RESILIENT COMMUNITIES THROUGH AWARENESS AND PREPAREDNESS AGAINST FIRE, FLOOD, AND LANDSLIDE RISKS

CHAPTER 3. LANDSLIDE DISASTERS

Prepared by: Metin Yamli and Huseyin Cakirca

KOCAELI PROVINCIAL DIRECTORATE OF DISASTER AND EMERGENCY

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CHAPTER

3

LANDSLIDE DISASTERS

A landslide, mass or soil movement is the movement of a slope whose ground structure consists of rock or artificial filling material by gravity, slope, water and other similar factors. Landslides are known as mass movements occurring when soil masses consisting of rocks and debris materials of these rocks break away from places where they are under the influence of gravity.

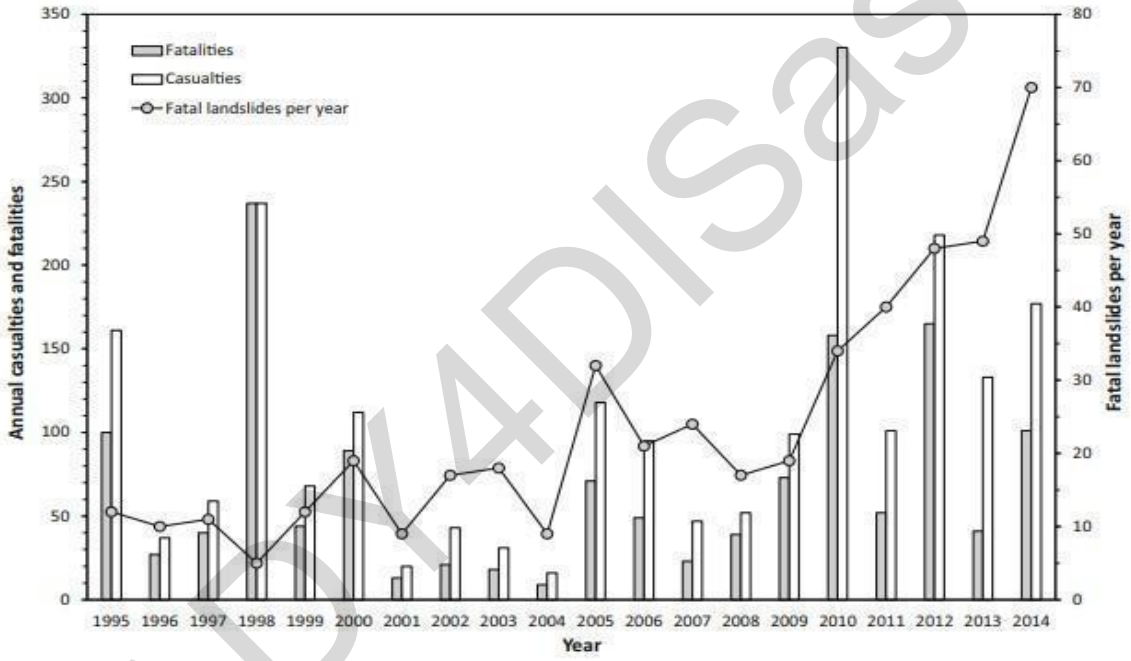

Figure 3.1. Annual casualties and fatalities and fatal landslides worldwide for the period from 1995 to 2014.

2,620 fatal landslide incidents causing 32,322 fatalities were documented worldwide from 2004 to 2010. Landslides also cause losses amounting to billions of Euro to infrastructural facilities such as roads, railways, pipelines, structures, embankments, buildings, and other property losses. For example, the total annual amount of losses caused by landslides in Italy is 3.9 billion Euros. In contrast, the annual total loss in Germany is only about 0.3 billion Euros where an approximate amount of 68 million Euros is incurred in connection with loss costs for the highway system (for costs in 2015). In comparison, the global total annual amount of losses caused by landslides is about 18 billion Euros, which is about 17 % of the annual average amount of global natural disaster losses, which makes up an approximate amount of 110 billion Euros [1].

Figure 3.2. A typical landslide event. (The Aberfan disaster, 1966, Great Britain).

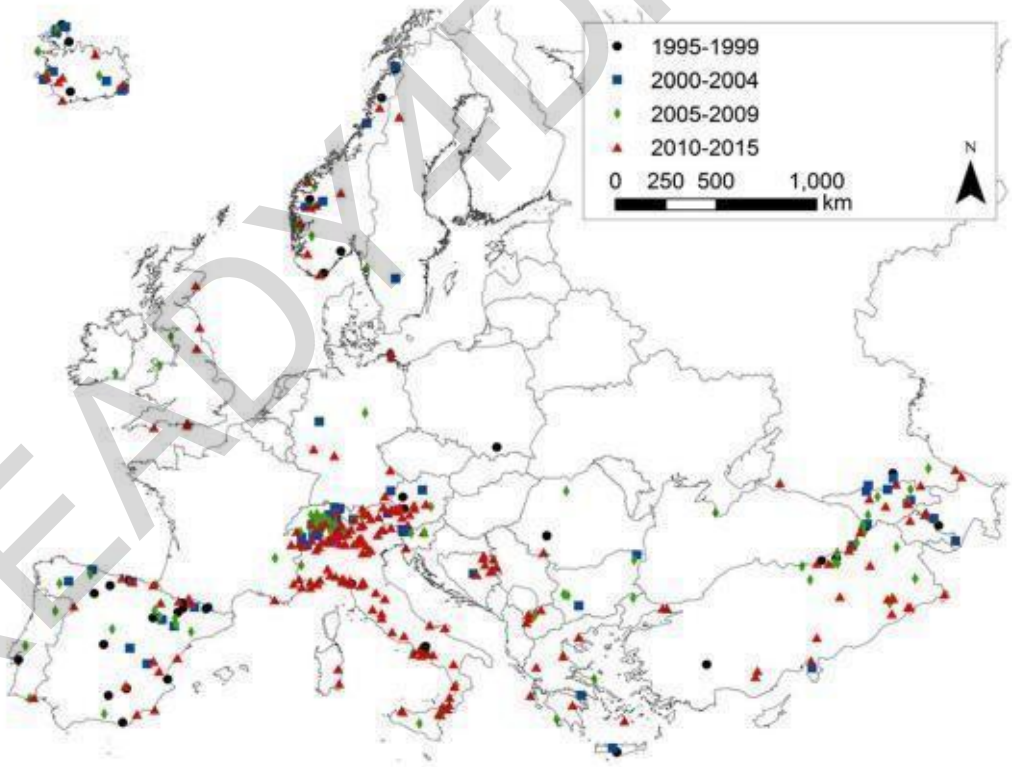

Figure 3.3. Spatial distribution of fatal (death, injury, and missing) landslides in the European Continent from 1995 to 2015.

3.1 Preparedness for Landslide Disasters

Landslide disaster preparedness forms an important part of the disaster risk management. In order to minimize the effects of disasters and ensure the human safety, the landslide risk management should be handled comprehensively. This requires a multidisciplinary effort with the cooperation of relevant institutions, local governments, and the public.

The disaster risk management is a set of principles and strategies aimed at ensuring that communities and regions are prepared for potential hazards and that they can respond effectively in disaster situations. According to the AFAD [2], a disaster risk management is the process of determining and analyzing the danger and risk at the scale of the country, region, city or settlement, determining opportunities, resources and priorities for reducing the risk, preparing and implementing the policy and strategic plans and action plans [3].

Landslide hazard areas should first be identified in order to be well prepared for landslide disasters. Landslide-prone areas should then be determined and a risk analysis of these areas should be carried out. In this way, potential landslide-prone areas can be mapped using geographic information systems and remote sensing technologies.

Landslide maps and monitoring systems are used to identify and continuously monitor potential risk areas. These maps provide information on disaster risks to local governments and the public. In addition, early warning systems of landslides can be established thanks to monitoring systems so that the public can be informed in advance and necessary measures can be taken. These systems have been explained under captions “Identifying landslide-prone areas and potential hazards” and “Landslide Maps and Monitoring Systems”.

Evacuation and rescue procedures followed as part of the landslide disaster preparedness are plans developed to quickly move people from disaster-affected areas to safe areas and provide necessary assistance.

Landslides can pose great dangers, especially in residential areas, so quick and effective evacuation and rescue plans are vital.

Protocols and solutions prepared for landslides are guides created for emergency teams to act in a coordinated manner. These protocols should include elements such as medical assistance, logistical support and communication [4],[5].

The evaluation of landslide losses and identification of hazards is important in the post-disaster process. The extent and type of losses are used to guide recovery and repair efforts. Hazard identification is a critical step for a better preparedness for future disasters. At this stage, factors such as the safety of structures, infrastructural and environmental losses and impacts are evaluated.

Landslide types and necessary precautions are defined in the following part.

Types of Landslides and Slope Failures:

- ✔ Falls: Falls are sudden movements of masses of geological materials, such as rocks and boulders that break off steep slopes or cliffs. (Fig. 3.4-D)
- ✔ Toppling: Toppling is the rotational movement of soil or rock masses forward from the slope along a point or axis above the centre of gravity. (Fig. 3.4-E)
- ✔ Sliding: Sliding is the movement of soil and rock masses resulting from shear deformation on one or more surfaces. (Fig. 3.4-A)
- ✔ Lateral spread: It is the spread of cohesive soils and rock masses on a softer ground at their underneath. (Fig. 3.4-J)
- ✔ Flow: It is the movement of the ground and completely decomposed rocks, even at a very slight slope, if they are saturated with water. (Fig. 3.4-F,I)

Types of landslides described above are shown in Fig. 3.4 and Table 3.1.

