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Community-Driven GIS – Based landslide hazard mapping for Kias, Baguio City, Philippines

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ABSTRACT

Rain-induced landslides pose a significant threat to areas where heavy rainfall and unstable terrain increase disaster risk. Geographic Information System (GIS)-based hazard mapping is a critical tool for disaster preparedness, mitigation, and early warning that can be used for disaster preparedness and policy-making. However, many local disaster management groups lack the technical expertise to create and update their maps. Hence, this study aims to develop a GIS-based landslide hazard mapping customized for community volunteers tasked with emergency response and minimizing the effects of disasters. In the Philippines, these community volunteers belong to what is known as the Barangay Disaster Risk Reduction and Management Committee, [BDRRMC] under Republic Act (RA) 10121. A participatory training program for the community volunteers was designed using simplified GIS manuals, hands-on workshops, and side-by-side mentoring. The program generated four different GIS hazard maps mainly 1) landslide points/locations and fault line, 2) Vulnerability Map, 3) Heat Map; and, 4) Purok (community subdivision) Boundaries and Geo-Tagging. Results showed based on observations and assessment during the training program indicated that the community volunteers were able to follow the manual with minimal guidance and were able to generate the required maps within the expected time period. Moreover, post-training assessment by the trainees showed that majority of them expressed confidence in teaching others, ensuring the sustainability of the community-led hazard mapping. With these, bridging the gap between scientific hazard mapping and localized disaster preparedness could hopefully contribute to the UN Sustainable Development Goals (SDGs) 11 “Sustainable Cities” and 13 “Climate Action”.

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INTRODUCTION

Landslides are common natural and destructive hazards in mountainous regions, often triggered by prolonged rainfall, seismic activity, or land-use changes. In the Philippines, Baguio City is particularly vulnerable due to its steep terrain, high precipitation levels, and the presence of fault lines. Effective landslide hazard reduction requires a clear understanding of landslide triggers, risk assessment techniques, and mitigation strategies. Anderson and Holcombe (2013) argue that this understanding enables (a) scientific accuracy in risk assessments, (b) appropriate disaster risk management strategies, (c) justification of risk reduction measures, (d) increased community confidence in disaster interventions, and (e) a comprehensive, multi-stakeholder approach to disaster preparedness.

Despite national disaster risk reduction initiatives, many local communities remain dependent on external experts to develop and interpret hazard maps. The READY Project (2005–2011), led by the National Disaster Risk Reduction and Management Council [NDRRMC], aimed to institutionalize disaster risk management by developing community-based hazard maps (NDCC, 2008). However, many barangays (subdivisions or sub-units of a city or municipality), including Kias, Baguio City, still lack the technical expertise to generate and update GIS-based hazard maps independently. Existing hazard maps often remain static and outdated, limiting their usefulness in disaster response. This highlights the need for a participatory approach that empowers local stakeholders with technical skills to maintain their own disaster preparedness tools.

Community participation in hazard mapping has been explored in various contexts. Klimeš et al. (2019) conducted a study in the Central Andes, Peru, where scientists collaborated with local communities to improve landslide risk awareness. Their research emphasized the integration of scientific knowledge and participatory methods, allowing communities to contribute to hazard monitoring. However, their approach relied on expert-led GIS analysis, which limited long-term sustainability. Similarly, Ahmad et al. (2023) studied slope risk awareness in Penang, Malaysia, using GIS and community surveys to identify high-risk zones. The study successfully integrated GIS and survey-based risk assessment but lacked a structured training program to enable communities to independently create and update hazard maps. Such limitation has been addressed by this research presented in this paper by designing a training materials and framework suited to the technical proficiency of the trainees. Beyond hazard awareness, hands-on training is essential for ensuring that communities can sustain disaster risk management initiatives. Thinda (2009) explored a community-based hazard and vulnerability assessment framework using the progression vulnerability model for Lusaka, Africa. Findings showed that risk reduction was more effective when local residents were actively engaged in both data collection and decision-making. This aligns with the participatory approach of this study, which aims to equip the BDRRMC of Kias, Baguio City, with GIS-based hazard mapping skills.

In the Philippines, Saint Louis University (SLU) has pioneered disaster risk reduction programs, aligning with its institutional mission of research, instruction, and extension. In 2015, SLU launched a community hazard mapping program in Irisan, Baguio City, training ten barangay volunteers to generate GIS-based maps. Evaluation surveys revealed that trained participants successfully applied their learning and even continued updating maps independently (Mallare, 2019). Due to high demand, the program expanded over the next three years, reinforcing the need for structured GIS training programs tailored for non-technical users. However, GIS mapping remains a highly technical field, often requiring expertise in spatial analysis, remote sensing, and software applications like Quantum GIS (QGIS). Many community members lack access to training, resources, or technical support, making it difficult to sustain hazard mapping initiatives. Campolet (2014) explored the feasibility of a GIS-based landslide early warning system, but its application still required expert oversight. The primary challenge remains on how GIS hazard mapping can be made accessible to non-experts, ensuring long-term usability at the community level.

This study addresses the gap in community-driven GIS-based hazard mapping by implementing a structured, hands-on training program for BDRRMC members in Kias, Baguio City. Unlike other studies that relied on expert-led GIS applications, this research introduces a participatory training model that enables local stakeholders to independently generate, interpret, and update hazard maps. By simplifying GIS methodologies and integrating customized manuals, workshops, and side-by-side mentoring, this study hopes to bridge the gap between scientific hazard mapping and community-based disaster preparedness that will provide a scalable framework, which can be replicated in other disaster-prone communities.

