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GEORGIA DEVELOPMENT COOPERATION

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13 CLIMATE ACTION — 11 SUSTAINABLE CITIES AND COMMUNITIES — SUSTAINABLE DEVELOPMENT GOALS

METHODOLOGY FOR THE AREA ASSESSMENT IN TERMS OF DEBRIS FLOW HAZARD USING INNOVATIVE TECHNOLOGY

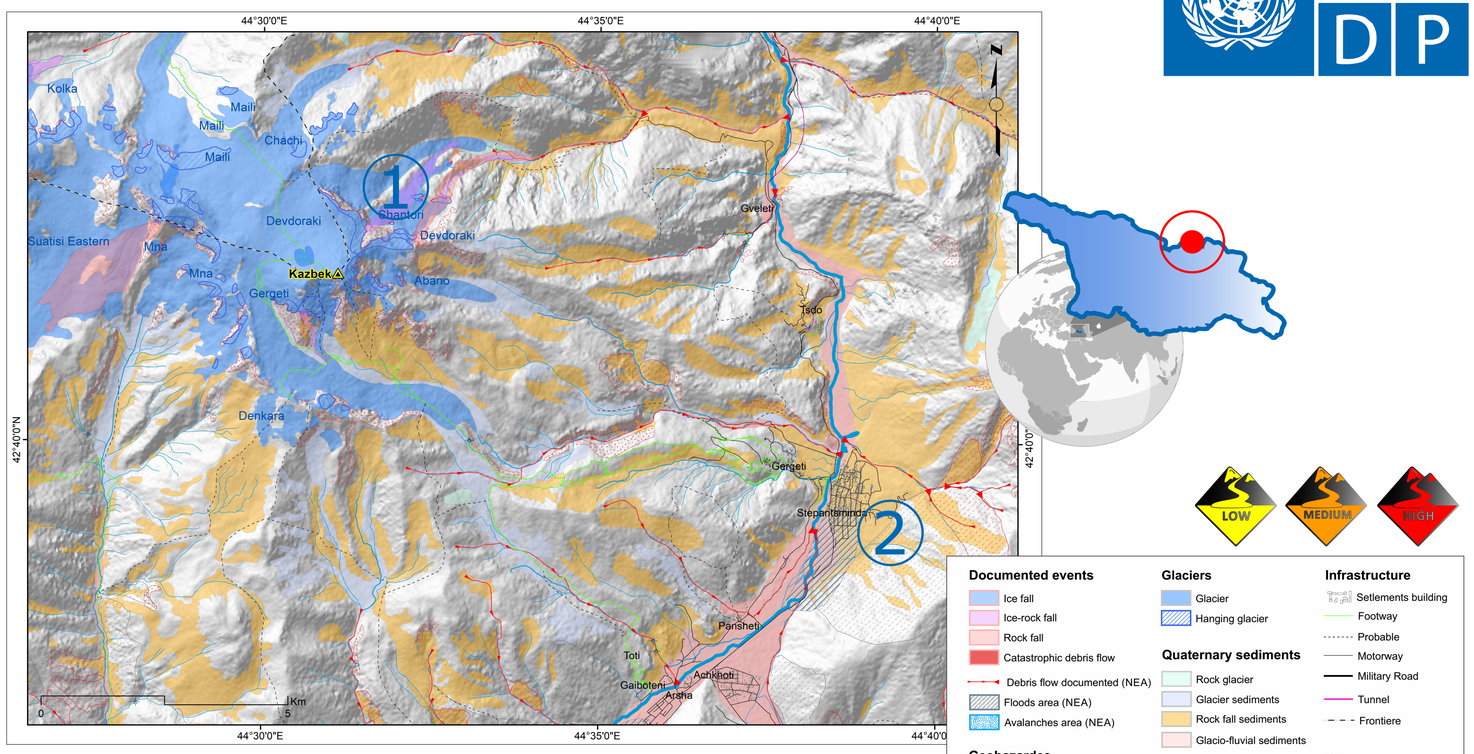
Abstract

Challenge Fund, within the Czech-UNDP Partnership (CUP) for Sustainable Development Goals between the Czech Development Agency and the United Nations Development Program has supported this project. The project brings expertise in the prevention of natural and geological hazards in the high mountain region of Kazbegi in northern Georgia.

The project will be conducted in cooperation between **Czech Geological Survey (CGS) and Georgian National Environmental Agency (NEA)** which is responsible for the monitoring, assessment and mapping of geological hazards in the country. The project is implemented by CGS experts in engineering geology together with experts in remote sensing.

The surroundings of Mount Kazbek are infamous for frequent catastrophic debris flows jeopardizing strategically important infrastructure. These geodynamic phenomena occur more frequently in some valleys and are triggered often by activity of glaciers (collapse of a hanging glacier, a glacier surge or the GLOF event) (Dostalík et al., 2020a). Based on historically recorded debris flow ranges and geomorphological conditions, individual valleys can be categorized in terms of hazard. The type of impending geodynamic phenomenon as well as the trigger can be determined very accurately and the approximate maximum range can be estimated (i.e. the endangered area can be defined). This can be used in urban planning to prevent inappropriate urbanization of vulnerable areas. For example, the infamous case of the Larsi hydroelectric power plant, which was damaged by debris flow in 2014. HPP Larsi (today nonfunctional) was built in the Dariali Gorge that was hit by debris flow several times in the past (Dostalík et al., 2020b).