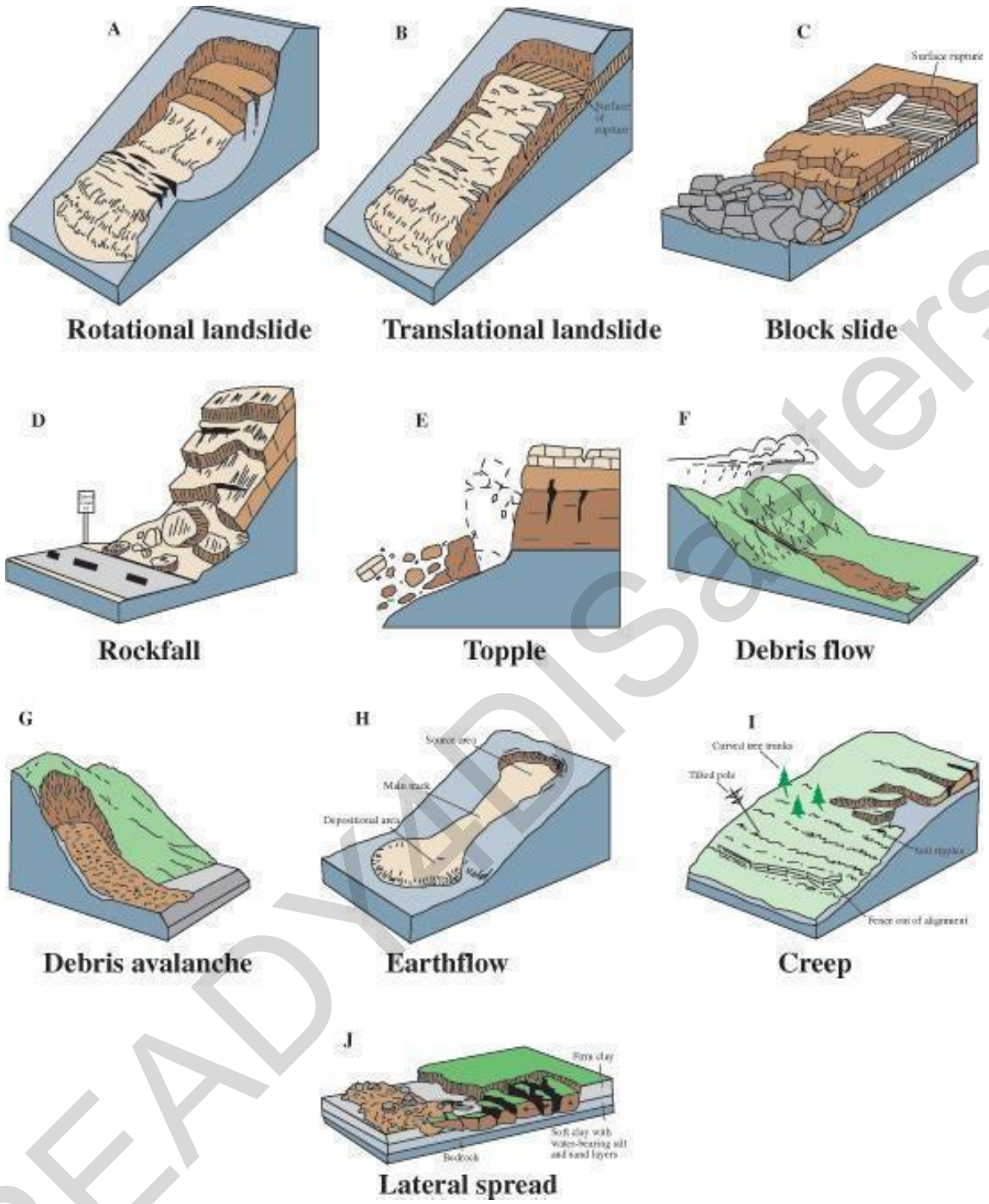

Figure 3.4. General landslide types

Table 3.1. Types of landslides. Abbreviated version of Varnes' classification of slope movements (Varnes, 1978).

<table>
<tr><th colspan="2" rowspan="3">Type of movement</th><th rowspan="3">Bedrock</th><th colspan="2">Type of material</th></tr>
<tr><th colspan="2">Engineering soils</th></tr>
<tr><th>Predominantly coarse</th><th>Predominantly fine</th></tr>
<tr><td colspan="2">Falls</td><td>Rock fall</td><td>Debris fall</td><td>Earth fall</td></tr>
<tr><td colspan="2">Topples</td><td>Rock topple</td><td>Debris topple</td><td>Earth topple</td></tr>
<tr><td rowspan="2">Slides</td><td>Rotational</td><td rowspan="2">Rock slide</td><td rowspan="2">Debris slide</td><td rowspan="2">Earth slide</td></tr>
<tr><td>Translational</td></tr>
<tr><td colspan="2">Lateral Spreads</td><td>Rock spread</td><td>Debris spread</td><td>Earth spread</td></tr>
<tr><td colspan="2" rowspan="2">Flows</td><td rowspan="2">Rock flow (deep creep)</td><td>Debris flow</td><td>Earth flow</td></tr>
<tr><td colspan="2">Soil creep</td></tr>
<tr><td>Complex</td><td colspan="4">Combination of two or more principal types of movement</td></tr>
</table>

What to do before a landslide:

- ✔ Do not build houses near steep slopes, drainage routes or natural erosion valleys in areas where they are prone to landslides or where landslides have already occurred.
- ✔ Have your house constructed with ground surveys approved by geotechnical experts against any landslide hazard.
- ✔ Learn about the assembly area and evacuation plans for your area.
- ✔ Develop your own emergency plan for your family or business.
- ✔ To prevent landslide danger, cover slopes with vegetation, plant trees and build retaining walls.
- ✔ Avoid building houses at the base of slopes that are prone to landslides.

3.1.1 Developing a landslide contingency plan

A landslide emergency plan is a document that includes precautions and intervention methods to be taken against such natural disasters in regions where mass movements (land movements or landslides) or slope movements such as landslides are possible. Its purpose is to ensure the safety of life and property in such dangerous situations, to respond effectively in an emergency and to minimize any loss or damage. In general, elements that a landslide emergency plan may include are:

- ✔ The plan should include detailed information (procedure or protocol) on how to perform evacuation and rescue operations in the event of a landslide or mass movement. The plan should state which tasks institutions or teams will undertake and how they will be coordinated.

- ✔ The plan should include safe evacuation routes in the case of a landslide danger as well as details on how to use these routes. Necessary markings, directions and backup roads should be determined.

- ✔ The plan should include general strategies on how to manage and reduce landslide risks. Issues such as preventive measures and soil stabilizations should be included in these strategies.

- ✔ Areas exposed to landslides in the region should be determined by using landslide risk maps. These areas should be prioritized and a more detailed plan should be created.

- ✔ The plan should explain what types of landslide risks the region faces and what kind of effects these risks may cause. Factors such as soil properties, slopes, and precipitation amounts should be taken into account.

The continuous updating of your landslide emergency plan, regular training sessions and drills (exercises or planned exercises for the preparedness for landslides disasters) will increase the effectiveness of the plan.

3.1.2 Identifying landslide-prone areas and potential hazards

According to the World Bank report (2005), a land surface of 3.7 × 106 km² is prone to landslides worldwide, and nearly 300 million people live in potential landslide-prone areas. [6]

The determination of areas exposed to landslides and potential hazards is very important to minimize landslide hazard effects of disasters and also to ensure the safety. This process requires a scientific and technical data-based approach to assess disaster losses and identify potential hazards. This process is explained step by step below:

Evaluation of Disaster Losses and Identification of Hazards:

- ✔ To evaluate effects of disasters, the type and magnitude of the disaster must first be determined. When assessments are carried out, it helps to determine what kind of hazards the landslide will cause.

- ✔ Determination of Disaster Areas and Disaster Risks:

The geographic, geological and meteorological data is taken into account to determine the disaster risk level of a region. For example, landslide-prone areas may be located on a sloping and barren (treeless) land. Areas situated around water basins are exposed to flood risks. Risk maps are formed by using such data and confirming which areas are at higher risks.

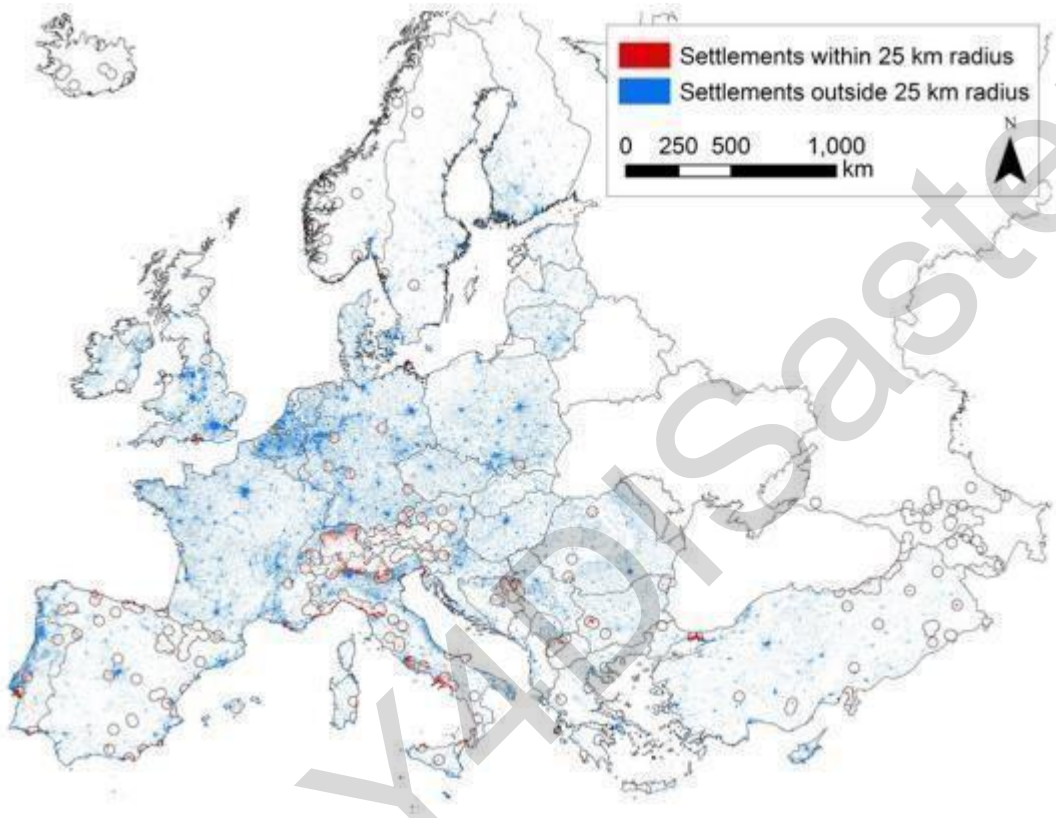

Figure 3.5. Map of settlements potentially at risk of fatal landslides [6].

