

Study of the Risks of Water Erosion Processes

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Abstract. For the purpose of studying the risks of water erosion processes, this paper presents the results of field, laboratory, and theoretical research. With the aim of implementation of the field research, five study sites (the villages of Melusheti, Kveda Chalovani, Mgvimevi, Zeda Chalovani, and Tkemlovana) were selected within the territory of Chiatura Municipality. To conduct a geological assessment of the soil/ground located on the mountain slopes, 5 samples were taken. These soil/ground samples were processed using the sieve analysis method at the Hydro-technical Laboratory of the Ts. Mirtskhulava Water Management Institute of Georgian Technical University. By analyzing the statistical series, the average diameter sizes of the soil/ground particles were determined, and integral granulometric curves were constructed for each sample. Using the Wischmeier Universal Soil Loss Equation (USLE), the erosion coefficient was determined for each of the five sites. Additionally, based on the scale of English professor Roy Morgan, the erosion class was established by considering the intensity of the mountain slope erosion processes, which varies between 3.21 and 45.0 tons/ha/year. Based on the theoretical calculations, taking into account GIS technologies, a digital erosion risk map was constructed for the territory of Chiatura Municipality, where the class of mountain slope erosion processes varies within the range of 2-4. © 2026 Bull. Georg. Natl. Acad. Sci.

Keywords: water erosion, Chiatura Municipality, ground granulometry, erosion risk, climate

Introduction

In order to predict water erosion processes on mountain slopes, field-scientific expeditions were carried out in the ecosystems of Chiatura Municipality in the years 2024-2025. As a result, 5 erosion-sensitive sites were selected, for which GPS coordinates and absolute altitudes above sea level were recorded (Table 1).

Soil/ground samples within the range of 3 kg were collected from the 5 study sites. At the Hydro-technical Laboratory of the “Tsotne Mirtskhulava” Water Management Institute of Georgian Technical University, sieves with the following diameters were selected: 1. $D > 40$ mm; 2. $D = 40-20$ mm; 3. $D = 20-10$ mm; 4. $D = 10-5$ mm; 5. $D = 5-2.5$ mm; 6. $D = 2.5-1.25$ mm; 7. $D = 1.25-0.63$ mm; 8. $D = 0.63-0.315$ mm; 9. $D = 0.315-0.14$ mm; 10. $D < 0.14$ mm.

Table 1. Geographical data of the study sites

Study site	GPS coordinates		Absolute altitude above sea level, H (m)
	X	Y	
Village Melusheti	42° 19' 38"	43° 11' 2"	860
Village Kveda Chalovani	42° 22' 6"	43° 15' 28"	920
Village Mgvimevi	42° 18' 33"	43° 17' 55"	650
Village Tkemlovana	42° 11' 30"	43° 17' 20"	700
Village Zeda Chalovani	42° 22' 48"	43° 16' 5"	980

The soil samples were processed using the sieve method, with the laboratory analysis results presented in Table 2 and the granulometric integral curves shown in Fig. 1.