Geodynamic natural processes are very difficult to prevent. However, it is possible to mitigate their consequences to avoid disasters and loss. This is mainly due to effective spatial planning with high-quality engineering and geological data. Georgia's traditional risk management system is rather reactive. It focuses on dealing with the consequences of natural disasters and involves considerable costs to rebuild. **The main idea of this project is not only to stimulate cooperation between the CGS and the Georgian NEA, but also to show a conceptual preventive approach to risk reduction. This will lead to improved spatial planning in the future. And preventing construction in vulnerable areas to reduce remediation costs.** This case study has the ambition to serve as a model for other alpine regions of Georgia, where these geodynamic phenomena also occur. For example, the area is Upper Svaneti (Dostalík, 2021). There is increasing the frequency and intensity of geodynamic processes due to climate change, as well as elsewhere.

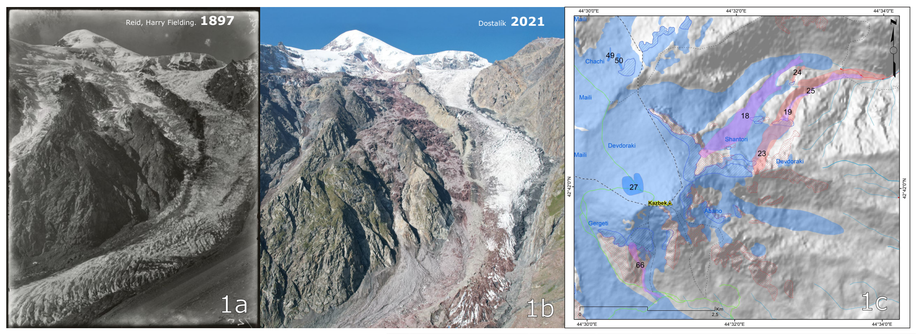


Excerpt from the map of geological hazards of the Kazbegi area (scale 1 : 50 000): This map is one of the outputs of the project and shows all the main types of geological hazards in this area. Hanging glaciers and rock walls prone to falling, sources of transportable material, previously documented debris flow trajectory, glacial lakes threatened by rupture, different types of slope deformations, flood and avalanche areas, etc.

① Devdoraki Glacier

The biggest threat in this region is the valley of the Devdoraki glacier. And that's why our first reconnaissance trip was right here. By analyzing the available satellite images (especially Sentinel 2), we registered all rock and glacial avalanches that were captured by satellite imagery. This layer is an important part of the geological hazard map, as it shows places with increased activity that need to be further monitored (Fig. 1c and Table 1). The area ranges of some landslides are shown in Fig. 1c. And numbers correspond to the numbers in the table below.

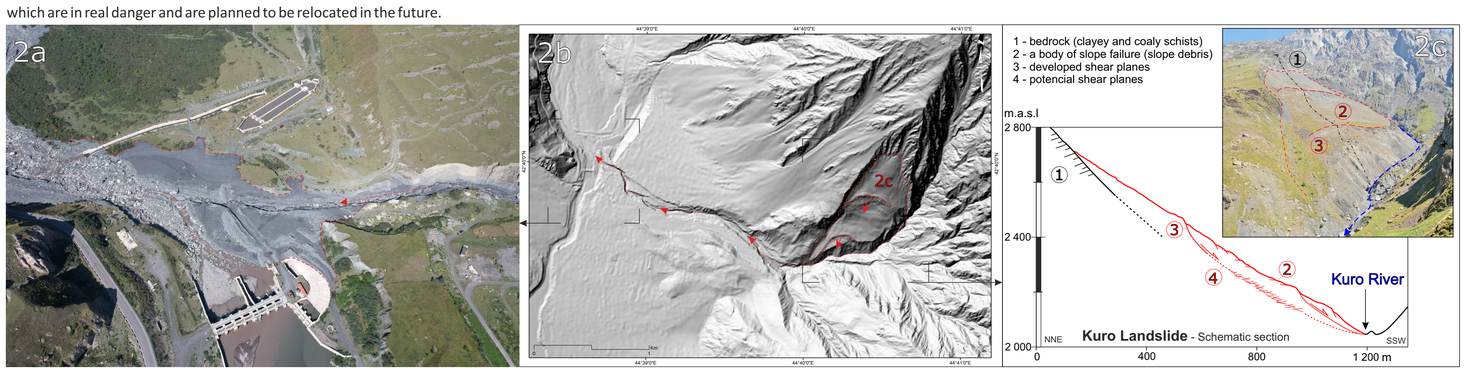
This relatively young volcanio rises is still covered with glaciers. After all, the official Georgian name of Mount Kazbek, in surroundings of which this project will take place, is Mqinvarc´veri, i.e. "glacier peak". Long glacial tongues descend into the valley, which are melting according to the global trend. However, by comparing the time series of satellite images, it was found that two of these valley glaciers show different dynamics than the others. The growth and forward movement of the glacier body called the "Glacier surge" is documented here. A comparison of the time series of satellite images of the Devdoraki Glacier can be seen at the link:
http://geologicalremotesensing.cz/flow2020/Devdoraki_14-19.mp4.



