ISSN – 1512 – 2344
DOI.ORG/10.36073/1512-2344

საქართველოს განათლების, მეცნიერების და ახალგაზრდობის სამინისტრო

საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი

სამეცნიერო შრომათა კრებული №76

ეძღვნება პროფესორ ვახტანგ თევზაძის დაბადებიდან 90 წლის იუბილეს

MINISTRY OF EDUCATION, SCIENCE AND YOUTH OF GEORGIA

TSOTNE MIRTSKHULAVA WATER MANAGEMENT INSTITUTE OF GEORGIAN TECHNICAL UNIVERSITY

COLLECTED PAPERS №76

DEDICATED TO THE 90 ANNIVERSARY OF PROFESSOR VAKHTANG TEVZADZE

თბილისი – Tbilisi - 2023

ISSN – 1512 – 2344
DOI.ORG/10.36073/1512-2344

საქართველოს განათლების, მეცნიერების და
ახალგაზრდობის სამინისტრო

საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის
წყალთა მეურნეობის ინსტიტუტი

სამეცნიერო შრომათა კრებული №76

ეძღვნება პროფესორ ვახტანგ თევზაძის დაბადებიდან
90 წლის იუბილეს

MINISTRY OF EDUCATION, SCIENCE AND YOUTH OF GEORGIA

TSOTNE MIRTSKHULAVA WATER MANAGEMENT INSTITUTE OF GEORGIAN TECHNICAL UNIVERSITY

COLLECTED PAPERS №76

DEDICATED TO THE 90 ANNIVERSARY OF PROFESSOR VAKHTANG TEVZADZE

თბილისი – Tbilisi - 2023

კრებული გამოდის 1934 წლიდან

The collection is published since 1934

ი. ჭავჭავაძის გამზ. 60ᵇ,
0179, თბილისი, საქართველო
სტუ-ს ცოტნე მირცხულავას სახელობის
წყალთა მეურნეობის ინსტიტუტი
ტელ.: (99532) 2-227-200, 2-224-094
ფაქსი: (99532) 2-227-300
ელ-ფოსტა: gwmi1929@gmail.com
ვებ-გვერდი: http://wmi.ge

I. Chavchavadze ave. 60ᵇ,
0179, Tbilisi, Georgia
Ts. Mirtskhulava Water
Management Institute of GTU
Tel.: (99532) 2-227-200, 2-224-094
Fax: (99532) 2-227-300
E-mail: gwmi1929@gmail.com
Website: http://wmi.ge

ტირაჟი 200

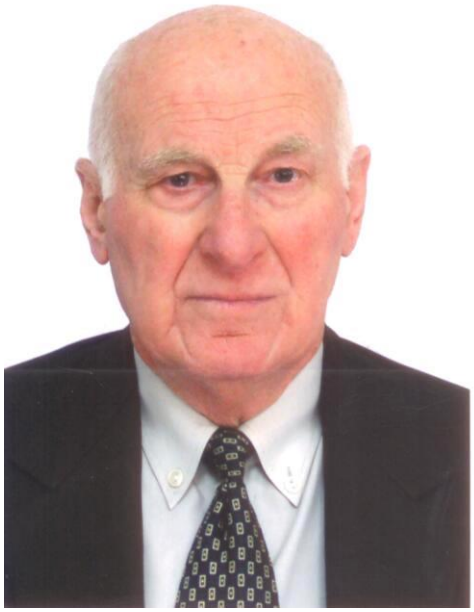
C O N T E N T S

pp.

C O N T E N T S

ს ა რ ჩ ე ვ ი

ვახტანგ თევზაძე - 90



ღვარცოფმცოდნეობის ერთ-ერთ თვალსაჩინო მეცნიერს, საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის ბუნებრივი კატასტროფების განყოფილების ყოფილ ხელმძღვანელს, მთავარ მეცნიერ-თანამშრომელს, ინსტიტუტის სამეცნიერო საბჭოს წევრს, საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემიის წევრ-კორესპონდენტს, ტექნიკის მეცნიერებათა დოქტორს, პროფესორ ვახტანგ თევზაძეს 2023 წლის 24 ოქტომბერს დაბადებიდან 90 წელი შეუსრულდებოდა.

ბატონი ვახტანგ თევზაძე დაიბადა 1933 წლის 24 ოქტომბერს ქ. თბილისში. 1952 წელს ოქროს მედალზე დაამთავრა თბილისის მე-7 ვაჟთა საშუალო სკოლა. 1957 წელს წარჩინებით დაამთავრა საქართველოს სასოფლო-სამეურნეო ინსტიტუტის ჰიდრომელიორაციის ფაკულტეტი და მიენიჭა ინჟინერ-ჰიდროტექნიკოსის კვალიფიკაცია. 1957 წლიდან გარდაცვალებამდე მუშაობდა საქართველოს მეცნიერებათა აკადემიის წყალთა მეურნეობისა და საინჟინრო ეკოლოგიის (ამჟამად _ საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი) ინსტიტუტში და გაიარა გზა ასპირანტობიდან - ინსტიტუტის დირექტორის მოადგილეობამდე სამეცნიერო ნაწილში.

1968 წელს დაიცვა საკანდიდატო დისერტაცია, ხოლო 1986 წელს კი - სანკტ-პეტერბურგში დაიცვა სადოქტორო დისერტაცია და მიენიჭა ტექნიკის მეცნიერებათა დოქტორის სამეცნიერო ხარისხი.

1990-93 წლებში კითხულობდა ლექციებს საქართველოს ტექნიკური უნივერსიტეტის ჰიდრავლიკისა და ჰიდრომანქანების კათედრაზე და საქართველოს აგრარული უნივერსიტეტის ჰიდრავლიკისა და ჰიდროტექნიკის კათედრაზე, სადაც მას ენიჭება პროფესორის წოდება.