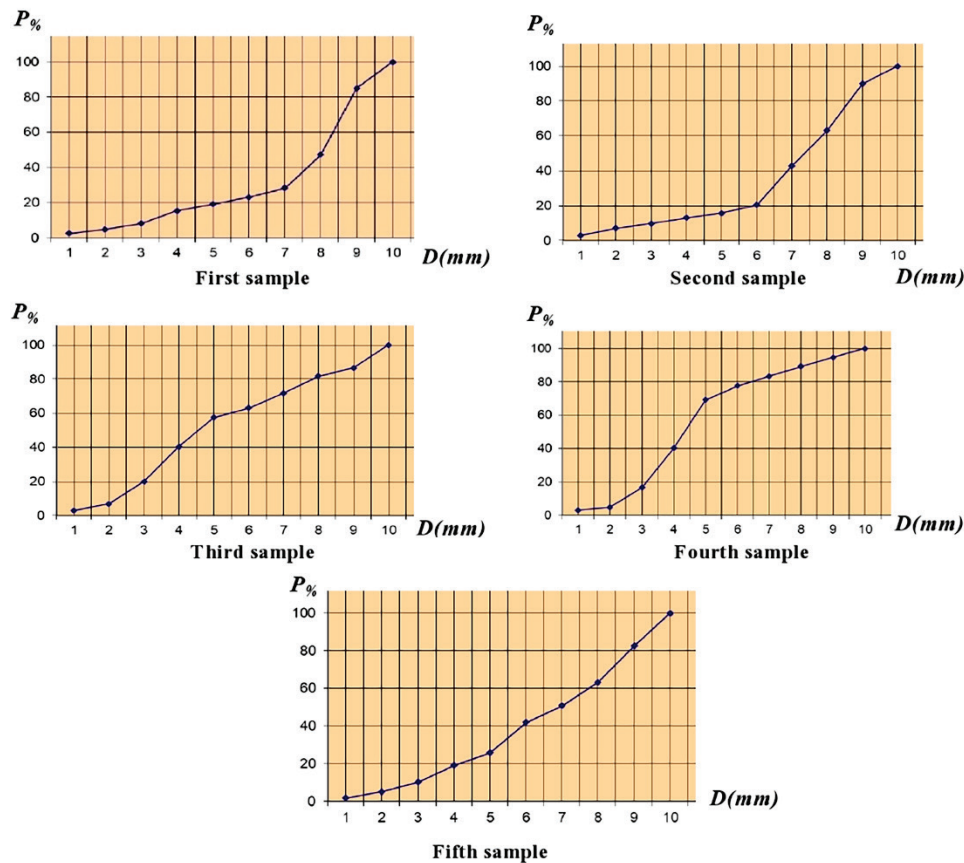


Fig. 1. Integral curves of the soil/ground granulometry.

Table 2. Soil granulometric analysis data

Date	Site #	Total weight (kg)	> 40.0	20.0 - 40.0	20.0 - 10.0	10.0 - 5.0	5.0 - 2.5	2.5 - 1.25	1.25 - 0.63	0.63 - 0.315	0.315 - 0.14	< 0.14
27.05.2024	1	2.625 100	0.390 14.86	0.995 37.91	0.500 19.05	0.135 5.14	0.105 4.00	0.095 3.62	0.190 7.24	0.090 3.43	0.060 2.28	0.065 2.47
28.05.2024	2	1.690 100	0.170 10.06	0.455 26.92	0.340 20.12	0.380 22.48	0.080 4.73	0.045 2.67	0.055 3.25	0.045 2.67	0.070 4.14	0.050 2.96
29.05.2024	3	2.820 100	0 0	0.515 18.26	0.125 4.43	0.155 5.50	0.245 8.69	0.160 5.67	0.480 17.02	0.570 20.21	0.375 13.31	0.195 6.91
30.05.2024	4	1.865 100	0 0	0.100 5.37	0.100 5.37	0.110 5.89	0.110 5.90	0.155 8.31	0.540 28.95	0.440 23.59	0.220 11.79	0.090 4.83
31.05.2024	5	3.015 100	0.530 17.57	0.580 19.23	0.370 12.27	0.270 8.95	0.490 16.25	0.200 6.65	0.265 8.78	0.155 5.14	0.100 3.32	0.055 1.84

With the aim of evaluating the climatic conditions, data from the automatic weather station in the city of Chiatura has been used, as well as the official bulletin – “Construction Climatology,” in accordance with design standards approved and published by the Ministry of Economy and Sustainable Development of Georgia (Climate Change, Impacts and Vulnerability in Europe. (2012). An indicator-based report. European Environment Agency. http://ec.europa.eu/agriculture/Climate-Change/%20factsheet_en.pdf; Morgan, 1979; Natishvili and Gavardashvili, 2019).

The average annual air temperature in the study area is 14.4°C. January is the coldest month of the year, with an average temperature of 4.7°C and an absolute minimum of -17°C. The hottest month is August, with an average temperature of 23.5°C and an absolute maximum of 41°C. The average annual precipitation total reaches up to 1200 mm (Gavardashvili and Modebadze, 2025; Gavardashvili et al., 2025).

The intra-annual distribution of maximum atmospheric precipitation is presented in Table 3, and the precipitation distribution diagram is shown in Fig. 2.

Table 3. Intra-annual distribution of maximum atmospheric precipitation

Station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Chiatura	347	375	251	196	161	195	287	200	287	402	378	374

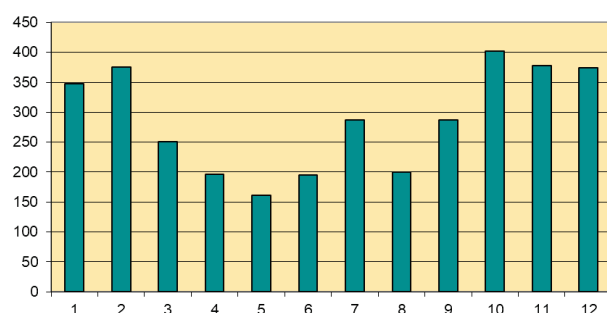


Fig. 2. Diagram of precipitation distribution in Chiatura Municipality.

The daily maximum precipitation is 145 mm. The maximum rain intensity is 0.279 mm/min, and the average annual relative air humidity is 76% (Mirtskhulava, 2003; Dudai et al., 2012).