✔ Determination of Landslide-Exposed Areas and Landslide Risks:

Landslides occur on sloping slopes, usually in areas with a poor soil structure, and in areas with a high rate of precipitation. For this reason, factors such as geographical data, ground structure and vegetation are taken into consideration while determining areas exposed to landslides.

✔ Evaluation of Landslide Losses and Identification of Hazards:

The extent and effect of losses caused by landslides is evaluated. These assessments may include loss of or damage to the infrastructure, housing, access roads and other structural features. Environmental effects are also taken into account. At this stage,

information about future risks is obtained by determining the relationship between the extent of the current damage and potential hazards.

Identifying areas exposed to landslides and potential hazards is a vital step to mitigate the effects of disasters and ensure the safety of the society. This process is supported by scientific data and expert opinions and forms the basis of a sustainable disaster management strategy.

3.1.3 Landslide Maps and Monitoring Systems

Landslide maps and monitoring systems are tools used to identify and monitor landslide risks. Thanks to the developing technology, mapping systems can be obtained more easily and conveniently by using monitoring systems day by day.

- ✔ Landslide Maps: Landslide maps are used to determine the landslide hazard. They are created according to factors such as geological and hydrological ratios, slopes, soil types, and amounts of precipitation and these maps also show landslide risk areas. These maps are used in fields including, but not limited to construction, infrastructural structure and emergency management [7].

- ✔ Monitoring Systems: Landslide monitoring systems are used to continuously monitor existing landslides and to identify potential hazards. These systems monitor factors such as humidity, slopes, groundwater levels and earthquake details. Sensors, observation stations, and remote sensing systems provide data for monitoring landslide movements and for early warning systems.

- ✔ Remote Sensing: Remote sensing systems are widely used in landslide monitoring and mapping studies. Satellite recordings, aerial photographs and data received from Copernicus as shown in Fig. 3.6. are used to monitor landslide movements and to detect landslides. These Landslides understanding techniques as shown in Fig. 3.6 offer an effective tool for mapping and mitigating landslide hazards in large areas.

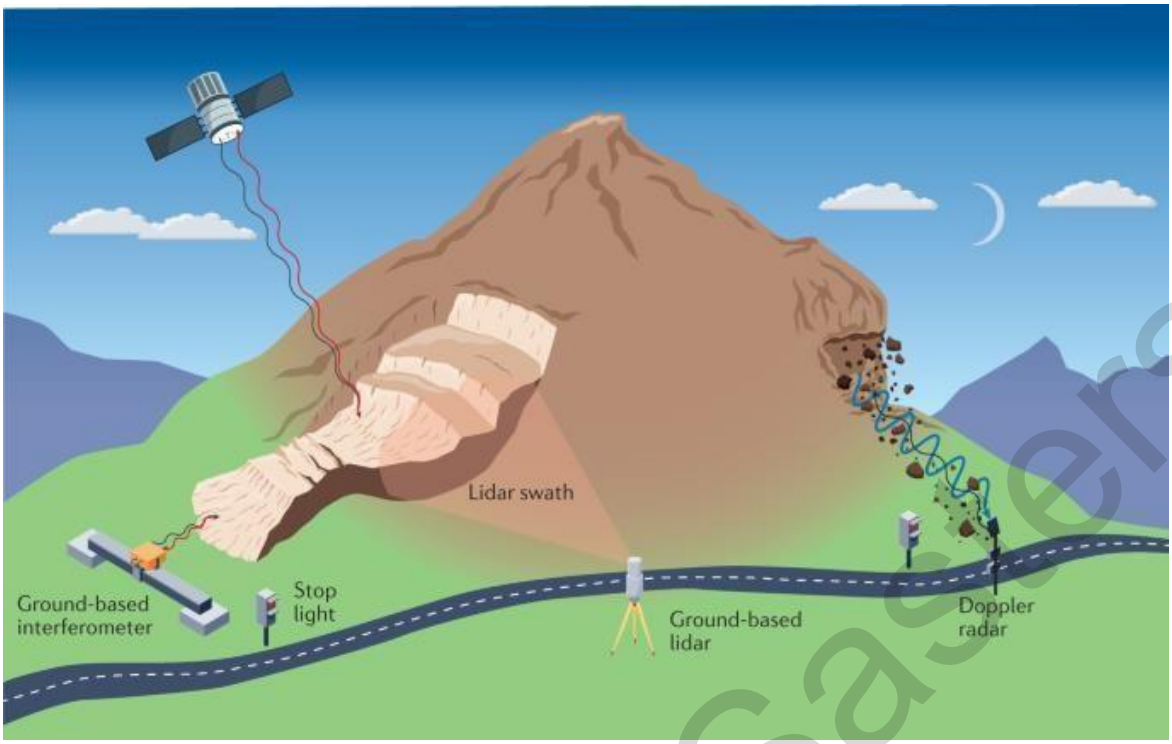

Figure 3.6. Remote sensing and ground systems are created together to digitally detect landslides or ground movements affecting the settlement and can be integrated into warning systems to enable the evacuation of people living in the area [9].

Use of Copernicus

Copernicus, also known as the Copernicus Sentinel missions, is a European Union Earth observation program that provides a wide range of information and data in relation to environmental monitoring systems.

The Copernicus program includes a constellation of Earth-observing satellites known as the Sentinel satellites that capture various types of data such as imagery, radar, and atmospheric measurements. These satellites are equipped with advanced sensors and instruments that monitor different aspects of the Earth's environment, including land, oceans, atmosphere, and climate.

The data collected by the Copernicus satellites are freely available to the public, scientists, policymakers, and businesses. This open data policy encourages innovation and the development of applications in various fields such as agriculture, forestry, urban planning, disaster management, and climate research.

Information provided by Copernicus improves people's safety, e.g. by providing information on natural disasters such as landslides, forest fires or floods, and thus help to prevent the loss of life and property, and damage to the environment.

The Copernicus Sentinel missions play a significant role in understanding landslide hazards by providing valuable data for monitoring, early warning, and post-event assessment. These satellites offer the tools necessary to detect and assess potential landslide-prone areas, helping to mitigate the impacts of these destructive natural events [8].

3.1.4 Development of evacuation plans

Evacuation plans are drawn up to move people in the emergency area safely from the incident location to the previously determined safe evacuation area. Things to consider when making an evacuation plan are listed below.

- ✔ The possibility that further disasters might be triggered by landslide disasters and that rescue and evacuation efforts may be affected by such a disaster needs to be reviewed.
- ✔ It is necessary to determine the emergency assembly area and temporary settlements agreed upon before the disaster.
- ✔ The training of people who can assist the rescue personnel by drills (exercise or planned study) before a disaster will shorten the evacuation time during the disaster.
- ✔ Landslide-prone areas must be determined and settlement and residence restrictions must be imposed across these areas.

Figure 3.7. To be prepared for all emergencies after landslide disasters.

3.1.5 Understanding warning systems and alerts

The Oxford Learner's English Dictionary defines an "early-warning" as "*a thing that tells you in advance that something serious or dangerous is going to happen*". First used in the military, the term "early warning system" is "*a condition, system, or series of procedures indicating a potential development or impending problem*", or "*any series of steps established to spot potential problems*" [10].

Landslide warning systems are used to inform people about possible landslide hazards. These systems monitor landslide risks by employing weather forecasts, soil moisture measurements and other data.

It is important to understand alerts and react properly. When landslide warnings arrive, it is important to immediately go to a safe place, leave the house, or follow the instructions given by the authorities. Areas that may be dangerous in terms of landslides can be detected with satellite images.

Landslide areas can be observed and information SMS can be sent to the people of the region about any landslide danger that may occur through base stations located in the region.

In the event that the SMS system has a notification problem or becomes ineffective, efforts to provide notification by announcement by connecting the local announcement systems with the central control continue with pilot applications. (Ground movements with the map system followed instantly digitally via the Copernicus system, LEWSs, etc)

✔ Copernicus EMS Early Warning and Monitoring:

Offers critical geospatial information at European and global level through continuous observations and forecasts for floods, droughts and forest fires.

✔ Landslide early warning systems (LEWSs):

are specialized setups designed to detect signs of potential landslides and issue advance alerts.