1982-1999 წლებში იგი არჩეულ იქნა ყოფილი საბჭოთა კავშირის მეცნიერებისა და ტექნიკის კომიტეტთან არსებული ღვარცოფული კომისიის წევრად და თავმჯდომარის მოადგილედ, საქართველოს მეცნიერებათა ეროვნული აკადემიის სოფლის მეურნეობის პრობლემათა განყოფილების საბჭოს წევრად (1994 წლიდან), საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემიის წევრ-კორესპონდენტად მიწათმოქმედების, ეროზიის, მელიორაციისა და ეკოლოგიის დარგში (1995 წლიდან), საქართველოს აგრარული უნივერსიტეტის სამეცნიერო ხარისხის მიმნიჭებელი სადისერტაციო საბჭოს წევრად (2000 წლიდან), ასევე საქართველოს გარემოს დაცვის სამინისტროს სალიცენზიო საბჭოს წევრად წყალდიდობების, წყალმოვარდნების, ეროზიულ-

ღვარცოფული მოვლენებისა და მათ წინააღმდეგ ბრძოლის საკითხებში ადამიანისა და ბიოსფეროს იუნესკოს ეროვნული კომიტეტის წევრად (2003 წლიდან).

პოსტ-საბჭოთა პერიოდში, როგორც ბუნებრივი კატასტროფების დარგის ცნობილი სპეციალისტი, 1973 წელს 1 წლით სტაჟირებით იგზავნება სამეცნიერო მივლინებაში იაპონიაში ქვეყნის ეროზიულ-ღვარცოფული მოვლენების გამოცდილების შესასწავლად, 2007 წელს კი მასთან ერთად ჩვენ სამეცნიერო მივლინებით ვიმყოფებოდით ისრაელში, აშშ-ისრაელი-საქართველოს ერთობლივი გრანტის შესრულების მიზნით, რაც გულისხმობდა ნიადაგის ეროზიასთან ბრძოლის ახალი ბიოსაინჟინრო მეთოდების შესწავლას.

ფოტო 1. მარცხნიდან პროფ. ვ. თევზაძე, ქ-ნი ლ. ფარკაში, პროფ. გ. გავარდაშვილი ისრაელის ნიადაგის, წყლის და გარემოს დაცვის სამცნიერო კვლევითი ცენტრი, ვოლკანი, ქ. თელ-ავივი (ისრაელი, 2007 წ.)

აკადემიკოს ვ. თევზაძესთან ერთად მქონდა პატივი ერთობლივად განგვეხორციელებინა საველე-სამეცნიერო კვლევები საქართველოს მოწყვლად ადგილებში, სადაც ინტენსიურად მიმდინარეობდა დედამიწის ზედაპირის ისეთი დესტრუქციული პროცესები, როგორიც არის ნიადაგის ეროზია, ღვარცოფული და მეწყრული პროცესები და ა.შ., რაც შემდგომ ეტაპზე გახდა საფუძველი, აკადემიკოსების - ცოტნე მირცხულავასა და ოთარ ნათიშვილის ხელმძღვანელობით, დაგვემუშავებინა ქვეყნის ნიადაგების ეროზიისაგან დაცვის სახელმწიფო პროგრამა (2000 -2004 წწ).

მდინარე ხრამის წყალშემკრებ აუზში (22.07.2008)

შავი ზღვის სანაპიროზე ნაპირდამცავი კედლის საექსპერტო სამუშაოებისას (სარფი, 24.08.2009)

ბათუმის ბოტანიკურ ბაღში შავი ზღვის ნაპირის მდგრადობის შესამოწმებლად. მარცხ. ბოტანიკური ბაღის დირექტორი, პროფ. გ. ლეონიძე, 2009

თანამშრომლობის ხელშეკრულების გაფორმებისას შპს საქგზამეცნიერების ინსტიტუტის დირექტორთან, პროფ. თ. შილაკაძესთან (26.12.2000)

ინსტიტუტში ჩინეთის ელჩის პირველი მდივნის, ბ-ნ ი. შენისა და ცენტრალური ჩინეთის ნორმალის უნივერსიტეტის (ქ. ვუჰანი) პროფ. იუჯინ ვუს სტუმრობისას (19.08.2007)

ვ. ლომონოსოვის სახელობის მოსკოვის სახელმწიფო უნივერსიტეტის დოცენტის. სერგეი ჩერნომორეცის ინსტიტუტში სტუმრობისას (30.04.2007)

პროფესორ ვახტანგ თევზაძესთან თანამშრომლობის ამსახველი ფოტო-მასალა

ბუნების სტიქიური მოვლენების საკითხებზე საქართველოსა და საერთაშორისო რეფერირებად და რეცენზირებად სამეცნიერო ჟურნალებში გამოქვეყნებული აქვს 200-მდე სამეცნიერო ნაშრომი, მათ შორის: 10-მდე მონოგრაფია და 5 გამოგონება. მისი ხელმძღვანელობით დაცული იქნა 10-ზე მეტი საკანდიდატო და სადოქტორო სადისერტაციო ნაშრომი.

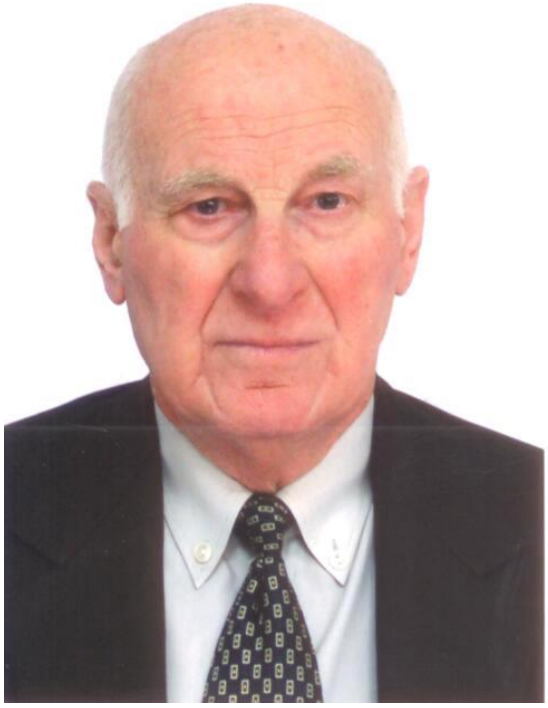
მისი თავდაუზოგავი სამეცნიერო-კვლევითი, პედაგოგიური და საექსპერტო საქმიანობა ქვეყნის მიერ აღინიშნა მისთვის ღირსების ორდენის მინიჭებით. იგი ასევე დაჯილდოებული იყო მრავალი დიპლომითა და მედლით. მისი თანახელმძღვანელობით ჩატარდა მრავალი საერთაშორისო და რეგიონალური სამეცნიერო-ტექნიკური კონფერენცია და სიმპოზიუმი მიძღვნილი სოფლის მეურნეობისა და გარემოს დაცვის საკითხებზე.