Throughout the year, the prevailing winds in the area are from the east (67% in January, 14% in July) and west (17% in January and 56% in July) directions; winds from other directions are insignificant (Table 4) (Gogichaishvili and Urushadze, 2006; Climate Change, Impacts and Vulnerability in Europe

(2012). An indicator-based report, European Environment Agency, http://ec.europa.eu/agriculture/Climate-Change/factsheet_en.pdf).

Table 4. Values of the highest possible wind speeds (m/s)

Annually	Once in 5 years	Once in 10 years	Once in 15 years	Once in 20 years
23	25	26	27	28

The weight of the snow cover is 0.50 kPa. The number of days with snow cover is taken as 16 days. The standard freezing depth for the soils on the research polygon is 0 cm (for any type of soil).

Materials and Methods

While evaluating the following fact of predicting the water erosion processes and determining the average diameter of the ground samples is of particular importance, the value of which has been calculated using the following relationship (Morgan, 1979; Gavardashvili and Modebadze, 2025).

$$D_g = \exp\left(0,01 \sum_{i=1}^n f_i \log m_i\right), \quad (1)$$

where f_i is the percentage of the particle size fraction (%); m_i is the particle fraction size (mm); The average diameter sizes for the 5 study sites were calculated using formula (1), the numerical values of which are given in Table 5.

Table 5. Average diameter measurements for the 5 study sites

Study site	Sample Weight (kg)	Humus Content (%)	Average Sample Diameter (mm)
Village Melusheti	2.625	0.720	0.565
Village Kveda Chalovani	1.690	0.370	0.306
Village Mgvimevi	2.820	0.210	0.398
Village Tkemlovana	1.865	0.400	0.327
Village Zeda Chalovani	3.015	0.240	0.403

To assess the erosive processes across the 5 study sites of Chiatura Municipality, Wischmeier's Universal Soil Loss Equation (USLE) was applied, which takes the following form (2):

$$A = R \times K \times L \times C \times P \text{ (t/ha per year)}, \quad (2)$$

where A is the average annual soil loss (t/ha per year); R is the rainfall erosivity factor (mm), calculated using the following relationship:

$$R = 0,4 P \times EI_{30} \text{ (mm)}, \quad (3)$$

where P is the total storm rainfall (mm); E is the unit kinetic energy of erosive rainfall, which equals:

$$E = 0,119 + 0,0873 \log I_{30}, \quad (4)$$

where I_{30} is the maximum 30-minute rainfall intensity (mm); K is the soil erodibility factor, calculated using the mean diameter of the soil/ground:

$$K = 0,0034 + 0,0397 \exp\left[\frac{-0,5(\log D_g + 1,533)^2}{0,7671}\right], \quad (5)$$

where D_g is the mean particle diameter, calculated by the following formula:

$$D_g = \exp\left(0,01 \sum_{i=1}^n f_i \log m_i\right), \quad (6)$$

where f_i is the percentage of the particle size fraction; m_i is the particle fraction size; S is the slope steepness factor, calculated using the following relationship:

$$S = 0,065 + 0,045 S + 0,0065 S^2, \quad (7)$$

where S is the slope steepness in percent (%); L is the slope length factor, calculated using the following relationship:

$$L = (l/22,13)^{0,5} \text{ (m)}, \quad (8)$$

where l is the slope length (m); C is the vegetation cover factor, calculated using the following formula:

$$C = e^{-0,06V}, \quad (9)$$

where V is the percentage function of vegetation cover; The value of V can be taken as $C = 1.0$ for bare soil areas and $C = 1.2$ for plots heavily compacted and hardened by vehicles; P is the protection factor). $P = 0.5$ in the case of diversion bunds, while $P = 1.0$ where no protection measures are applied.

Using the methodology described above, the soil erosion forecast for the mountain slopes within the corridor is given in Table 6.

Table 6. Key indicators of the intensity of erosive processes across the 5 study sites within the territory of Chiatura Municipality

Object	Atmospheric precipitation coefficient (R)	Soil erosion coefficient (K)	Slope gradient coefficient (S)	Slope length factor (L)	Vegetation factor (C)	Area protection factor (P)	Soil loss (A) t/ha	R. Morgan erosion class
Melusheti	157,00	0,012	2,449	2,65	1,0	0,5	6,11	3
Kveda Chalovani	157,00	0,013	0,698	4,51	1,0	0,5	3,21	2
Zeda Chalovani	157,00	0,009	18,565	3,43	1,0	0,5	45,00	4
Mghvimevi	157,00	0,010	5,629	1,84	1,0	0,5	8,13	3
Tkemlovana	157,00	0,011	2,449	1,84	1,0	0,5	3,89	2