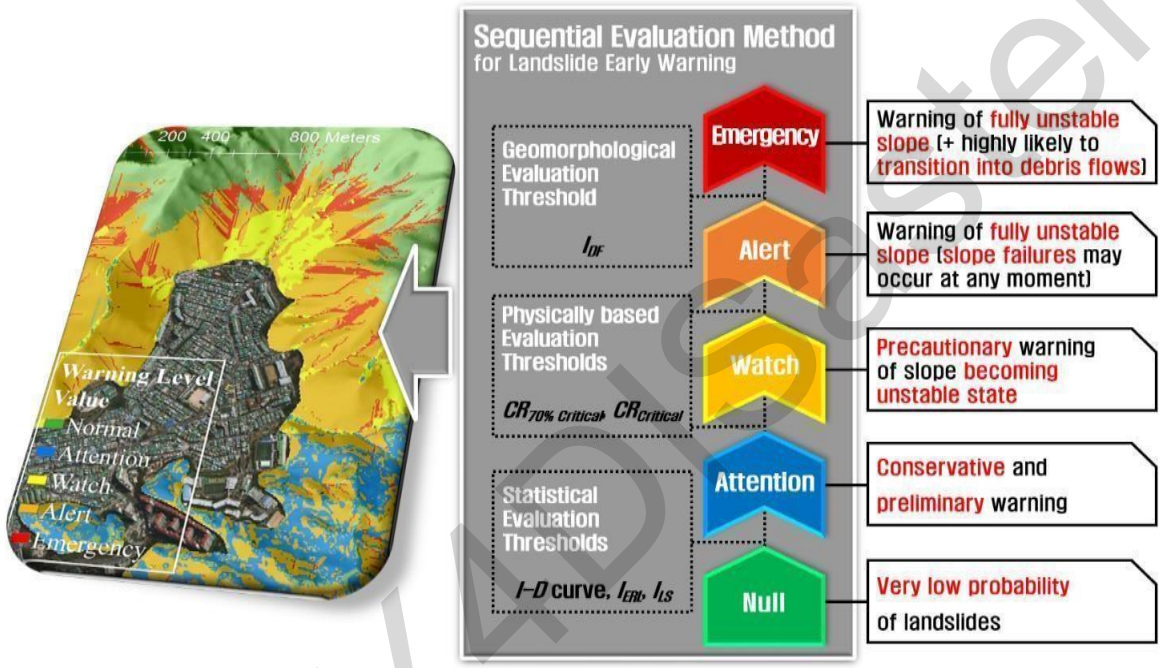

Figure 3.8. Evaluation method for landslides [11].

3.2 Post-Landslide Recovery and Restoration

Landslides among natural disasters are events that cause serious effects, and the ensuing recovery and restoration process is complex and demanding effort. At this stage, factors such as communication, data collection, leadership and rapid field assessment are of great importance.

✔ Communication Tools and Skills:

Effective communication tools and skills are vital in the post-landslide recovery process. Communication channels should be established in order to work in cooperation, to ensure the flow of information and to initiate the information process. Effective communications between teams play a critical role in identifying needs and directing resources efficiently.

✔ Data Collection Tools and Techniques:

Collecting the right data for needs assessments is essential for an effective planning and resource allocation. Reliable data should be collected through techniques such as field surveys, surveys, geological and geotechnical analyses. This data helps gain a better understanding of damage rating, risk levels and priorities.

✔ Leadership and Teamwork:

The post-landslide process requires strong leadership and teamwork. Leaders play a critical role in dealing with uncertainty, directing resources and keeping motivation high. The coordination of team members, assignment of clear roles and encouragement of everyone's participation is important.

✔ Rapid Area Assessment:

A post-landslide rapid area assessment is essential to quickly understand the extent of damage and urgency. This assessment is the first step to guide recovery efforts. Teams must locate damaged areas, identify emergency needs, and determine needs for immediate responses.

The post-landslide recovery and restoration process is complex but can be successfully navigated with effective communication, accurate data collection, sound leadership and rapid area assessment. Combining these factors helps communities recover faster and be better prepared for future events.

3.2.1 Evaluation of Landslide Losses

Landslides among natural disasters pose a significant risk in terms of the loss of life and property. It is therefore important to evaluate landslide losses. An assessment of landslide losses is a complex issue that requires a multidisciplinary approach among experts. It is important to bring together the knowledge of engineering, geology, geography, meteorology and other relevant disciplines. In addition, it is a dynamic process in which knowledge and experience are constantly updated with new research and technological developments.

Landslide losses are evaluated under the following headings:

- ✔ It is the set of processes in which the landslide area covered by the disaster is determined as a result of the field scanning of the expert personnel as well as the data received by means of remote imaging systems and the Geographic Information System (GIS) (Fig. 3.9).
- ✔ Structural Evaluation: Structures and infrastructure elements found on areas exposed to landslides are reviewed in terms of the extent of damage, integrity, stability and safety. It is the process in which issues such as how strong buildings are and how they can be strengthened are analyzed.
- ✔ Economic Evaluation: Economic consequences of losses caused by landslides. Loss costs are determined by taking into account the value of the lost property and other economic factors.

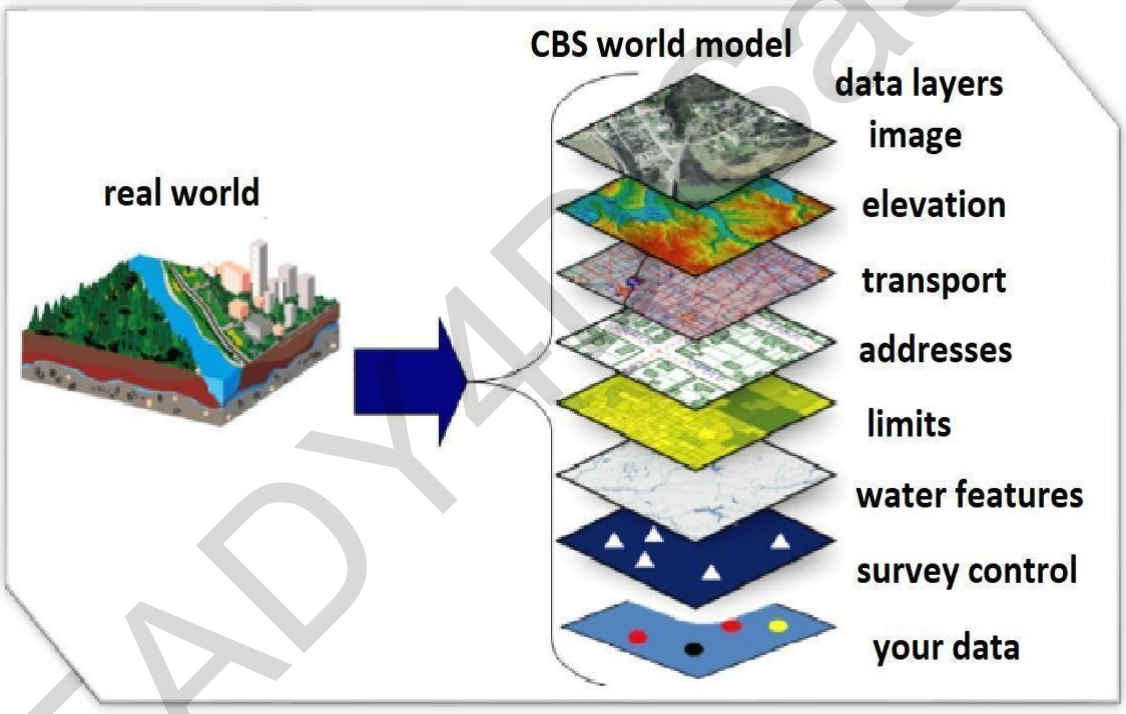

Figure 3.9. GIS systems [12].

3.2.2 Identifying urgent needs

Identifying urgent needs during a landslide disaster is one of the main issues that should be included in a pre-disaster planning process.

Points to be considered during the recovery process, which begins with the evacuation to a safe area after a landslide disaster, are listed below.

- ✔ By determining boundaries of the area affected by the landslide, the purpose is to ensure the prompt provision of assistance.
- ✔ Determining the number of injured people during a landslide and rescuing them is one of the most important information needed to request an ambulance.
- ✔ With the start of the recovery process, the determination of the number of people affected by the disaster is necessary for the installation of tents or containers for sheltering needs.
- ✔ Knowing the number of citizens affected by the disaster is important for confirming shelter requirements and dispatching resources to the region.

3.2.3 Working with emergency services and other organizations

Working with emergency services and other organizations in the context of landslide disasters involves coordinated efforts to prepare for, respond to, and recover from landslides. Landslides are natural disasters that can have devastating consequences, so collaboration between various entities is crucial to mitigate related effects. Here's an explanation with examples:

Preparedness:

Early Warning Systems: Collaboration between meteorological agencies, geologists, and emergency services can lead to the development of early warning systems that can provide alerts to the public about impending landslides. For example, the Japan Meteorological Agency works with local governments in Japan to issue landslide warnings based on rainfall and ground conditions.

Community Education: Local governments, NGOs, and emergency services can work together to educate communities in landslide-prone areas about risks as well as to train them about how to be prepared for disasters. This can include conducting drills and distributing educational materials. For instance, the Federal Emergency Management Agency (FEMA) in the United States provides guidelines and resources for landslide preparedness, which local emergency services can use to educate their communities.

Response:

Search and Rescue Operations: During a landslide event, emergency services like fire departments, law enforcement agencies, and specialized search and rescue teams collaborate

to rescue trapped individuals. For example, various local and state agencies worked together to search for survivors and provide immediate medical assistance after the 2014 Oso landslide in the state of Washington [13].

Shelter and Evacuation: Organizations such as the American Red Cross often work with local governments to set up emergency shelters for displaced residents. They coordinate with emergency services to ensure safe evacuations. A similar approach was taken during the Sierra Leone mudslide in 2017 when the Red Cross provided shelter and relief to the affected population [14].

Figure 3.10. Sierra Leone mudslide [14].

