal Training and Development

Through interviews, survey responses, and literature review, the principal training and development opportunities currently available to the professional geohazards community in Guatemala are summarized below.

Academic Training

- **Geology** – at USAC CUNOR. Technician in Geology (6 semesters); Geological Engineering (undergraduate degree with independent thesis, 12 semesters).
- **Engineering** – undergraduate and postgraduate degrees with optional geohazards-relevant courses at CESEM; undergraduate degree with compulsory geohazards-relevant courses at Universidad Mariano Gálvez; undergraduate degree with optional geohazards-relevant course at UVG.
- **Disasters** – specialized modules at CESEM; projects within CEDESUD-USAC; disaster and risk management module at Universidad San Pablo.
- **Physics** – undergraduate and postgraduate degrees in physics with option to specialize in geophysics at USAC's ECFM.
- **Risk management** – CONRED has a higher education risk management program (ESEGIR, Escuela Superior de Gestión de Riesgo or Advanced School of Risk Management) which includes a 2-month module of Geology and Hydrology.

Training and Development:

- **Fieldwork and mapping** – good relationships between individuals in different institutions provide opportunities and resources for field visits and evaluation of both professional skills and field sites visited.
- **'X' (formerly known as Twitter)** – used extensively to connect with geohazards professionals outside Guatemala, which then facilitates future opportunities including fieldwork, online and in-person training, and jobs in geohazards. Other social media sites (e.g., Facebook) are also widely used in Guatemala. Future work could explore the value of social media sites for creating professional opportunities.
- **CESEM** – offers training to community leaders on various geohazards, provides technical assessments to INSIVUMEH and CONRED, and training to various professionals in Earth Sciences.
- **ICC** – provides a significant amount of training.
- **In-country funding** – Through SENACYT and the National Council for Science and Technology (CONCYT), Guatemala has a funding program that those in university positions in Guatemala can access through a competitive application process. This has

previously funded work relating to geohazards. Both public and private universities also have funding opportunities (e.g., through the Research Directorate General, DIGI, at USAC).

- **Externally funded (international) research projects** – research projects have played a significant role in providing training and development to individuals in Guatemala, both historically and currently and through both formal and informal pathways. Examples include the GCRF-funded project, “Ixchel”, and a NERC Urgency Grant following the June 2018 eruption of Fuego (UKRI, 2018, 2020). Research projects are typically collaborations between Guatemalan scholars and foreign universities, which bring both opportunities and challenges. Analysis of these collaborations is beyond the scope of this report.
- **Self-motivation and self-teaching** – as stated by interviewees, many people in the professional geohazards community are working there because they ‘formed’ themselves despite a limited and impoverished system.
- **Virtual opportunities** – although the COVID-19 pandemic has generally disadvantaged the community, several professionals have found more training opportunities through the recent increase of geohazards resources available worldwide and in Spanish (e.g., through ALVO).

3.4.2. Opportunities and Challenges

Interviews provided the greatest opportunity for geohazards professionals to opine on gaps and opportunities in training and professional development. **Opportunities** and **Challenges** present gaps and opportunities identified by several interviewees, while **Potential Opportunities** and **Potential Challenges** were opinions expressed by fewer interviewees and thus require further exploration. Results are presented in alphabetical order. Non-bolded text after each result gives further insights from interviews. Some opportunities and challenges have significant overlap; in these cases, results are presented separately to give the most comprehensive view possible of current challenges and opportunities in the community.

Opportunities:

- **Good relationships within Guatemalan institutions.** Geohazards professionals often benefit from friendships with colleagues at different institutions, leading to informal invitation to training opportunities (e.g., fieldwork). While relationships between individuals are good, relationships at the institutional level may not always be positive, with tensions exacerbated by fierce competition for limited resources.
- **Good relationships with visiting institutions.** Foreign universities visiting Guatemala have contacted CUNOR to offer students fieldwork opportunities, both in Guatemala and abroad. Some students have been able to accept these offers. Barriers to acceptance include a lack of financial support for transport and accommodation, and restrictions imposed by the pandemic. Similarly, good relationships between Guatemalan and foreign institutions have provided training opportunities for staff in the Guatemalan institutions (e.g., INSIVUMEH/University of Bristol, CONRED/JICA). In addition, these relationships

have allowed a small number of Guatemalans to receive further education abroad (e.g., MSc and PhD at MTU).