რაც შეეხება ბატონ ვახტანგ თევზაძის შთამომავლობას, უფროსი ქალიშვილი - ირინა თევზაძე - მან დაამთავრა თბილისის სახელმწიფო სამხატვრო აკადემია სპეციალობით მხატვარ-დიზაინერი, ამჟამად ცხოვრობს ქალაქ ფენიქსში (აშშ, არიზონას შტატი) და მოღვაწეობს არიზონას უნივერსიტეტში. ჰყავს ორი შვილი - 28 წლის ვიქტორია (ვიკა) თოფურია, რომელიც ცხოვრობს კალიფორნიის შტატში, ხოლო 26 წლის ქეთევან თოფურია - ტეხასის შტატში (აშშ). მეორე ქალიშვილმა ანა (ნანუკა) თევზაძემ დაამთავრა ივ. ჯავახიშვილის თბილისის სახელმწიფო უნივერსიტეტი, სპეციალობით ტურიზმის მენეჯმენტი, რომელიც ამჟამად ცხოვრობს ნიუ იორკში (აშშ) და აქვს საკუთარი კერძო ბიზნესი. ჰყავს 22 წლის ვაჟიშვილი - ირაკლი ფორაქიშვილი, რომელიც ცხოვრობს ქ. ბუდაპეშტში (უნგრეთი).

ბატონი ვახტანგის მეუღლე ქალბატონი მანანა დიდებულიძე იყო თბილისის სახელმწიფო სამხატვრო აკადემიის დიზაინის ფაკულტეტის უფროსი მასწავლებელი, რომელიც გარდაიცვალა 2021 წლის 6 ნოემბერს.

დიდია საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემიის წევრ-კორესპონდენტის, ტექნიკის მეცნიერებათა დოქტორის, პროფესორ ვახტანგ თევზაძის მეცნიერული წვლილი ჩვენი ქვეყნის გარემოსდაცვისა და საინჟინრო ეკოლოგიის დარგის განვითარების საქმეში. იგი იყო ღირსეული მასწავლებელი, პროფესიონალი, ძირძველი თბილისელი (ვერის უბნიდან), გულისხმიერი მეგობარი, ტრადიციული ქართული ოჯახის ერთგული მეუღლე, მზრუნველი მამა და მოსიყვარულე ბაბუა.

გივი გავარდაშვილი
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის
წყალთა მეურნეობის ინსტიტუტის დირექტორი,
საქართველოს მეცნიერებათა ეროვნული აკადემიის აკადემიკოსი,
ტექნიკის მეცნიერებათა დოქტორი, პროფესორი,
საქართველოს დამსახურებული მშენებელი



Vakhtang Tevzadze - 90

One of the outstanding scientists in debris flow studies, former Head of the Department of Natural Disasters of the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, Chief Researcher, Member of the Academic Council of the Institute, Corresponding Member of the Georgian Academy of Agricultural Sciences, Doctor of Technical Sciences, Professor Vakhtang Tevzadze on October 24, 2023, would have turned 90 years old since his birth.

Mr. Vakhtang Tevzadze was born on October 24, 1933 in Tbilisi (Georgia). He studied at the Tbilisi 7th Secondary School for Boys, which he graduated with a gold medal. In 1957, he graduated with honours from the Faculty of Hydro-amelioration of the Agricultural Institute of Georgia and was awarded the qualification of a Hydraulic Engineer. From 1957 until his death, he worked at the Institute of Water Management and Environmental Engineering of the Georgian Academy of Sciences (presently – Tsotne Mirtskhulava Water Management Institute of Georgian Technical University) and passed from Postgraduate Study to the position of Deputy Director of the Institute in scientific direction.

In 1968, he defended his candidate's thesis, and in 1986 - in St. Petersburg, he defended his doctoral thesis and was awarded the scientific degree of Doctor of Technical Sciences.

In 1990-93, he gave lectures at the Department of Hydraulics and Hydraulic Machines of Georgian Technical University and Department of Hydraulics and Hydraulic Engineering of the Agrarian University of Georgia, where he was awarded the title of Professor.

In 1982–1999, he was elected as a member and deputy chairman of the debris flow commission of the Committee on Science and Technology of the former Soviet Union, member of the Council of the Department of Agricultural Problems of the Georgian National Academy of Science (since 1994), corresponding member of the Georgian Academy of Agricultural Sciences in the field of agriculture, erosion, melioration and ecology (since 1995), member of the Dissertation Council of the Georgian Agrarian University (since 2000), member of the Licensing Council of the Ministry of Environmental Protection of Georgia, member of the UNESCO National Committee on "Man and the Biosphere" in the field of floods, erosion-debris flow phenomena and fighting against them (since 2003).

In the post-Soviet period, as a well-known expert in the field of natural disasters, in 1973 he was sent on a scientific mission to Japan for a one-year internship to study the country's experience regarding erosion-debris flow phenomena. In 2007, together with him, we were on a scientific mission to Israel, in order to study modern bioengineering methods for combating soil erosion in order to fulfil a joint US-Israel-Georgia grant.

Photo 1. (*on the left*) Prof. V. Tevzadze, L. Farkashi, Prof. G. Gavardashvili Israel Scientific Research Centre for Soil, Water and Environmental Protection, Volkan, St. Tel Aviv (Israel, 2007)

Together with Academician V. Tevzadze, I had the honour to jointly carry out field-scientific research in sensitive areas of Georgia, where destructive processes of the earth's surface, such as soil erosion, debris flows and landslides, etc., were taking place intensively. At a later stage, it became the basis for us to develop the state program for protecting the country's soils from erosion under the leadership of academicians - Tsotne Mirtskhulava and Otar Natishvili (2000-2004).