The Red Crescent is a humanitarian organization that responds to various disasters and crises. It assists in natural disasters like earthquakes, landslides, floods, and wildfires, as well as man-made disasters such as conflicts and pandemics. They provide medical care, relief supplies, and support to affected communities. The organization also works on disaster preparedness and community resilience. Their actions are guided by humanitarian principles, including impartiality and neutrality, ensuring help reaches those in need.

Recovery:

Infrastructure Rehabilitation: Collaboration between local governments, engineering firms, and federal agencies is essential to restore critical infrastructures like roads, bridges, and utilities after a landslide. Repairs constitute a critical part of the recovery process, as seen in the rehabilitation of the California State Route 1 after a landslide in 2017 [15].

Psychosocial Support: Mental health organizations and local health services can collaborate to provide psychosocial support to survivors. For instance, mental health professionals worked with local authorities to provide counselling to affected individuals in the aftermath of the 2014 landslide in Hiroshima, Japan.

Data Sharing and Research:

Geologists, meteorologists, and emergency services can collaborate in the collection and analysis of data related to landslides. This data can be used to improve forecasting and response strategies. For example, the US Geological Survey (USGS) collects data on landslides to better understand their causes and impacts, which is essential for informed decision-making by emergency services and local authorities [16].

In summary, working with emergency services and other organizations in the context of landslides disasters involves a multi-faceted approach that spans preparedness, response, and recovery phases. Effective collaboration among various entities can save lives, reduce damage, and expedite the recovery process when landslides occur (An example for cooperation Figure 3.11).

Figure 3.11. Cooperation among official institutions and non-governmental organizations at AFAD Disaster Management Centre during the event of a disaster (AFAD 2021).

3.2.4 Managing volunteers and resources:

Properly trained volunteers are more effective in disaster situations. They need to understand safety protocols, communications, and specific tasks they will perform.

Developing and managing volunteers is not only about raising the moral of victims, but also about creating a motivated and skilled workforce that can effectively contribute to disaster responses and community services. This involves careful planning, comprehensive training, and ongoing support. By focusing on recruitment, training, motivation, supervision, and retention, volunteer programs can ensure that volunteers are assets rather than liabilities during times of need.

Organizations such as the International Federation of Red Cross and Red Crescent Societies (IFRC), Emergency Response Coordination Centre (ERCC), The Points of Light Foundation & Volunteer Centre National Network, Federal Emergency Management Agency (FEMA), United Parcel Service (UPS), Corporation for National and Community Service, and HM Government all play various roles in managing volunteers and resources during times of emergencies, disasters, and community service initiatives.

The International Federation of Red Cross and Red Crescent Societies (IFRC):

The International Federation of Red Cross and Red Crescent Societies (IFRC) is the world's largest humanitarian network. Our general secretariat supports local Red Cross and Red Crescent action in more than 191 countries, bringing together more than 16 million volunteers for the good of humanity [17].

Emergency Response Coordination Centre(ERCC):

To enhance preparedness for and response to disasters at the EU level, there is a 24/7 ERCC managed by the Commission in Brussels. The ERCC is a coordination hub and the operational arm of the mechanism [18].

- ✔ The common emergency communication and information system, an IT tool allowing for immediate emergency communication among the participating countries;
- ✔ Exercises and a training programme to improve Member States' disaster response capacity and coordination of civil protection assistance;

✔ Civil protection modules, which are units of personnel and equipment that are ready to be mobilized;

✔ The European civil protection pool, which is a voluntary pool of pre-committed Member States' disaster response resources, ready to be mobilized for EU civil protection operations. This includes high-quality modules of relief teams, experts and equipment, and higher rates of EU co-financing.

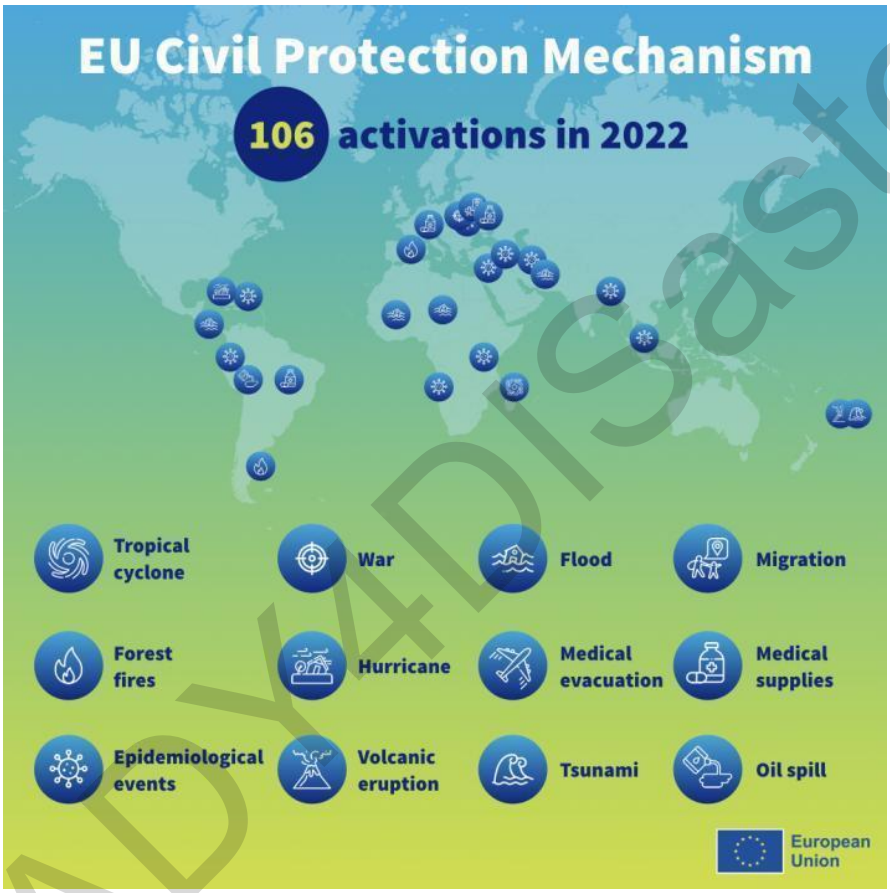

Figure 3.12. EU Civil Protection Mechanism of activities on worldwide [19].

Federal Emergency Management Agency (FEMA):

✔ Managing volunteers and resources with FEMA (Federal Emergency Management Agency) involves coordinating efforts to respond to and recover from disasters and emergencies. FEMA plays a critical role in disaster management in the United States [20].

✔ Developing by FEMA, The Emergency Management Baseline Assessment Grant Program (EMBAG) supports national level standards related to emergency management program accreditation or professional certification that have also been

accredited by a national level accreditation body for standards, like the American National Standards Institute (ANSI) [21].

- ✔ The EMBAG program office uses the EMBAG Logic Model to visually describe the intervention for the EMBAG program and how inputs of grant funding are used to achieve the short, mid, and long-term outcomes targeted by the grant through activities and outputs.

3.2.5 Planning for future disasters

This topic delves into the intricacies of planning for future landslide disasters, exploring key components essential for effective mitigation, preparedness, response, and recovery. The framework encompasses Risk Assessment, Preparedness and Mitigation, Early Warning Systems, Coordination and Response, and International Cooperation. Rigorous risk assessments involving geological and geotechnical analyses form the foundation, identifying landslide-prone areas. Preparedness and mitigation strategies, including land use planning and zoning regulations, contribute to the community resilience. Early warning systems provide timely alerts, facilitating a prompt evacuation. Coordination and response efforts are crucial, emphasizing the infrastructure planning, public awareness campaigns, and comprehensive emergency response plans. Additionally, international cooperation enhances the collective ability to address the global challenge of landslides. Post-disaster recovery and rehabilitation efforts focus on a sustainable development. Government policies and regulations are integral, fostering responsible land use practices and infrastructure constructions that consider landslide risks. This comprehensive and collaborative approach involves government agencies, scientists, engineers, and local communities to effectively plan and mitigate the impact of future landslide disasters. Below are disaster organizations engaged in facilities for a variety of purposes all around the world:

Risk Assessment:

- ✔ United Nations of Office for Disasters Risk Reduction (UNDRR):

  UNDRR assists countries in conducting comprehensive risk assessments by analyzing potential hazards, vulnerabilities, and exposures. This involves identifying areas prone to specific types of disasters and evaluating the potential impact on communities and infrastructure [22].

✔ World Health Organization (WHO):

WHO assesses health risks associated with disasters by evaluating factors such as the potential spread of diseases, healthcare infrastructure vulnerabilities, and the availability of medical supplies. This information guides the development of health-specific disaster risk reduction strategies [23].

✔ FEMA:

FEMA conducts hazard assessments and uses tools like the National Risk Index to identify vulnerabilities and assess the potential impact of various disasters. This information guides planning and resource allocation [20].

Preparedness and Mitigation:

✔ United Nations of Office for Disasters Risk Reduction (UNDRR):

UNDRR supports the development of national and local disaster risk reduction plans. These plans include strategies for preparedness, such as training and capacity building, and mitigation measures as well as precautions taken for the construction of resilient infrastructural facilities and for the land-use planning [22].

✔ World Health Organization (WHO):

WHO assists countries in building resilient health systems capable of responding to emergencies. This includes stockpiling medical supplies, training healthcare workers for emergency responses, and developing contingency plans for disease outbreaks and other health-related crises [23].

✔ Federal Emergency Management Agency (FEMA):

FEMA's approach emphasizes preparedness through a range of initiatives, including community and individual preparedness programs, training, and public awareness campaigns. Mitigation efforts involve supporting initiatives to reduce the impact of disasters through building codes, floodplain management, and risk-reduction grants [20].

Early Warning Systems:

✔ International Federation of Red Cross and Red Crescent Societies (IFRC):

IFRC engages in community-based early warning initiatives, ensuring that local communities are actively involved in monitoring and responding to potential threats. This may include training community members to recognize early signs of disasters and coordinating with national and international agencies for timely alerts [17].