OBJECTIVES OF THE STUDY

It was the goal of this research to design and implement a comprehensive GIS-based landslide hazard map for Kias Barangay to enhance Disaster Risk Reduction and Management [DRRM], with a particular focus on early warning and preparedness. Listed below were the specific objectives the study intended to meet:

1. Develop a GIS-based landslide hazard map specific to Kias Barangay, integrating historical landslide data, rainfall patterns, and topographical features to identify high-risk areas.
2. Simplify GIS hazard mapping for the community members -BDRRMC members
3. Enhance spatial analysis and disaster preparedness among BDRRMC members
4. Evaluate the impact of the training program and sustainability of the extension program
5. Contribute to global disaster resilience efforts by aligning with the United Nations Sustainable Development Goals, particularly SDG 11 and SDG 13

MATERIALS AND METHODS

Locale of the study

Kias Barangay, located in Baguio City, Luzon, Philippines, is a predominantly mountainous and hilly area characterized by a high incidence of rain-induced landslides and the presence of an active fault line. Its elevation of approximately 1,310.5 meters (4,299.5 feet) above sea level contributes to its vulnerability to geohazards, particularly during periods of heavy rainfall. According to the 2020 Census, Kias had a population of 6,374, accounting for 1.74% of Baguio City's total population. In the 2015 Census, the barangay recorded 5,992 residents across 1,627 households, with an average household size of 3.68 members. Geographically, Kias is situated at 16.3675° N latitude and 120.6316° E longitude (PhilAtlas, 2014). Given its terrain and susceptibility to landslides, Kias is a priority area for disaster risk reduction initiatives, including GIS-based hazard mapping and community-based preparedness efforts.

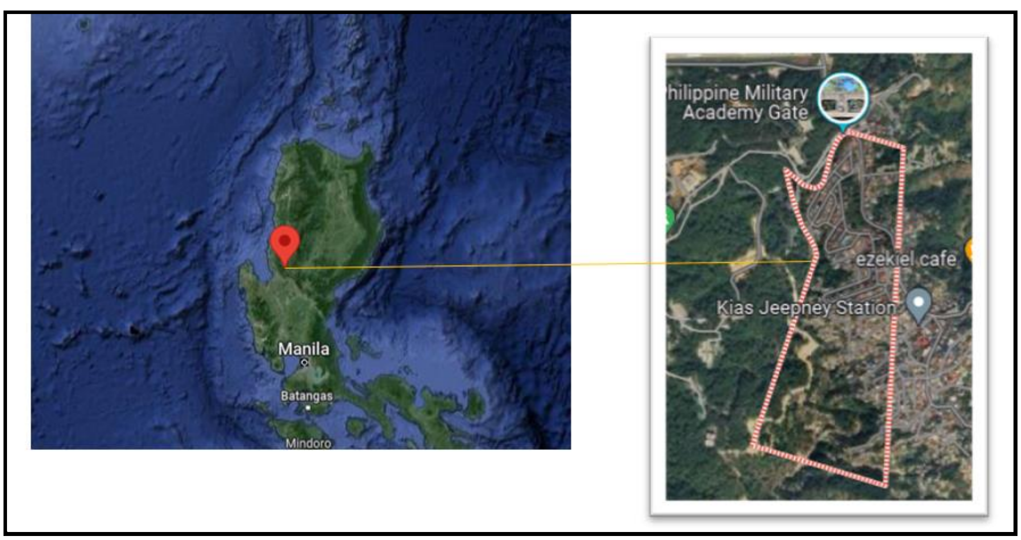


Figure 1. Locale of the study
(Source: PhilAtlas, 2014)

Needs Assessment

The need for a local or community hazard map is supported by the United Nations Inter-Agency Secretariat of the International Strategy for Disaster Reduction (UNISDR) as indicated in their initiative- Developing Early Warning Systems: A Checklist, a document from the Third International Conference on Early Warning ("Developing Early Warning", 2006). Moreover, in Republic Act 10121 of the Philippines, one of the functions of officials in the provincial, city and municipal, or barangay levels, is to "Consolidate local disaster risk information which includes natural hazards, vulnerabilities, and climate change risks, and maintain a local risk map" (RA 10121, 2019, Section 12 part c. no. 3). Since the focus of this study is community capacity-building on GIS-based landslide hazard mapping, a need assessment was conducted to determine if this intervention could be made in the community. An interview was conducted with the barangay captain, who is the head of the community, to determine the following: i) whether or not they have any version or form of hazard map; ii) the availability of computer terminals and wifi service; and, iii) the schedule of activities of the BDRRMC. Subsequently, the BDRRMC members were interviewed, to determine the following: i) their familiarity with GIS and spatial analysis tools; ii) their willingness to participate and complete the series of training; iii) their preferred learning methods to ensure accessibility and knowledge retention; and, iv) their awareness of any maps and hazard data of their community. The results of the interviews guided the trainers on how to effectively design and carry out the study in general, and the series of training in particular.

Pre-training Activity

To establish foundational knowledge, Campolet's (2014) study on GIS-Based Landslide Early Warning Systems was presented to the participants wherein the discussions were conducted in the vernacular language to enhance comprehension. Moreover, the presentation related complex GIS concepts to real-world applications relevant to the locality's disaster risk reduction efforts. Additionally, a step-by-step explanation of data collection and hazard mapping processes was provided, helping participants connect theoretical concepts with practical implementation. Building rapport between the extension team and BDRRMC members was prioritized to foster engagement and ensure long-term collaboration in sustaining GIS-based hazard mapping initiatives.

The Trainees

A total of eleven (11) members from the BDRRMC volunteered to participate as trainees in the study. These members are the front liners in times of health care emergencies and disaster response (evacuation, search and rescue, etc); they are in-charge of typhoon monitoring, participate in annual preparation of public schools before start of classes by cleaning classrooms and surroundings, repairing fixtures, and other related tasks. Also, they take care of the environment by tree-planting and regular clean-up drives and serve as marshals during community events. This group periodically attend training in order to enhance their skills or to learn new ones as part of their best practices.