He has published about 200 scientific works on the issues of natural disasters in high-ranking journals in Georgia and abroad, including about 10 monographs and 5 inventions. Under his supervision, more than 10 candidate and doctoral theses were defended.

His selfless scientific-research, teaching and expert activity was celebrated by the country by awarding him the Order of Honora. He was also awarded with many diplomas and medals. Under his co-leadership, many international and regional scientific-technical conferences and symposiums dedicated to agriculture and environmental protection topics were held.

At the water catchment basin of river Khrami (22.07.2008)

During the expertise activities of the coastal protection wall on the Black Sea coast (Sarpi, 24.08.2009)

To check the stability of the Black Sea shore in Batumi Botanical Garden, (*on the left*) director of the botanical garden, Prof. G. Leonidze, 2009

During the signing of the cooperation agreement with the director of the „Georoadscience" Institute of Georgia, Prof. T. Shilakadze (26.12.2000)

During the visit of the First Secretary of the Chinese Ambassador Mr. I. Shen and the Professor I. Whu of Central China Normal University (Wuhan, China) to the Institute (19.08.2007)

During the visit of the Associate Professor S. Chernomorets from Lomonosov Moscow State University to the Institute (04.30.2007)

Photo-material illustrating cooperation with Professor Vakhtang Tevzadze

As for the descendants of Mr. Vakhtang Tevzadze, the eldest daughter - Irina Tevzadze - graduated from the Art Academy with a specialty of artist-designer, lives in the city of Phoenix (Arizona, USA) and works at the University of Arizona. She has children - Victoria (Vika) Topuria, 28 years old, who lives in the state of California, and Ketevan Topuria, 26 years old - in the state of Texas (USA). The second daughter, Anna (Nanuka) Tevzadze, graduated from Iv. Javakhishvili Tbilisi State University, majoring in tourism management, who currently lives in New York (USA) and has her own business. Has a son, Irakli Porakishvili, 22 years old, who lives in Budapest (Hungary).

Mr. Vakhtang's wife, Mrs. Manana Didebulidze, was a senior lecturer at the Faculty of Fashion Design of Tbilisi State Academy of Art; she died on November 6, 2021.

The scientific contribution of the member-correspondent of the Academy of Agricultural Sciences of Georgia, Doctor of Technical Sciences, Professor Vakhtang Tevzadze to the development of the field of environmental protection and engineering ecology of our country is great. He was a worthy teacher, professional, native of Tbilisi (from the neighbourhood of Vera), kind friend, faithful wife of a traditional Georgian family, caring father and loving grandfather.

Givi Gavardashvili

Director of the Tsotne Mirtskhulava Water Management Institute
of Georgian Technical University,
Academician of the Georgian National Academy of Science,
Doctor of Technical Science, Professor,
Honoured Constructor of Georgia

GIS TECHNOLOGIES IN THE ASSESSMENT OF THE MORPHOMETRIC PARAMETERS OF THE MOUNTAIN RIVER

A. Arifjanov, D. Atakulov, U. Vokhidova, M. Osmonova
National research university "Tashkent institute of irrigation and agricultural mechanization engineers"
Tashkent, Uzbekistan
E-mail: obi-life@mail.ru

INTRODUCTION

Stream processes include various processes related to the interaction between the stream and the river bed. They are erosion related to the formation of the river bed, river bottom, banks, transport of soil particles by currents, that is, washing, accumulation of muddy particles, that is, silting and other processes. Under the influence of anthropogenic factors, this process is accelerating again. These changes are related to the seasonal, perennial, centuries-long influence of the flow. As a result of this, complex processes occur in the formation of the river bed and the relief of the river, its morphological parameters. The processes that take place between the stream and the soil forming the riverbed reflect the hydromechanical nature of the processes in the riverbed [1,2,3,4,5]. The hydrodynamic characteristics of the stream through its interaction with the riverbed affect the morphology of the riverbed, causing bends, branches, and various changes in the bottom and banks of the riverbed. The bed formed under the influence of the flow, in turn, affects the flow, and various hydraulic changes occur in the flow.

Deformations of the foothill river bed are caused by erosion, sediment transport and accumulation. These cause the rise or fall of the river bed level, erosion of the banks. The most complex affects hydrotechnical structures, reducing their reliable and safe use[1,2,3]. Deformation of the trunk can be directional and seasonal. For directional deformation, the change of the shape or position of the bedrock is the same over time, that is, it is constant, while seasonal - the change of the bedrock and bedrock relief shape is repeated over time [1,2,4,5,6].

Vertical deformations - reflect the vertical deformations that occur in the river section as a result of sediment accumulation or washing to the bottom of the river.

Horizontal deformations are close to slope erosion, which determines coastal erosion, and the displacement of the riverbed is observed by the accumulation of sediments in another part of the riverbed, where the accumulation of turbidite particles appears. When horizontal deformations occur together with vertical ones, branching increases in the river, washing and silting, etc. are observed.

As mentioned above, many factors affect the formation of the river bed. Taking into account these factors, only theoretical connections are not enough to calculate the morphometric parameters [1,2,3,7,8,9]. Therefore, the morphometric relationships proposed by various scientists are based on data and observations collected in natural field and laboratory conditions over the years. The essence of this is that the riverbed is formed as a result of the interaction between the flow and the bottom of the riverbed over the years, and the morphometric parameters of the formed riverbed are expressed by certain connections [7,8,9]. It is appropriate to conduct research based on the stated factors in the continuation of research in this direction.

Finding the relationship between the flow hydraulic elements and the shape of the cross-section was studied in the middle of the 19th century. It was noted that the greater the water consumption in the river, the smaller the ratio of the average depth to the average width. In flat rivers, this ratio is within the limits of 1/25...1/200 [1,2,3,7,8,9] .

V. G. Glushkov proposed morphometric connections in riverbed among the others [10,11]. Riverbed established the relationship between mean width B and mean depth h as follows:

$$\frac{\sqrt{B}}{h} = \Gamma \quad \text{or} \quad B^{\frac{3}{2}} = \Gamma\omega \tag{1}$$

there: ω- cross-sectional area, Γ-soil strength coefficient against erosion, Γ-1.4 for stony rocks, Γ-5.5 for slightly leachable soils.