✔ United Nations International Strategy for Disaster Reduction (UNISDR):

Early Warning Systems: UNISDR promotes the integration of technology and community engagement into early warning systems. This involves leveraging advances in communication technologies to disseminate timely and accurate information to at-risk populations, coupled with community-based training on response procedures [22].

✔ Federal Emergency Management Agency (FEMA):

In the U.S., FEMA works with various agencies to establish and maintain early warning systems, such as the Integrated Public Alert and Warning System (IPAWS), to disseminate emergency alerts and warnings to the public [20].

Coordination and Response:

✔ International Federation of Red Cross and Red Crescent Societies (IFRC):

IFRC coordinates the deployment of emergency response teams and resources during disasters. They work closely with national societies, governments, and other humanitarian organizations to ensure a harmonized and efficient response to the immediate needs of affected populations [17].

✔ United Nations Office for the Coordination of Humanitarian Affairs (OCHA):

OCHA plays a central role in coordinating humanitarian responses to disasters. This involves establishing clear lines of communication, mobilizing resources, and ensuring that different humanitarian actors work together seamlessly to address the diverse needs of affected populations [24].

✔ Federal Emergency Management Agency (FEMA):

FEMA plays a central role in coordinating disaster response at the federal level in the U.S. It works with state and local agencies to ensure resources, personnel, and funding are available for an effective response. FEMA also provides training and exercises for emergency responders [20].

International Cooperation:

- ✔ United Nations International Strategy for Disaster Reduction (UNISDR):

  UNISDR facilitates international cooperation by organizing conferences, workshops, and initiatives that bring together governments, organizations, and experts to share knowledge and best practices for the reduction of disaster risks. This collaboration aims to strengthen global resilience and response capabilities [22].

- ✔ United Nations Office for the Coordination of Humanitarian Affairs (OCHA):

  OCHA fosters international cooperation by mobilizing financial and logistical support from donor countries and organizations. This collaboration enables a rapid and effective international response to large-scale disasters that may overwhelm the capacities of individual countries [24].

- ✔ Federal Emergency Management Agency (FEMA):

  While FEMA's primary focus is on the United States, it also cooperates with international organizations and agencies to share knowledge and expertise regarding the disaster management [20].

These organizations collectively contribute to a comprehensive and integrated approach to the disaster management, addressing the spectrum from the risk assessment and preparedness to the early warning, coordination, and international cooperation. Their efforts aim to enhance the global resilience whilst reducing the disaster risk.

In summary, the planning for future disasters involves conducting thorough risk assessments, enhancing preparedness and mitigation efforts, establishing early warning systems, coordinating responses at various governmental levels, and fostering international cooperation. The goal is to minimize the impact of disasters, protect the safety of life and property, and facilitate a swift and effective response when crises occur.

3.2.6 Shelter and Settlement

"Shelter and Settlement" after landslide disasters refer to the critical aspects of providing housing, accommodation and infrastructural facilities for individuals and communities affected by landslides. Landslides can cause significant destruction to homes, roads, and other essential infrastructural facilities, rendering people homeless and in need of safe and stable shelters. Managing shelter and settlement needs after a landslide disaster is a crucial component of disaster responses and recovery efforts.

Here are key aspects to consider:

Emergency Shelter:

Immediate relief efforts often involve providing emergency shelters to those displaced by landslides. This may include setting up temporary shelters such as tents, makeshift camps, or public buildings that remain structurally sound. Fig. 3.13 shows simple and emergency shelter centres across the Emergency Shelter Sites. The goal is to ensure that affected individuals have a safe and dry place to sleep as well as a protection area, and gain access to basic amenities like clean water, sanitation facilities, and food.

Figure 3.13. An example of a tent city prepared by AFAD. Establishing a tent city is one of the fastest and easiest solutions in cases where rapid sheltering is required after landslides and all other disasters.

Assessing Loss of or Damage to Houses:

After a landslide event, authorities and relief agencies assess the extent of damage to houses. This involves the evaluation of the safety of existing structures and identification of homes that are uninhabitable due to the damage or the risk of further landslides.

Temporary Housing Solutions:

For those whose homes have been severely damaged or destroyed, temporary housing solutions are needed. This can involve providing prefabricated shelters (Fig. 3.14), portable housing units, or arrangements in unaffected or less affected areas.

These temporary solutions should be equipped with basic amenities and be designed to meet specific needs of the affected population where factors like climate, cultural considerations, and accessibility are also regarded.

Figure 3.14. An example of a container city prepared by AFAD. In the event of an extended use of shelter sites after landslides and all other disasters and a variety of different seasonal challenges, the construction of new container cities is the best solution for meeting sheltering needs of disaster victims.

Long-Term Settlement Planning:

A crucial aspect of recovery is planning for long-term settlements. This involves rebuilding homes and communities in a way that reduces the risk of future landslides.

Considerations include assessing the geological and environmental factors that lead to the landslide, implementing land-use planning regulations, and promoting sustainable construction practices.

Figure 3.15. An example of a permanent housing project constructed by AFAD. The reconstruction process starts after the local authorities decide to relocate the area subjected to landslide disaster to the same area or to change this area as a result of technical assessments. After risks associated with the new area for settlement are eliminated, the recovery process is completed with the construction of buildings and the relocation of victims.

Infrastructure Rehabilitation:

Landslides can damage critical infrastructure such as roads, bridges, and utilities. Restoring these services is essential for the resumption of the normal life in affected areas. This includes repairing or rebuilding damaged infrastructural facilities to improve accessibility and connectivity.

Community Engagement:

Involving the affected community in the shelter and settlement planning process is vital. Their input can help ensure that housing and infrastructure projects are culturally appropriate and resilient and can meet their needs.

Engaging with local communities can also help in the identification of safe and suitable locations for new settlements.

Risk Reduction and Preparedness:

To minimize the impact of future landslide disasters, efforts should be made to implement risk reduction measures, such as slope stabilizations, early warning systems, and community training sessions for landslide preparedness.

Government and NGO Coordination:

Government agencies, non-governmental organizations (NGOs), volunteers, and international humanitarian agencies often collaborate to provide shelter and settlement support after landslide disasters. Coordination among these entities is essential to ensure an efficient response.

In summary, managing shelter and settlement needs after a landslide disaster is a complex and multifaceted process that requires a coordinated effort among various stakeholders. The aim is to provide immediate relief, ensure the safety of affected populations, and work towards a long-term recovery while mitigating future landslide risks.

3.3 Case study

3.3.1 Case Study 1: The Thredbo landslide case

The Thredbo landslide search and rescue was one of the biggest and most dangerous challenges ever faced by Australian emergency services [25]. This case study details the heroic efforts of the rescue team in the face of this disaster.

Case Summary:

The Thredbo landslide occurred on July 30, 1997, when a section of the Alpine Way Road collapsed, causing two ski lodges to slide down the mountain. Eighteen people were killed, and only one person, the ski instructor survived.

Assigned Services:

The rescue was undertaken by a host of emergency services, comprised of NSW Police, Ambulance and Fire Brigade, the Bush Fire Service, NSW Volunteer Rescue Association and State Emergency Service.

Managing Volunteers or Other NGOs:

By 4 August, 600 rescuers were working on the site, including up to 300 SES volunteers. There were also people from the Disaster Victim Identification unit, Australian Federal Police, Salvation Army officers, Red Cross workers, grief counsellors and chaplains.

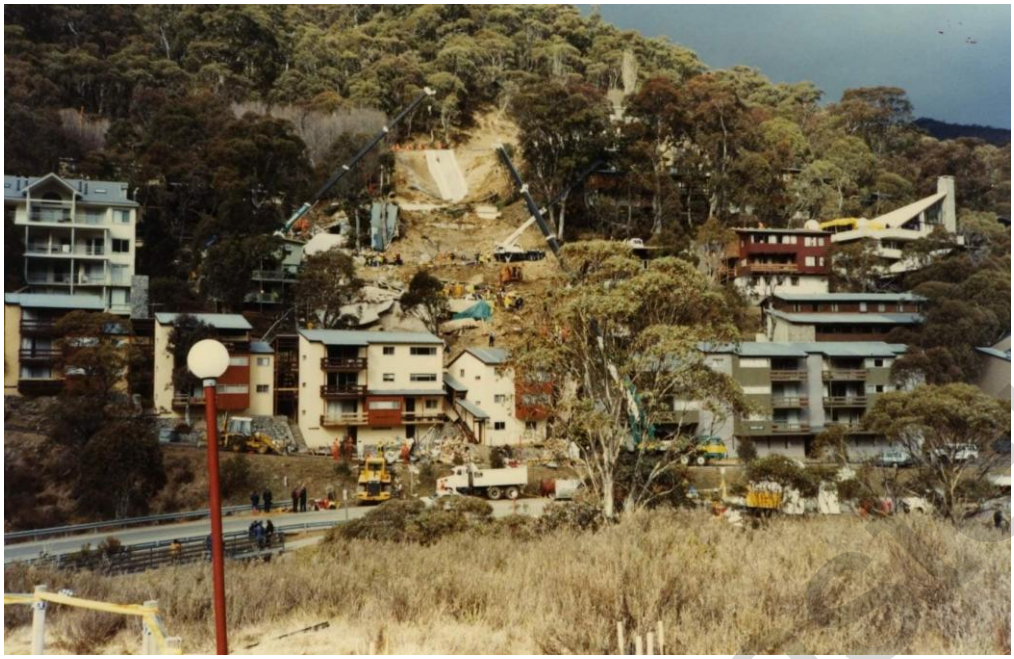

Figure 3.16. The Thredbo landslide landscape.