Training Design and Data Collection

Based on the results of interviews with barangay officials, the team designed a structured GIS training program that incorporated simplified instructional materials, hands-on activities, practical mapping exercises, and individual mentoring to accommodate participants with varying technical backgrounds. The training covered the following activities:

Activity 1. Microsoft Excel for Data Recording
Activity 2. Introduction to GIS and Hazard Mapping: Role of GIS in disaster risk reduction, with case studies from previous applications
Activity 3. Data Collection Using GPS: Using Global Positioning System (GPS) devices and mobile mapping applications to record landslide and fault line locations
Activity 4. Spatial Analysis Using QGIS: Map layering, geospatial analysis, and hazard visualization techniques using open-source GIS software.

Activity 5. Hands-on Hazard Map Development: Creating community-specific hazard maps, integrating historical landslide data, elevation models, and rainfall records.

The study was divided into three (3) phases:

Phase I. Activities for Data Collection; Data Recording and Organization using MS Excel

Rainfall and Landslide Data Collection

Rainfall data from 2006 to 2013 was obtained from Philippine, Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) Baguio Synop (Surface Synoptic Station) where daily observation of all meteorological processes was made at fixed observation times (Campolet, 2014). Data was updated from 2006 to 2019. Also, Kias Barangay had logged landslide occurrences for the period from 2006 to 2019. The set of data on hand was used in the workshop on Microsoft Excel.

Global Positioning System (GPS) Receiver Training

Two units of GPS Receiver from Saint Louis University were used in obtaining coordinates of hazard locations. In the landslide and fault line ocular survey, trainees were divided into 3 groups to gather data using the GPS receiver. The trainees were divided into three groups, and each group was tasked to collect the x and y coordinate of previous landslide events in their assigned area.

Phase II. Activities for QGIS Hazard Mapping

Preparation of presentations, manuals, and topics

The research team prepared the manuals, topics, and presentations that were based from collaborative ideas from a multidisciplinary perspective. With these, all manuals and power point presentations were prepared according to the technical proficiency of the trainees. The venue of training is at Saint Louis University, Baguio City. Based from the study of Campolet (2014), the following topics were considered for workshop/training under QGIS Hazard Mapping:

1. Familiarization and Updates on QGIS 3.22 Biatowieza Software: Orientation on mapping software- how to install, importance of the software, applications and how to use the QGIS graphic user interface; with hands-on activity
2. Generating Landslide Coordinates: Mapping landslide points using the x and y coordinates obtained with the GPS Receiver.
3. Generating Fault Line Data and Purok Boundaries: Marking district or zone found inside the barangay (a subdivision or sub-unit of the city). The output map displays the barangay and its district/zone.
4. Identifying Hotspot areas for Landslides using the Heat Map: Highlighting the area’s most prone to rain-induced landslides, output map displays red regions, considered as hot spots or most hazard-prone areas.
5. Geo-Tagging: Affixing geographical coordinates to an image (photograph or video) of a location where a landslide had occurred. Geo-tagging can be done online or offline.
   Vulnerability Mapping: Incorporating census data such as population of children, persons with disability (PWD), women and seniors; the census data is displayed at each purok in the map; red regions or hot spots are those puroks with the highest vulnerable population and thus prioritized in disaster mitigation and response efforts.
6. Map Composer: Final mapping activity in which the trainee customizes the map with legends, scales, map title and other details to make the map more understandable.

Evaluation of Learning Outcomes

To assess the effectiveness and success of the series of activities, the following evaluation methods were used:

1. Observational Assessment – The researchers monitored the trainees during hands-on training sessions, evaluating their ability to apply GIS concepts and complete mapping exercises.
2. Practical Mapping Outputs – Each trainee was required to generate a digital hazard map, either displayed on the computer monitor or as a printout as a final assessment. These maps were reviewed for accuracy, completeness, and usability.
3. Knowledge Retention and Confidence Check – After each training day, the trainees individually evaluated their experience; and after completing the program, the trainees were asked to assess their confidence in applying GIS skills on their own and training other community members.

Addressing Potential Biases and Limitations

As with any participatory research, challenges and biases were considered:

1. Participant Representation – Within the study period (particularly during the COVID-19 pandemic) some original trainees were assigned to other tasks before training resumed. So, new BDRRMC representatives participated in their place. While this ensured that active volunteers received training, it meant that some initial insights from the pre-pandemic period were no longer applicable.
2. Variation in Technical Proficiency – Some participants had limited computer skills, requiring additional mentoring during the GIS training. Customized manuals and a step-by-step approach helped address this gap.
3. Long-Term Skill Retention – While the training was successful, continued application of GIS skills is needed to prevent knowledge loss over time. Further follow-ups or refresher training sessions could enhance sustainability.

Phase III. Impact Assessment

Survey questionnaires for the trainees were used to evaluate each activity. Comments and suggestions from the trainees were also collected. During training – workshops, observations on the output monitor of the trainees are done through side – by – side mentoring. In this way, for those who cannot follow the steps in the manual, they can be guided in actual hands – on training. Any questions or clarifications on the steps in the manual is also verified by during the training. After the training – workshop, the target group were allowed to keep the manuals and continue training on their own.

Sustainability

The knowledge imparted to the partner community assures sustainability as the participants are willing to share the lessons that they have learned with the other members of the community who did not participate in the training program. Furthermore, the participants can be invited as resource speakers for the next Barangay Disaster Risk Reduction and Management Committee [BDRRMC] (RA 10121, 2019) target group.