S.T. Altunin proposed the following expression for morphometric connections [3,4].

$$B^m = kh \tag{2}$$

there: m- is a parameter that varies from 1.0 to 0.5, depending on the type of soil; k-coefficient, the average value is 10 for strong beds, 3-4 for difficult leachable soils; and it is assumed to be equal to 16-20 in slightly leachable soils [1,2.3.4,5,6,7].

In the above connections, the discharge factor, which has the main effect on the formation of the ooze, has not been fully taken into account.

The following expression was proposed by M. V. Velikanov [2] on the basis of the theory of units of measurement to determine the morphometric connections for the river bed:

$$\frac{Bi}{ad} = A_B \left[\frac{Qi^{\frac{5}{2}}}{(ad)^2\sqrt{agdi}}\right]^{y_1} \tag{3}$$

$$\frac{Hi}{ad} = A_H \left[\frac{Qi^{\frac{5}{2}}}{(ad)^2\sqrt{agdi}}\right]^{y_2} \tag{4}$$

there: A_B, A_H – coefficients, y_1, y_2 – degree indicators, d – sediment average diameter, i – channel bottom slope, Q – water discharge, $a = \frac{\rho_к}{\rho} - 1$, $\rho_к$ – solid fluid average density, ρ – density of water.

By performing some arithmetic operations on the equations (3) and (4) given above, it is possible to derive the following relationship:

$$A_B^{\frac{1}{1-y_1}} = \left(\frac{1}{A_H}\right)^{\frac{1}{y_2}} \tag{5}$$

Effective use of equations requires determination of coefficients and exponents. Various scientists have conducted research in this regard in various conditions and determined the resulting values to a certain extent [1,2.3.4,5,6,7].

From the analysis, it can be concluded that the purpose of this article is to use modern technologies for rapid assessment of processes, taking into account the kinematic parameters of the turbulent flow, the soil of the river bed, the amount and fractional composition of the sediments in the stream.

SOLUTION METHOD

In the study of these issues, there is a growing demand to analyze the conditions observed in the river bed with the help of geoinformation technologies and to ensure their reliable operation [8,9,10,11,13,14,15,16]. At the time of rapid development of innovative technologies, rapid assessment of morphometric changes in the river bed, continuous monitoring, prevention of washing and silting processes, and forecasting for the future are the main issues.

As a solution to the problem of quick and accurate assessment of river morphometric links, it is possible to show the geographic information system (GIS), widely used in the field of application [19].

The morphometric relationships described above by various scientists have been developed on the basis of numerous field studies and laboratory data. In most cases, these connections are appropriate for the conditions under which the research was conducted. But for mountain rivers, it is necessary to improve the given connections. Today, it is required to study the degree indicators and constant coefficients in the equations on the basis of accurate, reliable, fast observations.

The Sokh stream located in Fergana region was selected as a research object. The results of field experiments and satellite data were combined and analyzed in order to find out the reason for the sudden change in shape of the bed and washing in Sokh stream. In this case, the change of the morphometric parameters of the bed in each section along the length of the stream, the change of the hydraulic elements of the stream were checked based on the conditions of the dynamic stable bed. On the basis of observation and analysis, it was determined that the riverbed formation consists of 3 parts along the length of the Sox stream. These are as follows:

Part 1 – between PK12-PK23. In this interval, the main part (80-90%) of the sediments contained in the stream is collected;

Part 2 – between PK29-PK55. In this interval, the shape of the riverbed changes very sharply, and over the years the banks are washed away. In this section, the stream bed does not meet the conditions of a dynamic solid section bed;

3 parts – between PK55-PK92. In this part, the riverbed has not changed its shape very much over the years, and the banks have not been washed, so we can call this part a riverbed with a dynamic solid section.

Level indicators and connection coefficients were determined using the morphometric connections proposed by M. Velikanov for each selected part of the river bed with solid section.

In order to study and analyze the observed morphometric changes in the river bed, several operations were performed on the data downloaded through the ArcMap application of ArcGIS software, necessary data were measured and maps were developed. This was done in the following order:

(a) Water area was extracted from the downloaded daily trapezoidal image using the normalized difference water index (NDWI) (Figure 1). The following calculation formula was used:

$$NDWI = \frac{NIR - SWIR}{NIR + SWIR};$$

There: NIR – Near Infrared layer of satellite image;

$SWIR$ – Short-wave Infrared layer of satellite image.