Teamwork and Collaboration:

The rescue team managed to find and rescue the sole survivor, ski instructor Stuart Diver, by cutting through a concrete slab and communicating with him. Specialized rescue experts trained in retrieving people from caves and confined spaces were called to Thredbo, but they were not directly involved in Diver's rescue. Instead, they were assigned to clearing debris and watching for movement in the rubble. The rescue operation was a massive undertaking, with rescuers working around the clock in shifts of four hours on, four off, and later eight hours on, eight off, and 10 hours on followed by a 16-hour break.

Search and Rescue Equipment:

People power worked hand in hand with an extensive range of apparatus provided for the rescue, including earthmoving equipment, Bobcats, 12- and 14-tons trucks, engineering equipment, blasting mats, compressors and lighting. Smaller items included thermal imaging cameras, hard hats and lamps, mobile phones, computers, and photocopiers.

Planning for Future Disasters:

The rescue operation was not without its challenges. The site was unstable, and there was a risk of further landslides. The weather was also a factor, with heavy rain and snow hampering the rescue efforts. The rescuers had to work in difficult conditions, with limited access to the

site and the constant risk of injury or death. Despite these challenges, the rescue team never gave up. They worked tirelessly to clear the rubble and search for survivors, even when the chances of finding anyone alive seemed slim.

Rain posed a significant threat to the rescue operation, as it could fill the network of tunnels that had been dug, making it impossible to find any survivors. To mitigate this risk, SES crews erected a "high-tech" tarpaulin across the site, allowing work to continue even in wintery weather.

Engineers also worked to stabilize nearby Schuss Lodge, which had its foundations undermined during the landslide. The fear was that if rain and snow arrived, the exposed soil could turn to mud, potentially causing a second landslide. The efforts to shore up the lodge were crucial in ensuring the safety of the ongoing rescue operations. The rescue team faced bitter wind and rain, which eventually arrived two days later, on August 6.

Shifts were reduced to prevent workers from suffering hypothermia. Despite the challenging weather conditions, the team persevered. By the end of the following day, Thredbo was covered in a blanket of snow that had also coincided with the removal of all other buried bodies.

Search and rescue:

Remarkably, the weather had held off for the entire search and rescue operation. The search and rescue operation came to an end with the recovery of the final victims, who were identified as being trapped in a specific area covered by concrete slabs.

Suggestions and Evaluation:

- ✔ The cooperation and importance of search and rescue officers, volunteers and NGOs in the Thredbo landslide events has been understood.
- ✔ It was understood that a disaster task sharing had to be carried out among local governments, rescue teams and non-governmental organizations prior to a landslide incident.
- ✔ The evaluation of landslide losses and identification of hazards is important in the post-disaster process. The extent and type of damage is used to guide recovery and repair efforts. The hazard identification is a critical step for better preparedness for

future disasters. At this stage, factors such as the safety of structures, infrastructural and environmental losses and impacts are evaluated.

3.3.2 Case study 2: The Yuvam Akarca Landslide Case

A landslide incident occurred at Yuvam Akarca Residences at Yakutlu Street in the District of İzmit in the Province of Kocaeli on April 13, 2023 (Fig. 3.17).

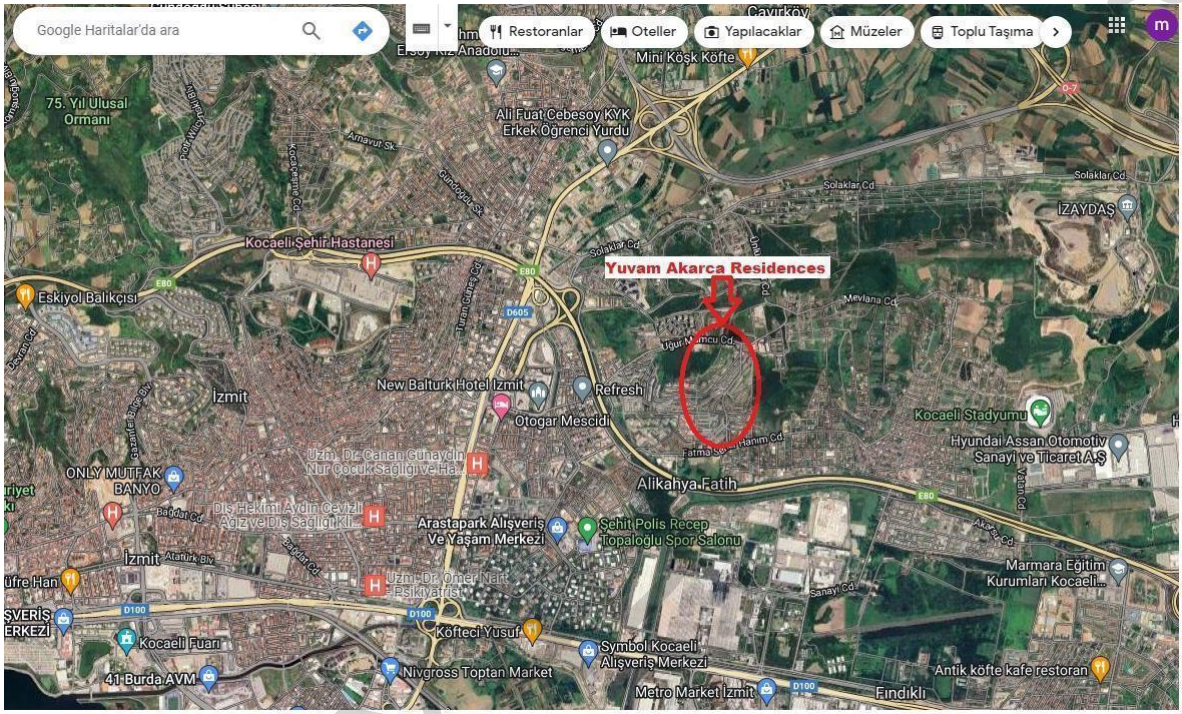

Figure 3.17. Examination area satellite image.

Case Summary:

The Landslide incident took place at Yuvam Akarca Residences located at Yakutlu Street in the District of Fevzi Çakmak. According to the information obtained, the retaining wall on the back of buildings collapsed after a heavy rainfall where the other buildings had also been affected during this incident (Fig. 3.18 and 3.19). Citizens, who were frightened by what suddenly happened, took to the streets in fear and reported the situation to the 112 Emergency Call Centre [26, 27].

Assigned Services:

112 Emergency, AFAD, Police Department, Fire and Municipal teams were dispatched to landslide area upon the Report.

Figure 3.18. Collapsed retaining wall and landslide (or mass movement.)

Figure 3.19. A room whose wall collapsed due to the landslide.

Teamwork and Collaboration:

The landslide area was checked by 112 Emergency teams for the injured; by the Fire Department for fire dangers and by AFAD for landslide dangers. After these surveys, security tapes were setup around the landslide site to allow no access until landslide precautions were to be taken.

Working with emergency services and other organizations:

After this incident, 4 apartment buildings damaged as a result of the collapse of the retaining wall were sealed by municipal teams.

Planning for Future Disasters:

24 flats of 3 apartments were damaged, thus these residential buildings were evacuated. The other apartment of 8 flats that was near the landslide area was evacuated for the purpose of preventive measures. It had decided to carry out a "Landslide prevention project" for the wall that collapsed due to the landslide that occurred on the retaining wall at Yuvam Akarca Residences at Yakutlu Street. Within the scope of this Project, precautions were taken against landslides by manufacturing 2039 meters (86 pieces) of double rows of Q120 cm diameter bored piles with lengths of 25 m and 23.50 m and 432.50 tons of ribbed reinforcements (Fig. 3.20).

Figure 3.20. Newly built retaining wall.

Shelter and Settlement:

Necessary arrangements were conducted to ensure the accommodation of landslide victims at social facilities of Kocaeli Metropolitan Municipality.

Search and Rescue:

On the other hand, a person residing on the ground floor, was injured when a pile of soil collapsed to the wall of his room. The person's life was not in danger, and he was taken to the hospital after first aid was given by the medical teams.

Suggestions and Evaluation:

- ✔ As a result of the incident that occurred at Yuvam Akarca Residences; it was observed that “Zoning Plans” were not complied with by the contractor in a region where a building zoning permit was granted, thus causing a landslide disaster.
- ✔ It was seen that the engineering service was incomplete during the construction of the retaining walls in question.

- ✔ It was understood that a disaster task sharing had to be carried out among local governments, rescue teams and non-governmental organizations prior to a landslide incident.

- ✔ After these precautions were taken against the landslide, citizens returned to their evacuated homes and life returned to normal. (Fig. 3.21)

Figure 3.21. Citizens returned to their evacuated homes and life returned to normal.

3.3.3 Case study 3: Examining Slope Instabilities in the Corinth Canal using UAV-Enabled Mapping

The study titled "Analysis of slope instabilities in the Corinth Canal using UAV-enabled mapping" focuses on analyzing the slope stability of the Corinth Canal using unmanned aerial vehicles (UAVs) for mapping purposes. The authors aim to assess the geological hazards and potential slope failure risks on the area. To achieve this, the researchers adopted a methodology that involved data acquisition using UAVs equipped with high-resolution cameras. They captured aerial images of the canal slopes, which were then processed to generate orthomosaics and digital elevation models (DEMs). The resulting data provided a detailed topographic representation of the canal slopes.