RESULTS AND DISCUSSION

Needs Assessment Results

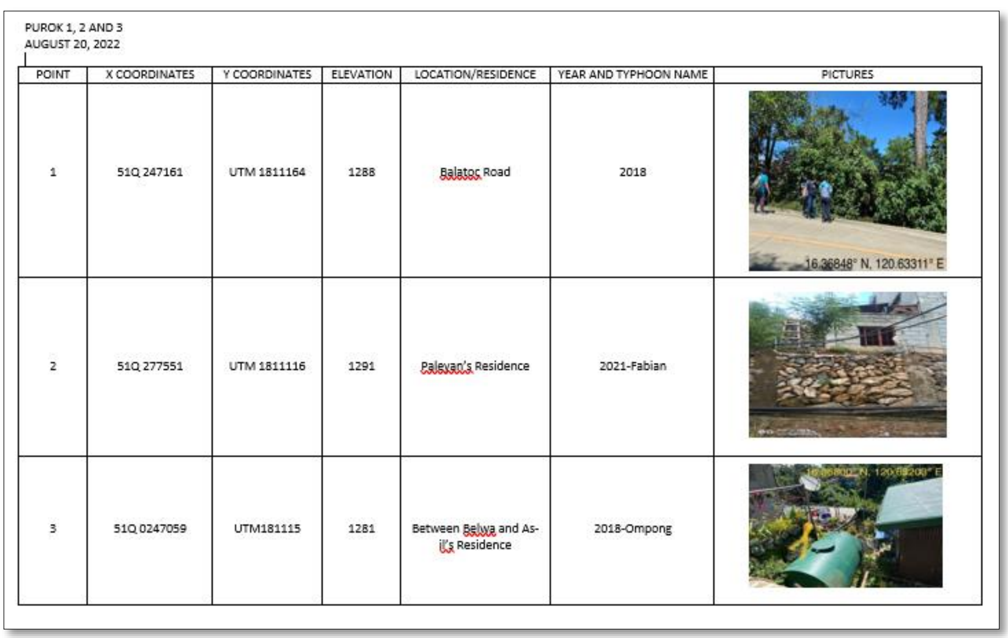
From the interviews with the barangay captain and the participants, the following information were determined: i) the community does not have a hazard map but they have hazard data from 2006 to 2019; ii) the community has a map that shows the Purok boundaries (see Figure 2 below); iii) the barangay has only two (2) computer terminals, iv) wifi service is available; v) majority of the BDRRMC members were not familiar with GIS hazard mapping; some were familiar with GPS receivers; vi) eleven (11) BDRRMC members were willing to participate in the program; vii) the volunteers were available for training on Saturdays; and, viii) the volunteers preferred one-on-one tutorial.

Figure 2. Kias Barangay Map (snapshot from Google Maps)

Global Positioning System (GPS) Receiver Training

Since the Kias BDRRMC members were more familiar with the landslide locations in the area, they led the extension team/trainers to the hazard areas. With the guidance of the trainers on the use of the GPS Receiver, the trainees read from the Receiver the x-and y coordinates of each hazard location. Subsequently, these were converted to latitude and longitude coordinates. Also, the elevation of each hazard location was obtained. Furthermore, interviews were done in between ocular inspections to verify details such as the year or date the landslide happened, typhoon name, name of residents occupying the area, type of landslide, daily rainfall recorded by PAGASA during the landslide occurrence. Photos were taken to have a visual representation of each hazard area. All GPS readings were written down on paper and then subsequently recorded on MS Excel worksheet. The trainees were able to obtain the location coordinates of previously recorded sixty-eight (68) rain-induced landslide events (from 2006 to 2019) and four (4) fault lines.

Figure 3a presents sample data collected by the target group using the GPS receiver. **Figure 3b** presents the generated sample map for landslide and fault line data.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AUGUST 20, 2022

POINT	X COORDINATES	Y COORDINATES	ELEVATION	LOCATION/RESIDENCE	YEAR AND TYPHOON NAME	PICTURES
1	51Q 247161	UTM 1811164	1288	Balatoc Road	2018	
2	51Q 277551	UTM 1811116	1291	Paleyan's Residence	2021-Fabian	
3	51Q 0247059	UTM181115	1281	Between Belwa and As-il's Residence	2018-Ompong	

Figure 3a. Sample Landslide Data from GPS Receiver Activity

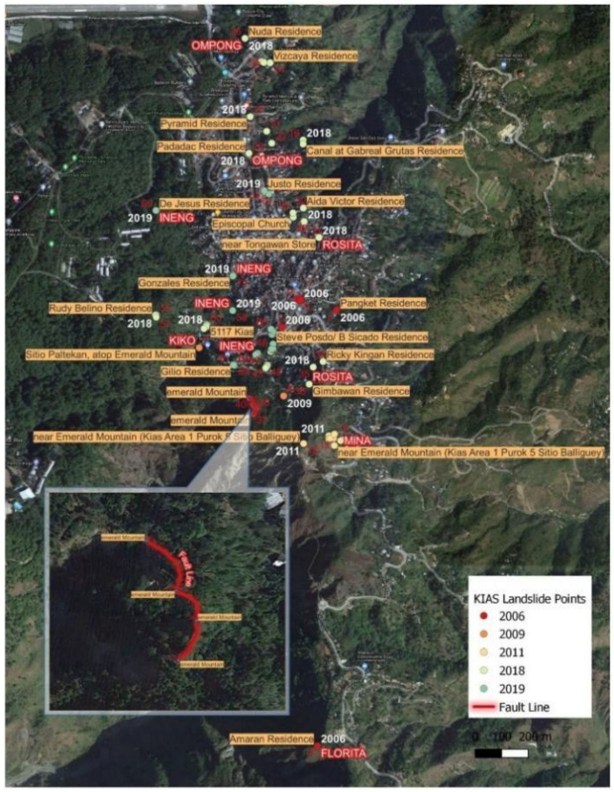
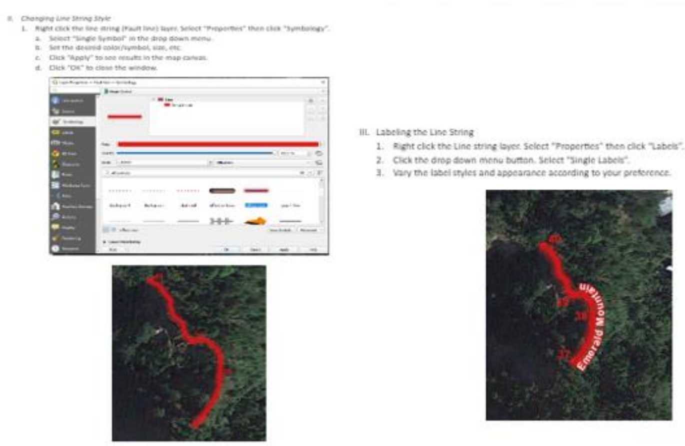


Figure 3b. Sample Map on Landslide and Faultline Data

Hazard Mapping Manual

Figure 4 present shows a part of the set of manuals; it details instructions on how to generate the fault line of Kias found along Emerald Mountains.