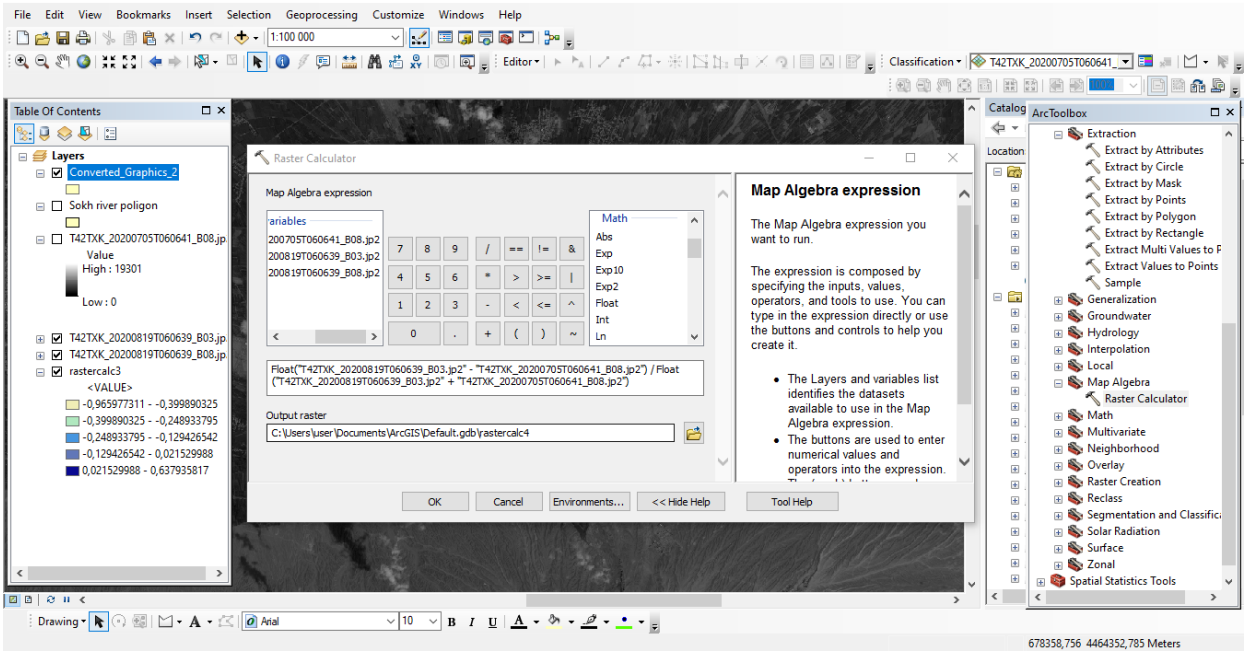


Figure 1. Extraction of water area

b) After extracting the water area separately, the Sokh river basin was cut separately from the total downloaded area in order to facilitate and speed up the performance of several operations on the data of each studied day (Fig. 2);

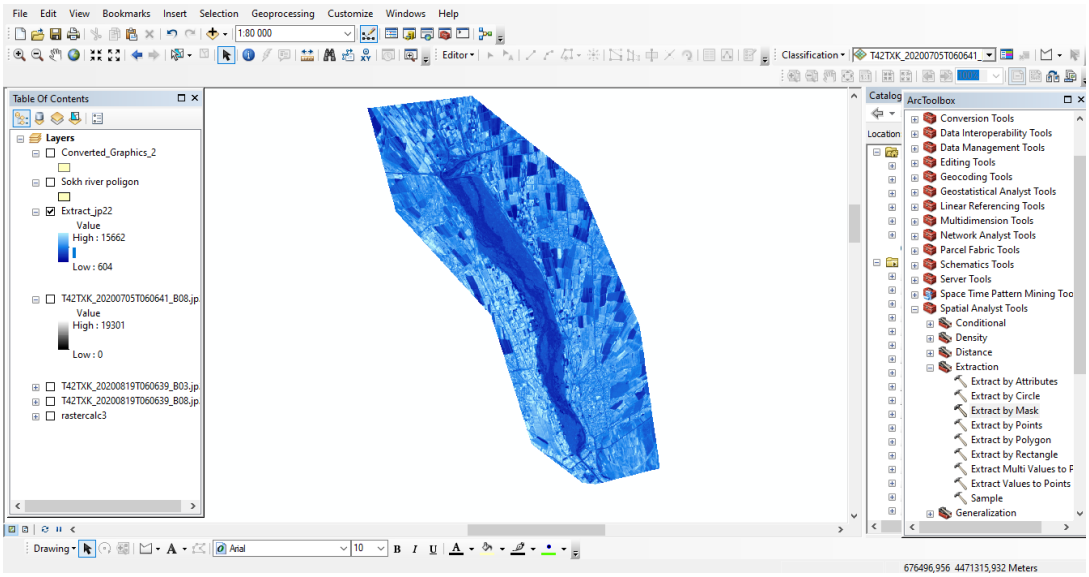


Figure 2. Extraction of the Sox basin

c) The width of the water level in each selected dam was measured in relation to the change in water consumption along the length of the stream. Based on the measured and calculated values, a 3-year database was created for the Sox stream.

ANALYSIS OF RESULTS

Using the data measured by the ArcMap software, the unknown constant coefficient and the level indicators in equations (9) and (10) were determined. Initially, the constant terms on both sides of the equation were designated by certain letters (K and C):

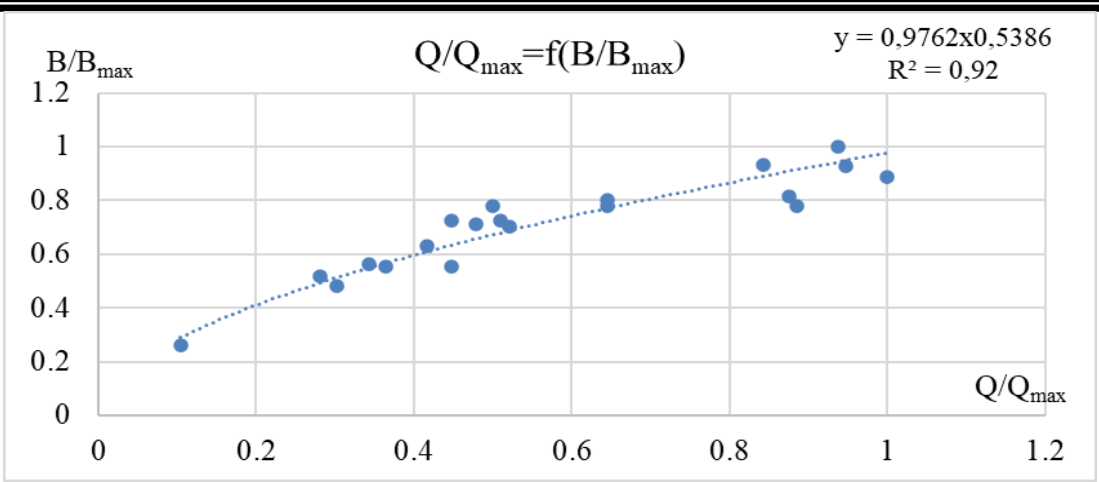
$$K = \frac{ad}{i} \qquad C = \frac{Qi^{\frac{5}{2}}}{(ad)^2\sqrt{agdi}}$$

After the notations, the equation (3) looks like this:

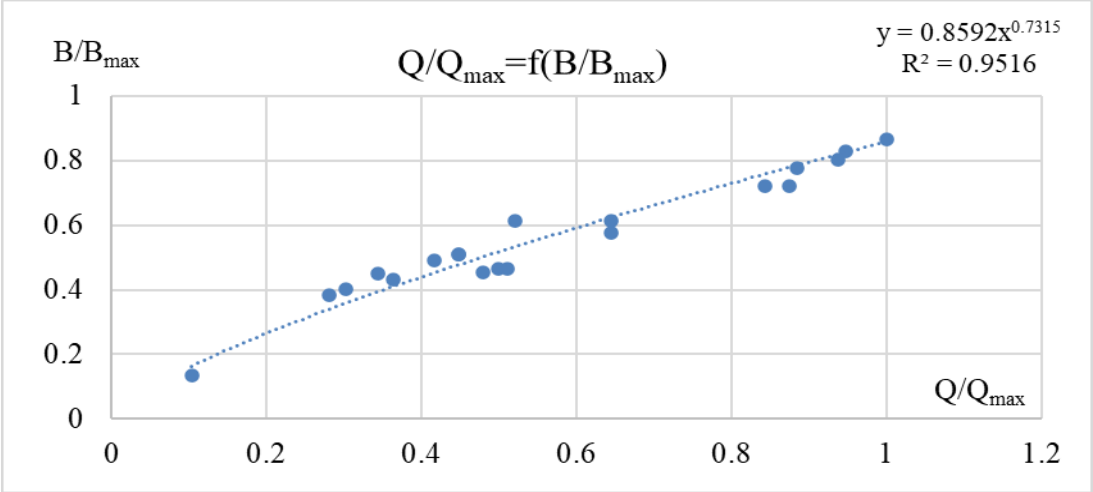
$$B = A_B K[C]^{y_1} \tag{6}$$

In the equation (12) above, A_B - is the coefficient of constancy, y_1 – is the level indicator, and it was determined using a graph developed by experiment and the width of the water surface. In order to study the morphometric relationship in the river, the part where the stream flows relatively inseparable was selected in each section. The determined values were tabulated and graphs were drawn. It was analyzed based on the morphometric connections of the watercourse determined by experiment and GIS, hydraulic and hydrological equations.

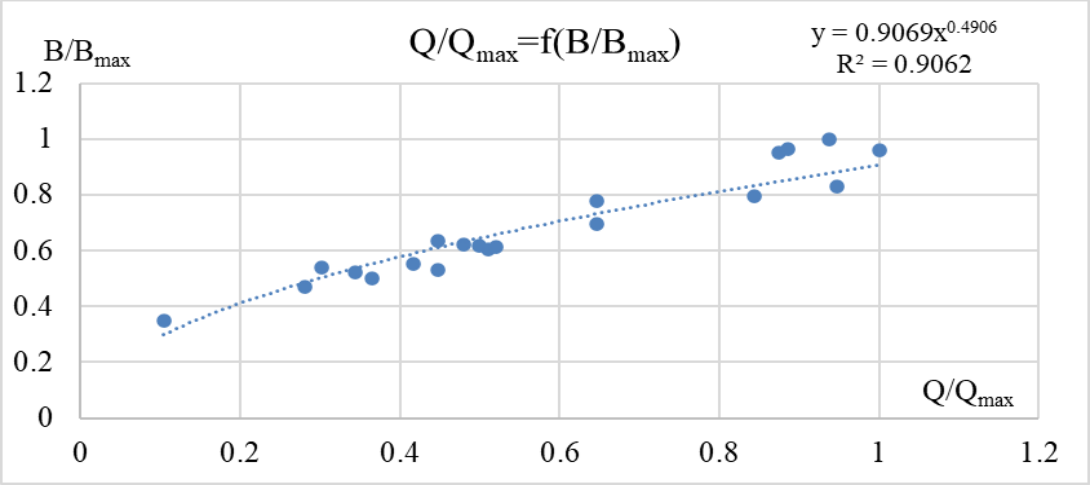
A graph was created on the basis of the function $Q/Q_{max}=f(B/B_{max})$ by relating the change of the flow level width B along the length of the stream to the flow consumption (graph 1, 2, 3).



Graph 1. Graph of dependence of river width on water discharge in Sokh river bed PK 22



Graph 2. Graph of dependence of river width on water discharge in Sokh riverbed PK 52



Graph 3. Graph of dependence of river width on water discharge in Sokh riverbed PK 82

Were compared different formulas of river morphometric parameters which proposed by different scientists with formula which determined through GIS by us.

Table 1

Table of recommended equation values

Source	A_B	A_H	y_1	y_2
M.A. Velikanov	5,6	0,12	0,4	0,375
N.S. Sharashkina	4,0	0,14	0,51	0,33
O.V. Andreev	7,9	0,16	0,53	0,3
X.A. Ismagilov	3,8	0,095	0,48	0,28
X. Aidov	2,2	0,2	0,44	0,34
Values determined by GIS	8,5	0,22-0,26	0,39-0,43	0,34-0,40

In the equation proposed by M.V. Velikanov for determining the morphometric links of the bed, it can be observed that the coefficient of constancy and degree indicators are variable even for certain conditions. From the results determined by GAT, it appears that these changes depend on the flow rate and the width of the water table. Based on the analysis of the obtained results, these changes can be proposed in the fore-mountain part of the river in the following intervals (Table 3).

Table 2

Correlation coefficient of the width of the water surface and table of dependence on level indicators

B, м	A_H	y_1	y_2
20-40	0.22	0.39	0.4
40-60	0.23	0.4	0.39
60-80	0.24	0.4	0.38
80-100	0.24	0.4	0.37
100-120	0.25	0.41	0.35
120-140	0.26	0.41	0.34
140-160	0.26	0.42	0.34
160-200	0.27	0.43	0.33

CONCLUSION

A new approach to the assessment of erosion and accumulative processes in open riverbeds was recommended as a result of the water level increasing with the increase of water consumption to a certain level.

Based on the application of RS data from GIS technologies, the use of ultra-high-resolution Sentinel 2 images and data obtained in natural field conditions, a map of the Sokh Soy riverbed was developed.

It enables remote management based on the database developed for the assessment of erosion and accumulation processes in riverbed. As a result of this, we will be able to quickly identify cases of washing or turbid sediments in the bed and form databases on the object.