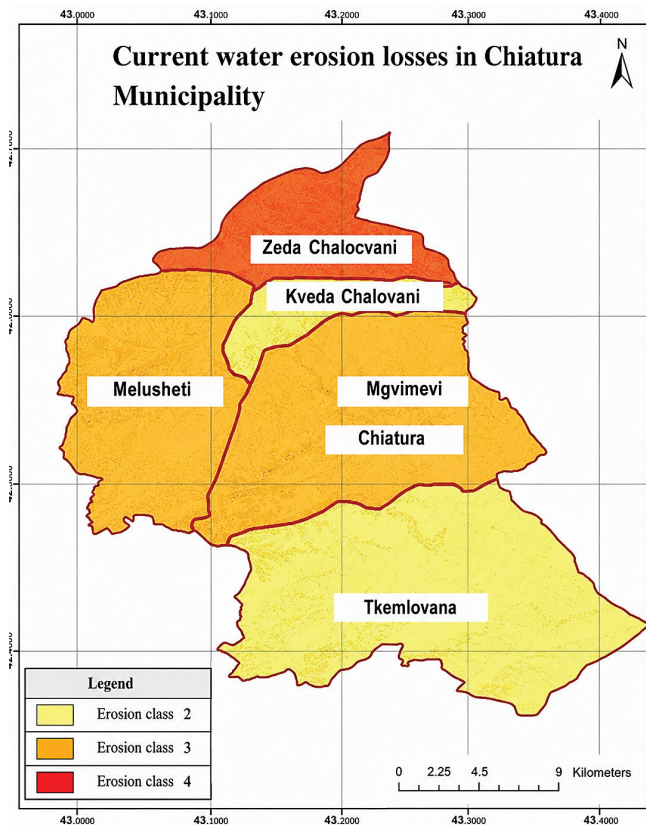


Fig. 3. Water erosion risk map of Chiatura municipality.

Using the data from Table 5 and GIS technology, an erosion risk map for Chiatura Municipality was constructed, which is shown in Fig. 3.

Conclusion

Based on the field scientific, laboratory, and theoretical research conducted within the territory of Chiatura Municipality, it was determined that the activity of erosive processes in dry gullies and ravines across the five study sites ranges within classes 2-4 of erosion, according to the scale developed by the British scientist, Professor Roy Morgan. The corresponding intensity of water erosion processes on the mountain slopes ranges from 3,21-45,0 t/ha per year, which indicates a significantly high risk of soil loss on these slopes.

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გეოლოგია

წყლისმიერი ეროზიული პროცესების რისკების კვლევა

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წინამდებარე ნაშრომში წარმოდგენილია წყლისმიერი ეროზიული პროცესების რისკების კვლევის სავსე-სამეცნიერო, ლაბორატორიული და თეორიული შედეგები. სავსე კვლევების განხორციელებისათვის შეირჩა 5 საკვლევი უბანი (სოფლები მელუშეთი, ქვედა ჭალოვანი, მღვიმევი, ზედა ჭალოვანი და ტყემლოვანა) ჭიათურის მუნიციპალიტეტის ტერიტორიაზე. მთის ფერდობებზე განთავსებული ნიადაგ-გრუნტის გეოლოგიური შეფასებისათვის აღებულ იქნა 5 ნიმუში და საქართველოს ტექნიკური უნივერსიტეტის ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის ჰიდროტექნიკურ ლაბორატორიაში განხორციელდა ნიადაგ-გრუნტის საცრული მეოდიტ დამუშავება. სტატისტიკური რიგის დამუშავებით დადგენილია ნიადაგ-გრუნტის საშუალო დიამეტრის ზომები და აგებულია თითოეული ნიმუშისათვის გრანულომეტრიის ინტეგრალური მრუდები. ვიშმაიერის უნივერსალური განტოლების გამოყენებით თითოეული 5 უბნისთვის დადგენილია ეროზიის კოეფიციენტი და ინგლისელი პროფესორის როი მორგანის შკალის მიხედვით დადგენილია ეროზიის კლასი, მთის ფერდობის ეროზიული პროცესების ინტენსივობის გათვალისწინებით, რომელიც იცვლება 3,21-45,0 ტონა/ჰა/წელიწადში. ჩატარებული თეორიული გამოთვლებით და GIS ტექნოლოგიების მიხედვით აგებულია ჭიათურის მუნიციპალიტეტის ტერიტორიისათვის ეროზიის რისკების ციფრული რუკა, სადაც მთის ფერდობების ეროზიული პროცესების კლასი იცვლება 2-4 საზღვრებში.

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