ID No.	Year Occurred	ite Occurr	Typhoon Name	Daily Rainfall (mm)	Purok	Location	x-coordinate	y-coordinate	elevation
32	2018	06-Nov	ROSITA	147.6		Aida Victor Residence	247023	1811170	1286
33	2018	06-Nov	ROSITA	147.6		Henry Justo Residence	246984	1811152	1299
34	2018	06-Nov	ROSITA	147.6	5	Ricky Kingan Residence	247097	1810592	1379
35	2018	06-Nov	ROSITA	147.6	5	Nora Posdo Residence	247060	1810571	1358
36	2018	06-Nov	ROSITA	147.6	5	Gimbawan Residence	247045	1810507	1369
37						emerald Mountain	246835	1810394	1378
38						emerald Mountain	246844	1810414	1375
39						emerald Mountain	246834	1810429	1371
40						emerald Mountain	246819	1810454	1358

Figure 4 Sample Procedures from Extension Activities

Figure 5 below shows a sample output map on vulnerability mapping generated by the researchers, which was customized or updated depending on the area under study.

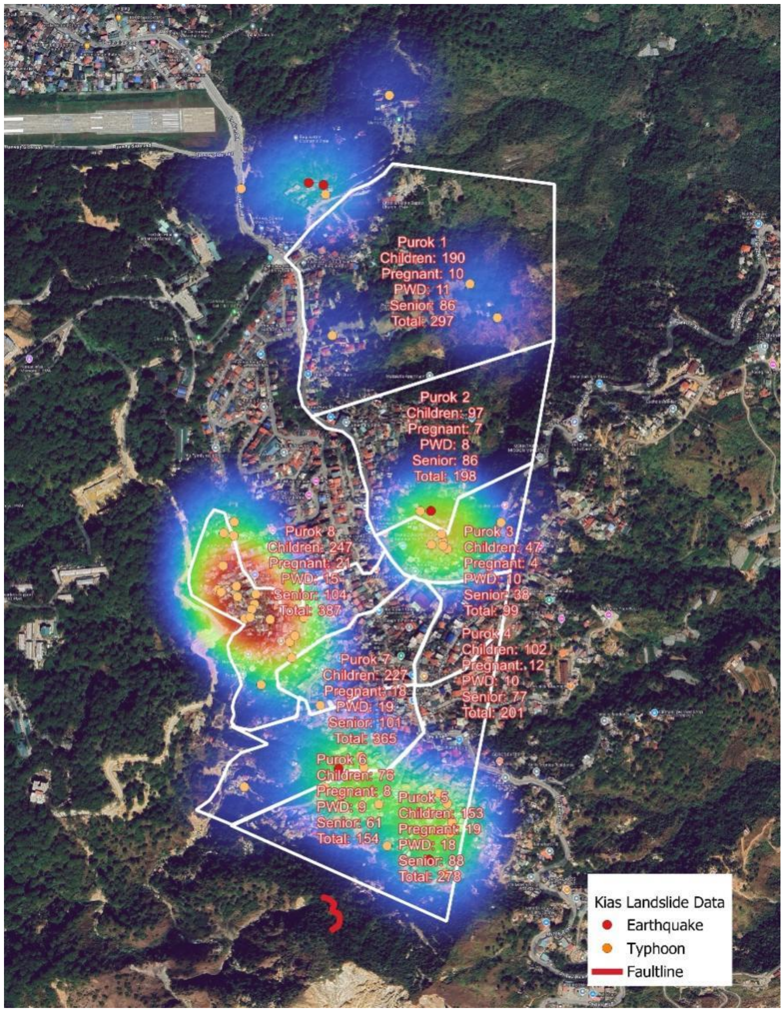


Figure 5 Sample Kias Vulnerability Maps with Purok Boundaries
from Extension Team GIS Hazard Map Manual

Sample Hazard Map Outputs from Trainees

The following figures showed the hazard map outputs of the participants during the training.
Figure 6 shows regions with bright prominent colors which represent the hotspot areas for landslides.
Figure 7a shows documentation of lecture workshop on generating the fault line in the GIS user interface.
Figure 7b shows documentation of lecture workshop on generating the fault line in the GIS user interface.
Figure 8 shows a sample final output of the Kias BDRRMC team leader on heat map and vulnerability mapping.