- **Multiple worldviews.** Guatemala has a particularly rich culture that includes the Maya cosmovision. Several interviewees stated that working in geohazards gave them the opportunity to work with people who relate very differently to the natural world. Two documented examples of successful integration of western and cosmovision knowledges of geohazards are the Tzunun'Ya' cultural centre in San Pedro La Laguna and the intercession of Maya priests following the passage of Hurricane Stan through the Mam altiplano in 2005 (Hermesse, 2014). One current externally funded research project (Ixchel) is working in decolonial approaches to DRR in the Guatemalan cordillera. Several Guatemalan geohazards professionals are involved in this project.
- **'X' (formerly known as Twitter).** X provides an opportunity for geohazards professionals in Guatemala to connect with others around the world. The platform has provided many individuals with training and exchange opportunities they would not otherwise have found. Although other social media websites (e.g., Facebook) can provide information and opportunities, X was particularly cited by interviewees as a useful resource.

Potential Opportunities:

- **Entrepreneurial opportunity.** The private sector has a well-established role in Guatemala, employing most of the professional earth sciences community. This includes some companies with a focus on geohazards. For example, several recently-founded private consultancies provide various geotechnical services (e.g., Latitud Geología and AGEO – see **Figure 2**). This suggests there is demand for skilled geologists in Guatemala. Future work could explore how demand within this sector for geohazards professionals has changed with time, the motivation behind development of new consultancies, and current levels of demand for these professionals.

Challenges:

- **Connections.** There appears to be little connection between CUNOR and INSIVUMEH. Some interviewees noted that as a geosciences school and a national geohazards institution, these two entities should naturally be linked. However, others stated that CUNOR's focus has historically been mining and oil, and consequently the university lacks expertise in many areas relevant to INSIVUMEH. If there is demand for greater connection between the two, future work could focus on understanding the priorities of each institution and identifying areas of overlap for potential collaboration.
- **COVID.** COVID is commonly agreed to both slow progress and to inhibit opportunities.
- **Geohazards education.** Several people stated that geohazards education in Guatemala was insufficient to meet the country's DRR needs. The geology school at CUNOR was criticised for not providing adequate geohazards education. Opinion differed on whether this was due to a lack of resources or a lack of interest; the answer may be both. One interviewee remembered a lack of interest among both students and staff but suggested

that students' indifference was due to either a lack of information on pathways towards a professional career in geohazards or an absence of said career opportunities. Another thought that CUNOR staff's disinterest in practical geohazards education was because they had already established research interests in other areas. Research programmes around the world are shaped by availability of financial resources. If private sector finance for mining and/or oil focused research is easier to access, these themes will dominate research programmes. Some interviewees stated that DRR-relevant geohazards education is insufficient because historically, such education was geared towards mineral exploitation and petroleum (as such companies need a pipeline of trained geologists/technicians). These interviewees were optimistic, however, citing slow but increasing appreciation that geoscience education is essential for DRR efforts. Whatever the cause for current lack of interest, all respondents agreed that geoscience education in Guatemala was hampered by a lack of resources. Several key facilities in the geology school were described as inadequate, including the library and a laboratory that contained little equipment – much of it in poor condition.