Documented events from Fig. 1c				
No.	year / period	affected area (km²)	length (km)	Type
18	2010	0,73	3	ice- rock fall
19	19.4 - 5.5 2013	0,75	3,8	rock fall
20	17.05.2014	3,7	10,9	kolaps ledovce / ledovcový - kamenitý přívalový proud
23	09.06.–16.06.2019	0,2	1,1	rock fall
24	3. 11. 2019 - 16. 11. 2019	0,018	0,4	rock fall
25	3. 2. 2021 - 29. 4.2021	0,125	1,8	ice- rock fall
26	2014 - still ongoing			glacier surge
27	31.08.2021	0,126	0,4	snow avalanch
66	1. 10. 2010 - 8. 11. 2011	0,088	1,26	ice- rock fall

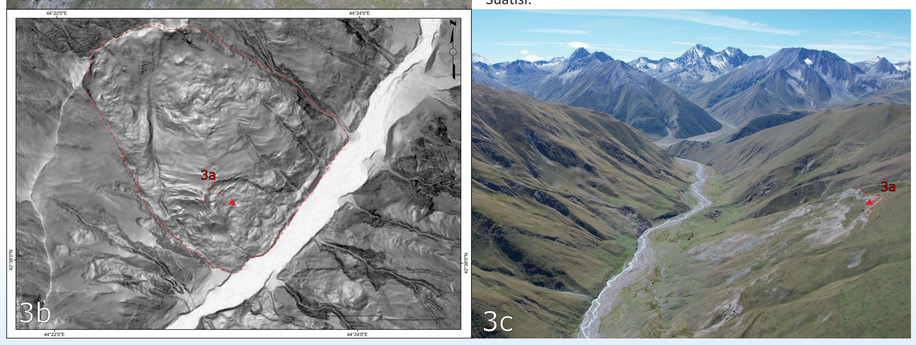
② Debris Flow on the Kuro River

The Kuro River is a tributary of the Terek River, which drains the entire territory towards Russia. The Dariali hydroelectric power plant was built at the confluence of these two rivers, despite the fact that this place is periodically affected by debris/mud flows. Figure 2a shows the accumulation of the last event of September 2021, which covered and damaged the HPP structure. The huge rock amphitheater of clayey and coaly schists is the source of a huge amount of material. It is regularly transported to the estuary in the form of debris / mud flow. The transported material is also sponsored by the active landslide of the debris cone on the left bank of the Kuro River. Which is continuously under-eroded and constantly contributes other clastic sediments to the river bed (Figs. 2b and 2c). Fig. 2b is a digital terrain model with a resolution of 5m/pixel. The Kuro riverbed is also crossed by two strategic large-capacity gas pipelines, which are in real danger and are planned to be relocated in the future.



③ Landslide in the Suatisi Glacier Valley

Deglaciation causes relaxation of the geological environment. The side slopes of the valley are destabilized and slope deformations develop. Here is an example of the Suatisidon river valley. On the right side of this valley, in a weakly metamorphic and heavily weathered shale, a complex deep landslide with active partial landslides has been developed. Figure 3a shows a detail of the 400 m wide scarp area of the partial active landslide at the foot of the slope. Figure 3b is a digital terrain model (slope view) with a resolution of 5m/pixel.The whole complex slope deformation is up to 2.5 km long with an elevation of 1000 m. Figure 3c is a side view of a 920 m long active landslide. In the background is the village of Suatisi.



Mapping of hanging glaciers

The key goal of the field expedition was to verify the condition and stability of the hanging glaciers on Mount Kazbek. Rock falls and the collapse of hanging glaciers are the main initial factors in the emergence of catastrophic debris flows not only here. Most of these historically recorded tragic events in the area were caused by the detachment of a mountain glacier. Including the tragedy of 2014, when a huge block of hanging glaciers and rocks collapsed. The ensuing debris flow blocked the Dariali Gorge and caused significant losses. The most active source areas of rock and glacier avalanches were also documented in detail during the field expedition using a drone (UAV).

The main objectives of the project

The aim of the project was to develop a harmonized methodology for assessing geological hazards. And implement it into the activities of the partner organization NEA within the prepared workshops and field trainings. An important part of the project was also the development and implementation of the map interactive tool Flow2020 into the activities of NEA. This interactive software application is used to evaluate and display the susceptibility of individual river basins to the activation of torrential currents. The FLOW2020 application is focused on visualisation of available spatial data and calculation of elemental morphological characteristics of the terrain based on the analysis of a digital relief model. This will help in the preparation and implementation of field work. Subsequently, these morphological characteristics enter into the final calculation of the hazard rate of individual river basins together with the parameters that the specialist enters into the application after the field survey. Risk categorization of individual valleys based on geological and geomorphological criteria is one of the goals of this project.

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