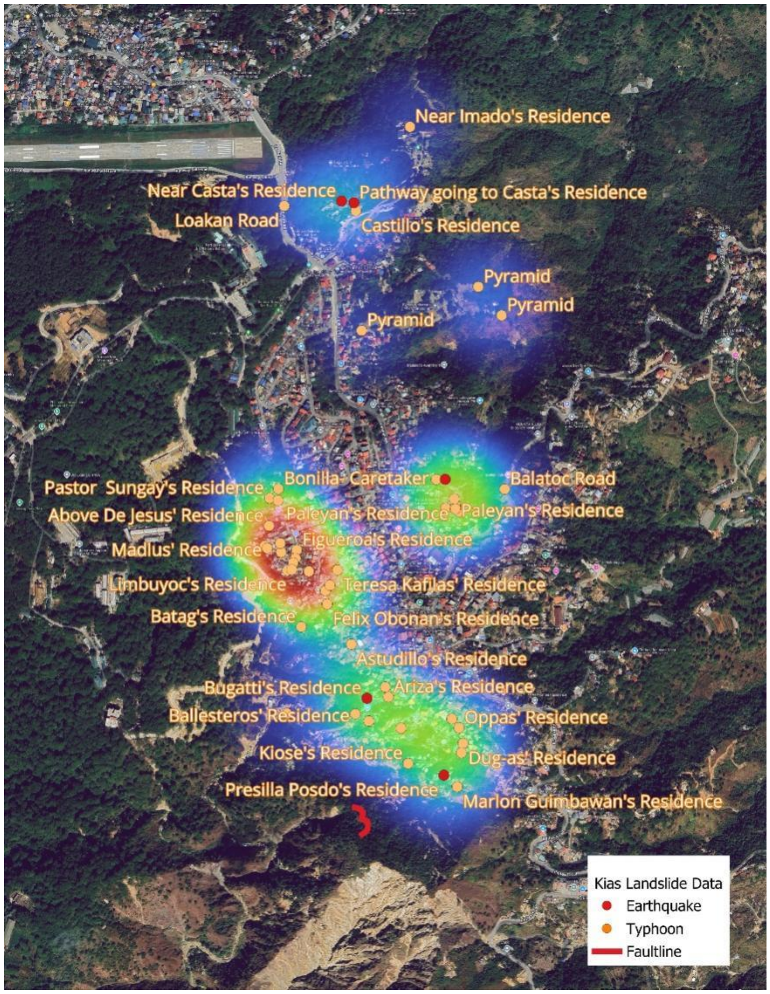


Figure 6 Sample Heat Map of Kias Barangay

Figure 7a Lecture – Workshop Training on Fault Line

Figure 7b. Sample Output Fault Line Heat Map from Barangay

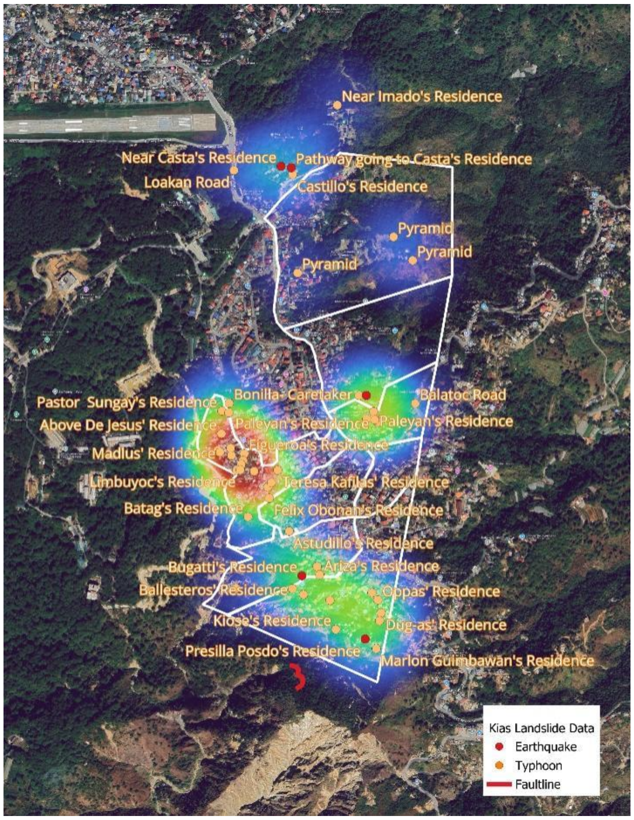


Figure 8 Sample Heat Map with Purok Boundaries and Hotspot Areas

Evaluation of Intervention

Table 1 presents the total number of responses of the target group. This form was given every after meeting to assess whether or not the participant was able to understand the topic or needs more intervention or assistance. The manuals were provided at the start of the lecture. Initially, the trainer discusses the concepts and its importance in disaster preparedness and response, how it is done in the QGIS software and its relation to the previous topics. Afterwards, participants are taught with hands-on experience on QGIS hazard mapping. Facilitators observe the displayed output of the audience after each step is carried out by the facilitator or trainer. If the generated map is correct, then the participant waits for the others to finish the sequence. Some members may finish the activity ahead of the others depending on their mapping skills and attention to instruction.

Table 1 Summary of Evaluation Responses of KIAS BDRRMC

Date/Topic	**Q1: Topic is useful for barangay disaster preventio n**		**Q2: Instruction s In the mapping are easy to follow**		**Q3: Materials and visual aids were helpful and effective**		**Q4: The facilities were adequate**		**Q5: The time allotted was sufficient**		**Q6: My knowledg e on computer -based mapping has increased**		**Q7: I can teach others what I have learned**	
	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO	YES	NO
20 Aug 2022 GPS Rx Training	11								11		11		11	
27 Aug 2022 GPS Rx Training	11								11		11		11	
3 Sept 2022 -MS Excel -Introduction to QGIS -Generating Landslide Coordinates	9		9		9		9		9		9		9	
10 Sept 2022 Identifying Faultline and Purok Boundaries	9		9		9		9		9		9		9	
15 Oct 2022 Heat Map	3		3		3		3		3		3		3	
22 Oct 2022 Geo-Tagging Heat Map	6		6		6		6		6		6		6	
12 Nov 2022 QGIS Vulnerability Mapping	7		7		7		7		7		7		7	
19 Nov 2022 QGIS Map Composer	5		5		5		5		5		5		5	

As gleaned from the table, majority of the trainees answered YES to:1) usefulness of the map in barangay disaster prevention, 2) ease of following mapping instructions found in the manual, 3) usefulness and effectivity of materials and visual aids, 4) adequacy of facilities, 5) allocation of time for the lecture-training, 6) increase of knowledge in hazard mapping and 7) ability to share the knowledge to others. The results of the evaluation indicate that the target community was able to acquire the necessary skills and knowledge for each topic, especially when the expected output map has been properly generated in the QGIS software. For some of the results, 3 YES responses were collected due to reasons that the target community had an emergency rescue. In general, at the end of the extension program, 11 participants were able to finish and produce their own QGIS hazard map. This indicates that the study was able to share the knowledge on hazard mapping to the target group for their disaster preparedness and mitigation.