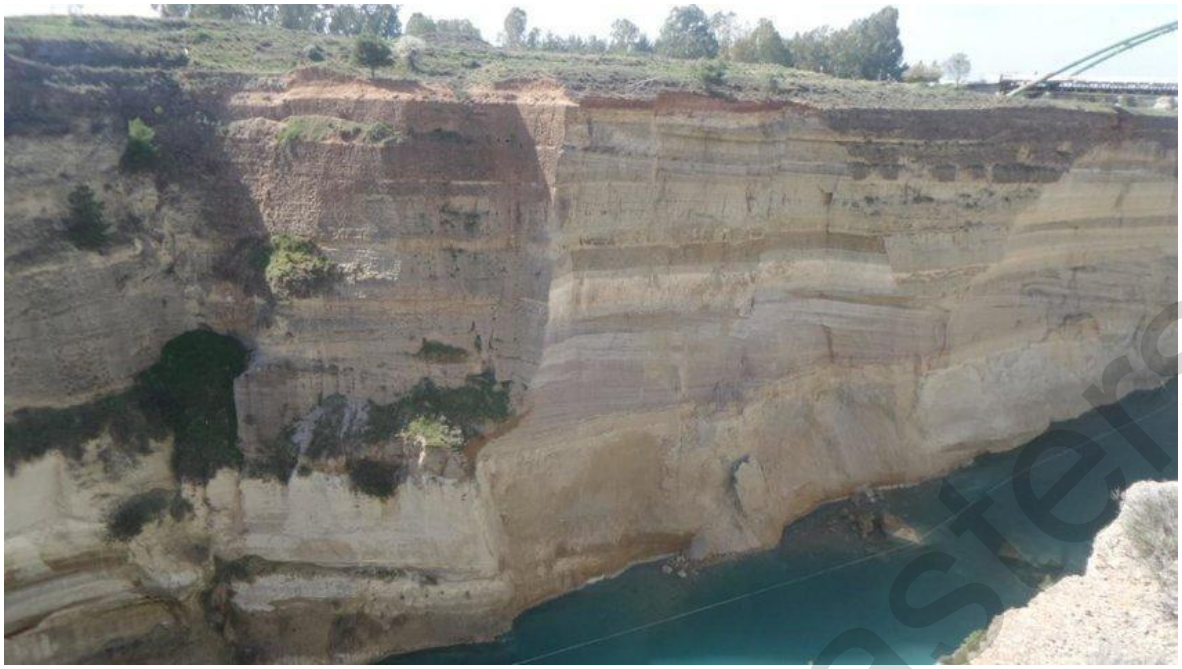

Figure 3.22. View of the slope failure which occurred on the south slope of the Corinth Canal on February 26, 2018.

In addition to the aerial survey, the researchers conducted in-situ field investigations, including geological mapping and geotechnical sampling studies to understand the subsurface conditions and bedrock properties. They also analyzed historical records of slope failures and documented their characteristics. By integrating the UAV-derived data, geological investigations, and historical records, the researchers were able to identify and characterize various slope instabilities along the canal. They classified the slope failures based on their size, mechanism, and location. The authors observed that the most common type of failure was planar sliding due to the jointed nature of the rock masses in the area.

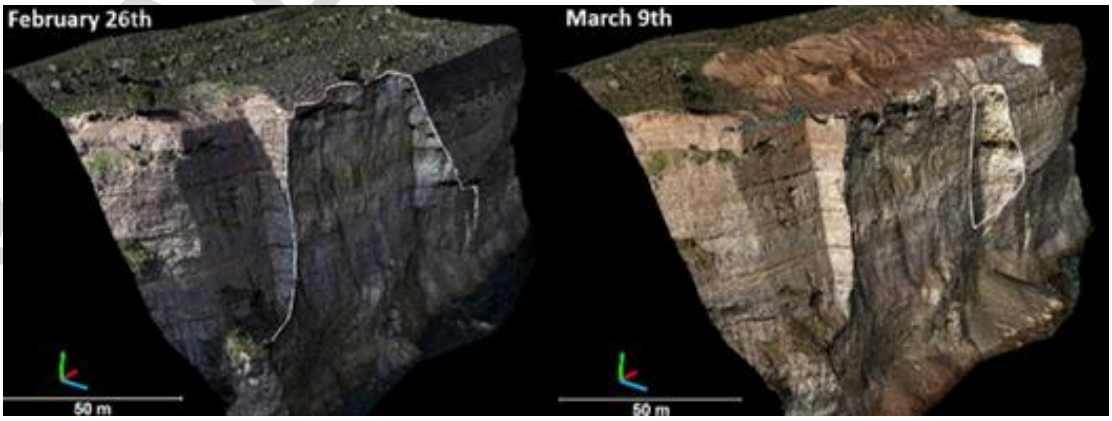

Figure 3.23. Pix4d presentation of the point cloud showing the slope failure in the Corinth Canal that took place on February 26 and March 9.

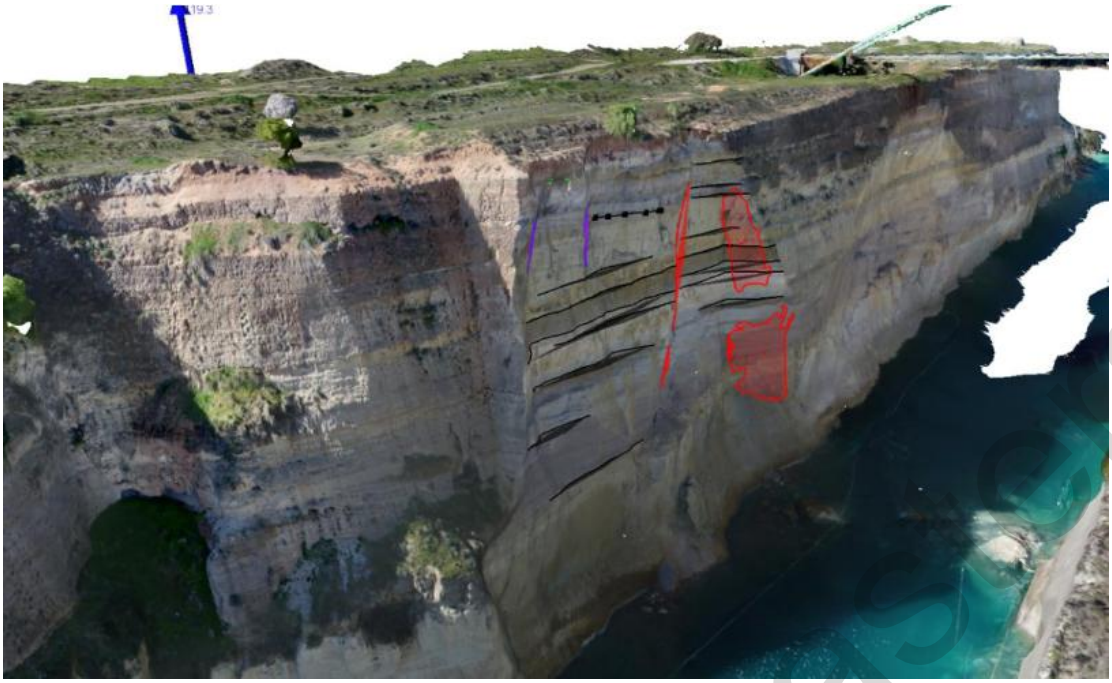

Figure 3.24. 3D model from ShapeMetriX UAV illustrating faults and main discontinuity surfaces controlling the slope failure that took place on February 26 (fault surfaces in red, joint surfaces in blue, bedding surfaces in black).

Furthermore, the study quantified the slope stability by analyzing the factor of safety using limit equilibrium methods. The researchers considered the shear strength parameters of the rock masses based on laboratory tests and previous studies. They compared the factor of safety values with the critical threshold and identified areas where the slopes were more susceptible to the failure. The results of the analysis indicated that certain sections of the canal slopes had lower factors of safety, suggesting a higher risk of slope failures. The authors proposed several recommendations to mitigate slope instability, such as implementing support measures like rock bolts and mesh, monitoring the slopes using geotechnical instruments, and periodic inspections of the canal walls.

Overall, the study provides valuable insight into the characterization and analysis of slope instabilities in the Corinth Canal using UAV-enabled mapping. The findings can contribute to better understanding and managing the geological hazards associated with the canal slopes, ultimately ensuring the safety and stability of this critical infrastructure.

3.3.4 A Landslide Case in Racha, Shovi on August 3, 2023

On August 3, at 3 pm, a landslide hit the popular mountain resort of Shovi in Georgia. In a few minutes, the entire disaster area, including the cottages where people rested, was buried under several meters of landslide mud. The flooded river carried away bridges, cars, huge trees.

The victims called the emergency services. Rescuers soon arrived on the scene, but the scale of the disaster made it difficult for them to work. A rescue helicopter arrived at the scene in the evening, three hours after the incident, and evacuated 210 people from the disaster zone overnight. More than 20 of them (according to media reports) were trapped in several meters of landslide mud and fought for their lives for almost three hours. They were saved thanks to the locals. 32 people died in the tragedy. On August 29, a military person was killed while performing rescue works in the natural disaster zone.

Figure 3.25. Landslide area in Shovi, the Racha region of Georgia.

Reasons of landslide

About 24 hours before the tragedy of Shovi, a video was published on the social network "Facebook" showing a sudden flood in the Gamruli riverbed in the village of Jinchvisi, near the disaster area. The residents also suggested that the water of the Bubi river had dried up two days before the tragedy and then moved towards the village.

According to the National Environmental Protection Agency report, the natural disaster developed "rapidly" and caused by the uniform collapse of the ice mass, what was 5 million m^3. Experts in the field note that at least 1 million m^3 of water is needed to move this amount of mass.

Figure 3.26. Photos showing Landslides in Shovi.

Survival Activities

On August 3, around 4.00 PM, the news spread that landslides had occurred in Racha, Shovi. The rescue operations started about 3 hours after receipt of emergency calls. On August 4, the army was involved in search and rescue operations.

According to a report of September 4, 2023, "Search operations have been ongoing in Shovi for more than a month. The rescuers are still unable to find two missing people. According to the latest data, a total of 31 bodies have been found, 29 have been identified. Two are undergoing a DNA research."

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