- **INSIVUMEH.** Some people stated that as a sub-department of the Ministry of Transport and Communications (CIV), INSIVUMEH has little independence. They believed INSIVUMEH would function better as an autonomous institution.
- **Institutional responsibility.** Although CONRED is ostensibly responsible for disaster reduction at the national level, several interviewees commented that the institution is much more focussed on post-disaster recovery than preventative DRR.
- **Pay conditions.** Multiple staff in INSIVUMEH and CONRED have left for other institutions that provide better pay. This is a long-standing issue. In addition, several former female staff have left because they are paid less than their male counterparts.
- **Precarity.** INSIVUMEH technical staff are employed on short-term contracts (between 3 and 9 months), creating a chronic lack of stability and sense of precarity.
- **Physical volcanology.** There is insufficient formal education in physical volcanology in Guatemala. There is no graduate volcanology course, and undergraduate study of physical volcanology at CUNOR is limited to a single theoretical module. No university in Guatemala provides opportunity for practical volcanological fieldwork. However, Uni. Mariano Gálvez is holding discussions to develop a master's course in Volcanology that will likely be available from 2024. Although the course would be a new educational opportunity, this report highlights the limited employment opportunities and challenges that face professional volcanologists in Guatemala (e.g., Interviewee 1, pg. 9). A master's course focussed on natural hazards would have a wider market for applications.
- **Political corruption.** A universal problem in Guatemala. With respect to geohazards, corruption can divert funds from or delay educational initiatives and work projects by months or years. Corruption can also affect the public opinion of an institution. This is a potentially serious issue for geohazards institutions responsible for providing reliable

information; lack of trust in an institution may complicate willingness to take in information they provide.

- **Poor retention of professional staff.** Related to Pay conditions and Precarity. This appears to be a particular problem with INSIVUMEH; reasons cited included low salaries, no work stability, a lack of benefits, no contractual obligations to the institution, and limited opportunity to develop professionally within the institution to make a fulfilling career. Qualified geohazards professionals working in governmental institutions are frequently offered positions in private companies in Guatemala, or positions outside Guatemala. These positions provide greater benefits, salary, and security. People leaving institutions for these positions leave behind a void. When people leave agencies, for a variety of reasons (including those identified), the collective knowledge is diminished and the opportunities to strengthen institutional knowledge and ensure this is accessible by future generations are reduced.
- **Single points of failure.** These exist in many critical areas of geohazards in Guatemala. For example, Gustavo Chigna is a volcanologist with uniquely rich knowledge and connection to communities around active volcanoes. Several interviewees expressed anxiety at the thought of his retirement, as he has no replacement with equivalent breadth of experience in the field knowledge of Guatemalan volcanoes.

Potential Challenges:

- **Extractive procedures.** Foreign universities collaborating with Guatemalan institutions may be guilty of extractive research procedures and one-sided communication. Avoiding these issues, and promoting more equitable collaboration and research, requires extended reflection and discussion between involved parties. Foreign institutions interested in collaborating with Guatemalan institutions may be guided by best-practice documents, such as the (preliminary) guidelines by IAVCEI's International Network for Collaboration in Volcanology, INVOLC (INVOLC, 2022).
- **Intellectual freedom.** One interviewee suggested that professionals working within a governmental institution (e.g., CONRED or INSIVUMEH) were required to agree with a 'party line'. Future work could explore how widely this constraint is felt, and the impact of this culture on disaster risk management efforts.
- **Lack of integration.** Guatemalan universities were accused of creating an artificially large separation between physical and social sciences, preventing integration of methods for successful DRR as the two groups could not "communicate in each other's language". This split can occur even within disciplines, e.g., citing incidents of territorialism within the physical sciences. Like Extractive procedures, this challenge could be reframed as an opportunity for future interdisciplinary investigative projects that allow cross-fertilization between natural and social sciences. However, an important part of the challenge is the competition for attention and resources. Unless this part is addressed and made to work in a fair way, it remains difficult for different groups to work together.

4. Summary and Scope for Future Work

Summary

The results of this report identify several major challenges for the professional geohazards community in Guatemala. These challenges include insufficient geohazards education, lack of connection between universities and institutions and therefore opportunities to gain experience necessary for professional development, and poor retention of staff within governmental institutions related to employment conditions. Relationships with organizations outside Guatemala appear to be an important source of opportunity for many professionals but are also potentially problematic when that interaction distracts agencies from what should be their proprietary work according to their mission.