Impact Assessment Results

Table 2 below presents the summary of results on how the extension program provided an impact to the target group. The results gathered are descriptive and qualitative.

Table 2. Impact Assessment Results

DESIRED OUTCOME	INDICATOR	DATA COLLECTION METHOD	FREQUENCY	RESULTS
•Build knowledge and capacity in the target group on data collection and computer-based hazard data recording and mapping	•Hazard database of rain-induced landslides and fault line •Longitude/Latitude or x-y coordinates of landslide events	•Analysis/Inspection of individual computer monitor display and hard copies of MS Excel output •Analysis/Inspection of existing notes/records of landslide data caused by typhoons in the barangay	•After each lecture - workshop topic	•Target group transitioning from a notebook/logbook recording of data, to computer method (Microsoft Excel) which is easier to edit/update
•Increased knowledge and awareness in the Project team about the needs of the community on disaster preparedness and prevention	•Census Data By Purok	•Analysis/Inspection of recorded GPS readings •Photos of landslide areas on the ocular inspection	•1st two meetings of the training phase	•Target group has more accurate mapping of hazard locations using GPS receiver (the barangay need to request the Punong Barangay for the purchase their own GPS receiver after the training phase)
	•QGIS Hazard Maps and Attributes	•Analysis/Inspection of recorded data	•During training period	•Increase knowledge in the target group

				regarding vulnerable population - residents of the community who need priority attention before, during and after a hazard event
• Project team exhibiting creativity in customizing a highly technical topic for the target group	•Individual observation of trainees on their ability to follow instruction	•Analysis/Inspection of maps	•3rd to the 8th meeting of the training phase	•Target group transitioning from hand-drawn maps to computer-generated maps that are easier to edit/update ◊ Target group having heatmaps that show areas in the community most prone to particular hazards- these could guide them in i) their selection of locations for their evacuation shelter and route , ii)their land use planning, etc.
• A target group that is self-reliant in sustaining the computer-based mapping system	•Performance, feedback and reaction of the trainees	•Inspection of computer display	•During training	•Trainees who are able to follow the instructions given by the resource speaker/facilitator
		•Evaluation by means of a questionnaire in order to determine i)	•After each lecture-	•The target group 1) acknowledged an increase in technical

		their reaction and perception of the series of trainings in particular and on the extension program in general; ii) the efficacy of the mode of training, and on iii) capacity to pass on their learning	workshop/ training phase	knowledge that was taught at their level 2) expressed confidence and willingness to echo the lectures to the other current members and future members of the BDRRMC
•Increased awareness and knowledge in the project team on organizational learning in the context of the institution's vision-mission	•Feedback and reaction of project team members	•Questionnaire	•Conducted once after the closing ceremonies	•The project implementers acknowledged 1)gaining insight on community needs and the importance for the academe to get involved and share their expertise 2)learning new skills and enhancing other skills on technical, relational and management aspects

Table 3 below shows the elements of the training program. The template used is patterned after the Program Logic Model for Extension Program of Saint Louis University, Baguio City.

Table 3 Program Logic Model

OBJECTIVES	INPUTS	ACTIVITIES	OUTPUTS	OUTCOMES
-To contribute to the disaster preparedness and prevention of Kias Barangay, Baguio City by training BDRRMC members on GIS – based hazard mapping	-Current practices of the target community on disaster preparedness and prevention	-Assessment of 1) Kias BDRRMC files and maps on disaster preparedness and prevention 2)Methods practiced by the community in the collection and recording of hazard and	-Lecture – workshop topics that contribute to the community's preparedness for disasters and for prevention of disasters -Training and manuals suited to the technical	-Increased knowledge and awareness in the project team about the need of the community on disaster preparedness and prevention

		vulnerability data 3) Needs in the disaster preparedness and prevention of the community	background of the trainees	
	-Materials: computers with Microsoft Office and Quantum Geographic Information System (QGIS); memory/storage devices and printers -Internet access for Google maps and other information -Technical Support from School of Engineering and Architecture Computer Laboratories (2019 – 2020) -Funding from the University and provision of training facilities -Trainers: full-time and part-time SEA faculty -Online Peer Training of Faculty on the latest version of QGIS	-Preparation of Updated Manual on: **Project I** 1) GPS Receiver 2) MS Excel **Project II** 3) QGIS 3.22 Biatowieza Software Updates 4) Generating Landslide Coordinates 5) Generating Fault Line Data and Purok Boundaries 6) Identifying Hotspot areas for Landslides using the Heat Map 7) Geo-Tagging 8) Vulnerability Mapping 9) Map Composer	-Training Manuals	-Project team exhibiting creativity in customizing a highly technical topic for the target group

	-Trainees: Members of KIAS BDRRMC -Support group to the trainees: Barangay Council of Kias -Global Positioning System (GPS) Receivers from Mining Engineering Department	-Lecture and Workshops: **Project I** 1) GPS Receiver (on-site landslide ocular inspection) 2) MS Excel **Project II** 3) QGIS 3.22 Biatowieza Software Updates 4) Generating Landslide Coordinates 5) Generating Fault Line Data and Purok Boundaries 6) Identifying Hotspot areas for Landslides using the Heat Map 7) Geo-Tagging	-Updated raw landslide data with spherical coordinates -Organized database on landslide locations caused by typhoons and heavy rains - QGIS Hazard Map with the following layers: - the base map/1st layer comprising of KIAS landslide coordinates and fault line -2nd layer consisting of administrative boundaries with the aid of QGIS polygons -3rd layer consisting of the hotspot areas for landslides (heat map) -sample map on geo – tagged facilities can be identified by photos and by incorporating exact latitude and longitude coordinates of important facilities	-Build knowledge and capacity in the target group on data collection and computer-based hazard data recording and mapping -Increase knowledge in the target group on disaster preparedness and prevention -A target group that is self-reliant in sustaining the computer-based mapping system