Preliminary findings of this report indicate that stronger geohazards education, better inter-institutional collaboration, and greater job security for government staff would greatly improve the situation. This report included responses from a limited number of professionals within the community; further research may confirm or revise first conclusions, as suggested below. Guatemala suffers more from resource distribution than resource need: although it has the highest GDP per capita (\$4,603.3) among the CA-4 countries (El Salvador, Honduras, Guatemala, Nicaragua) (World Bank, 2023), it also has the 18th-highest wealth inequality globally (World Population Review, 2023). Future work that focusses on how the geohazards community in Guatemala can meet the SDGs must consider the impacts of unfair resource distribution and wealth inequality on institutions, and how these institutional impacts in turn affect the training and development opportunities available to current and future members of the community.

Considerations:

1. The facilitation of strengthened connection between CUNOR and professional geohazards institutions in Guatemala (e.g., INSIVUMEH, CONRED, ICC).
2. The development of educational resources (online, library, & laboratory) and themes in geohazards education (e.g., volcanology, meteorology, DRR) for use at CUNOR and other departments with relevant degrees.
3. For foreign geohazard-related research teams working in Guatemala: actively seek out more opportunities for Guatemalan students and partners to gain experience both in-country (e.g., in the field) and abroad, including facilitation of financial support. Currently active research teams from the Universities of Bristol and Edinburgh (UK) and MTU (USA) provide examples of good practice in this.
4. Advocation for better pay conditions and job security for INSIVUMEH staff. We recognise, however, that this is a very complex problem, likely addressed at a Governmental level within INSIVUMEH's parent institution, the Ministry of Communications, Infrastructure and Housing (Ministerio de Comunicaciones, Infraestructura, y Vivienda – CIV).

Scope for Future Work

1. Facilitate geohazards study at CUNOR by (i) investigating factors such as limited resources and career pathways identified previously, and (ii) designing actions to tackle the limiting factors determined to be at play.
2. Create space(s) for dialogue between the rapidly developing geohazards education initiatives offered by SSG and CESEM and CUNOR, to identify potential areas of overlap and encourage collaboration rather than competition.
3. Develop institutional mapping for DRR in Guatemala and clarify related institutional roles and responsibilities in preventative and responsive DRR. (This point may clarify potential career pathways for students of CUNOR, as mentioned in point 1).
4. Consider impact(s) of resource distribution on institutional strength and consequently training and development opportunities available to geohazards professionals working within those institutions.
5. Undertake subsequent research with the professional geohazards community in Guatemala to review and update results presented in this report. Subsequent research will be valuable in determining in what ways the training and development landscape for the community has changed. Specific areas that we recommend for review in subsequent research are:
 - a. Resources available at CUNOR for undergraduate geology degrees, and career prospects and pathways for graduates of CUNOR (and other degrees mentioned in this report).
 - b. The geohazards-relevant degrees available at undergraduate and postgraduate levels offered by Uni. Mariano Gálvez and USAC.
 - c. Job precarity and contracts of INSIVUMEH staff⁴.
 - d. The impacts of previous international research projects (e.g., Ixchel) on training and development opportunities available to the geohazards community.

Author Contributions

AKN designed the study, compiled the literature review, conducted interviews, designed, delivered, and analysed results of the survey, and led the writing of the report. ESC, REW, and JG contributed significantly to the written report and provided additional information on various aspects of the Guatemalan professional geohazards community that are included in the literature review.

⁴ This may be strongly influenced by how INSIVUMEH operates within its parent institute, the Ministry of Communications, Infrastructure, and Housing (*Ministerio de Comunicaciones, Infraestructura, y Vivienda, CIV*). Research on INSIVUMEH should therefore consider the constraints placed on it by CIV.

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