		8)Vulnerability Mapping 9) Map Composer	-sample map on the population distribution for seniors, pregnant women, children and person with disability on the different Puroks of Brgy. Kias -sample map showing other information such as title, symbols, scale, legend and attribute table	
		Project III -Evaluation of: a) Trainees' Performance during training b) Program by Trainees c)Program by Implementers	-Observations of trainers; computer-generated maps from proficiency testing -Response to questionnaires -Response to questionnaires	-Increased awareness and knowledge in the project team on organizational learning in the context of the institution's vision-mission

Evaluation of Learning Outcomes and GIS Application

The effectiveness of the GIS training was evaluated through observational assessments, practical mapping exercises, and participant feedback. Results indicate that all 11 BDRRMC volunteers successfully generated and interpreted GIS-based hazard maps, demonstrating a clear improvement in spatial analysis skills. Additionally, majority of participants expressed confidence in independently updating maps and training others, suggesting a high potential for sustained community-led hazard mapping.

These findings align with Ahmad et al. (2023), who emphasized that community-based GIS training enhances risk awareness and disaster response. However, while their study in Malaysia revealed that fewer than 50% of participants felt fully aware of landslide risks, the structured, hands-on approach in this research resulted in higher retention and self-sufficiency rates among participants. This suggests that interactive, practical GIS training models lead to greater long-term adoption compared to lecture-based approaches alone.

A key insight from participant evaluations was the varying levels of technical proficiency at the start of the program. Some BDRRMC members were able to, on their own, follow the manual on their own, and adapt quickly to the QGIS software and GPS data collection. The rest were able to follow the procedures more quickly with side-by-side mentoring. This finding is consistent with Klimeš et al. (2019), who reported that local communities benefit most from simplified GIS tools and step-by-step guidance. Their study in Peru, however, relied on expert-led GIS applications, whereas the research being described in this paper demonstrated that non-expert community members can sustain GIS mapping efforts independently with the right training framework.

Impact of Generated Maps on Community Preparedness and Policy Integration

The hazard maps developed in this study identified three major landslide-prone zones in Kias Barangay, providing critical geospatial data that was previously unavailable at the community level. The barangay council has already expressed interest in integrating these maps into official disaster preparedness plans, reinforcing the potential for policy-driven disaster risk reduction strategies.

Additionally, the barangay council is exploring the use of GIS data for evacuation planning, mirroring best practices from Thinda (2009), who found that community-based hazard assessments in Africa improved evacuation route planning and emergency response efficiency. This research contributes to similar policy applications by equipping local DRRM teams with the ability to visualize and analyze hazard-prone areas, thereby enhancing decision-making in disaster mitigation and resource allocation.

Comparison with Other Studies on GIS Training for Non-Technical Users

This study provides a practical, community-centered approach to GIS training, setting it apart from more expert-driven GIS applications. Unlike Campolet (2014), whose GIS-based landslide early warning system required external technical oversight, this research proved that barangay-level disaster teams can independently conduct GIS mapping when training is structured for non-technical learners.

Moreover, recent findings from University of the Philippines, Los Baños, UPLB (2024) on participatory video training for youth in disaster risk reduction suggest that interactive learning significantly enhances skill retention. The positive responses of the trainees in this Kias study further supports the argument that practical engagement—rather than passive instruction—leads to stronger knowledge retention and application.

Real-World Implications and Future Considerations

The success of this study highlights the importance of community-driven GIS training models in strengthening disaster resilience at the barangay level. However, long-term sustainability requires:

1. Institutionalizing GIS training within barangay DRRM programs to ensure continuity as volunteers change.
2. Integrating hazard maps into official DRRM frameworks, particularly for evacuation planning, zoning regulations, and resource distribution
3. Continuing engagement from the barangay government and BDRRMC volunteers; and establishing a formal integration of GIS hazard mapping into barangay DRRM policies, ensuring that newly appointed volunteers receive GIS training as part of their disaster management responsibilities.
4. Providing periodic refresher courses to reinforce GIS skills and prevent knowledge attrition.

CONCLUSION AND RECOMMENDATION

This study addressed the challenge of limited to no GIS expertise in community-based disaster risk reduction by developing a participatory GIS training program for BDRRMC volunteers in Kias, Baguio City. The findings demonstrate that non-technical community members can effectively learn, apply, and sustain GIS-based hazard mapping, provided that training methods are simplified, structured, and interactive. All participants successfully generated and interpreted hazard maps, with the majority expressing confidence in updating maps and training others, reinforcing the program's potential for long-term sustainability. The hazard maps created through this initiative identified three major landslide-prone zones, providing valuable geospatial data for local disaster preparedness and response efforts. To ensure the sustainability of GIS-based hazard mapping at the barangay level, it is recommended that community plans formally integrate GIS training as part of standard BDRRMC operations in preparing for disasters. This can be achieved through regular refresher courses, the allocation of barangay resources for GIS software and equipment, and the designation of trained volunteers to oversee continuous hazard mapping efforts. Additionally, Local Government Units (LGUs) should adopt GIS hazard maps in policy-making, particularly for land-use planning, evacuation route optimization, and risk-informed resource allocation.

Further studies are needed in order to evaluate the long-term impact of GIS training on disaster readiness. Future studies should explore how well GIS knowledge is retained over time, the effectiveness of refresher training programs, and the extent to which community-driven hazard mapping improves disaster response efficiency. Expanding this initiative to other landslide-prone communities could provide a more comprehensive model for scaling participatory GIS training, ensuring that more vulnerable areas can benefit from scientific, data-driven disaster risk management. By closing, or at least narrowing, the gap between scientific hazard mapping and community-based disaster preparedness, this study contributes to localized disaster risk reduction strategies, supporting Sustainable Development Goals 11 and 13 (The 17 Goals, n.d.). Through continued efforts in capacity-building, policy integration, and scalability, GIS-based hazard mapping can serve as a cornerstone for more resilient, data-driven disaster risk management systems across disaster-prone communities.

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