The method of determining the morphometric connections of the riverbed using GIS technologies was developed taking into account the change in the flow level

REFERENCES

1. Mirsxulava S.Y. Fundamentals of physics and mechanics of channel erosion. Gidrometeoizdat. 1988. 303 p.;
2. Velikanov M.A. Channel process. - Fizmatgiz. 1958. 396 p.;
3. Abalyans S.X. Stability and transition regimes in artificial channels. - Hydrometeoizdat. 1981. 245 p.;
4. Arifjanov A.M. Distribution of Suspended Sediment Particles in a Steady-State Flow. Water Resources. Volume 28, Issue 2, 2001, Pp.164-166. DOI: 10.1023/A:1010375500148;
5. Arifjanov A., Akmalov Sh., Akhmedov I., Atakulov D. Evaluation of deformation procedure in waterbed of rivers. XII International Scientific Conference on Agricultural Machinery Industry. 2019. DOI:10.1088/1755-1315/403/1/01215;
6. Kasvi E. Fluvio-morphological processes of meander bends – combining conventional field measurements, close-range remote sensing and computational modelling. Sarja - ser. A II osa. tom. 298. Painosalama Oy-Turku, Finland 2015;
7. Arifjanov A., Samiyev L., Qurbonov Q., Apakxo'jaeva T., Yusupov Sh., Atakulov D. Processes of Mirishkor channel using GIS technologies. IOP Conference Series: Materials Science and Engineering Volume 918, Issue 1, 6 October 2020, DOI: 10.1088/1757-899X/918/1/012143;
8. Rebecca A.H., David A.S., Julian L. Spatial variations in surface sediment structure in riffle-pool sequences: a preliminary test of the Differential Sediment Entrainment Hypothesis (DSEH). Earth Surface Processes and Landforms. Volume 38. Issue 5. Pp. 449-465. 2013. doi.wiley.com/10.1002/esp.3290;
9. James D. Riley, Bruce L. Rhoads Flow structure and channel morphology at a natural confluent meander bend. Geomorphology 163–164 (2012) Pp.84–98. doi.org/10.1016/j.geomorph.2011.06.011;
10. Daniel A., Getachew W. Quantitative analysis of morphometry on Ribb and Gumara watersheds: Implications for soil and water conservation. International Soil and Water Conservation Research 7 (2019) Pp. 150–157. doi.org/10.1016/j.iswcr.2019.02.003;
11. Fang X., Hengxu H., James G., Hongbo Zh., Dongya K. Quaternary sediment characteristics and paleoclimate implications of deposits in the Three Gorges and Yichang areas of the Yangtze River. Geomorphology 351 (2020) 106981 Contents. doi.org/10.1016/j.geomorph.2019.106981;
12. Salmela J., Kasvi E., Vaaja M.T., Kaartinen H., Kukko A., Jaakkola A., Alho P. Morphological changes and riffle-pool dynamics related to flow in a meandering river channel based on a 5-year monitoring period using close-range remote sensing. Geomorphology 352 (2020) 106982 Contents. doi.org/10.1016/j.geomorph.2019.106982;
13. Zhang H., Steven M., Paul V., Xiaodong Zh. A remote sensing method for estimating regional reservoir area and evaporative loss. Journal of Hydrology. Volume 555. Pp. 213-227. 2017. doi.10.1016/J.JHYDROL.2017.10.007;
14. Jeleznyakov G.V., Talmaza V.F. Zavisimost parametrov profiley skorostey ot gidravlicheskix soprotivleniy. Gidrotexnicheskoye stroitelstvo. – Moskva. 1973. S 33-35.;
15. Samiyev L., Allayorov D., Atakulov D., Babajanov F. The influence of sedimentation reservoir on hydraulic parameters of irrigation canals. IOP Conference Series: Materials Science and Engineering Volume 883, Issue 1, 20 July 2020, DOI: 10.1088/1757-899X/883/1/012031;
16. Abduraimova D., Atakulov D., Ibragimova Z., Apakhodjaeva T. Evaluation of erosion and accumulative process with using Geoinformation systems in water resource management. International Conference on Information Science and Communications Technologies: Applications, Trends and Opportunities, ICISCT 2019, 9012020;
17. Kadirov A.A. Morfometricheskiye zavisimosti dlya ustoychivix rusel kanalov v melkopeschanix gruntax.- Trudi SANIIRI, 1985. 174 s.;
18. Babajanov F., Atakulov D. Evaluation of the hydraulic and morfometric connections of the riverbed with using GIS. IOP Conference Series: Materials Science and Engineering. Volume 869, Issue 4, 9 July 2020, DOI: 10.1088/1757-899X/869/4/042028.

DETERMINING THE AVERAGE DIAMETER OF SEDIMENTS TRANSPORTED BY THE DEBRIS FLOW

K. Dadiani, I. Qufarashvili, M. Mghebrishvili, L. Maisaia, N. Nibladze
Ts. Mirtskhulava Water Management Institute of Georgian Technical University
Tbilisi, Georgia
E-mail: q.dadiani@gtu.ge

INTRODUCTION

Based on reconnaissance works and field studies conducted on the results of the passage of the debris flow in the debris flow-generating basins, the need to study the sedimentary processes in the channels, their stability, and the development of new innovative engineering solutions, building norms and rules are identified.

Due to the most difficult problems raised in the transit zones of the debris flow channels, the issue needs to be solved in a complex manner during the selection of various stabilization measures against debris flows, namely, blind and open structures. The issue of regulation is being carried out with an insufficient volume and long intervals. This applies both to the construction of run-of-river structures and to their cleaning works, where the leading role is played by the stream condition.

The assessment of natural disaster events and the quantification of their parameters, which are then considered as determining factors for engineering decisions, play a special role in the establishment of a decentralized infrastructure for a sustainable environment.

In order to determine the power of debris flow sand their dynamic impact on structures of different purposes, determining the average diameter of sediments transported by the debris flow is of great importance.

MAIN PART

In order to solve the problem, field studies were carried out in the Monastic ravine. Three reporting sections were selected, samples of sedimentary mass, within 10-12 kg limits, were collected from the riverbed. The collected samples were analysed in the Hydraulic Engineering Laboratory of Ts. Mirtskhulava Water Management Institute of Georgian Technical University. Granulometric sieves with different gradations were selected for the research.

As a result of the study of the soil sedimentary mass, the following indicators were obtained (see Table 1):

Table 1

Laboratory Tests (Sample I)

#	Sieve sizes	Weight of the sample (kg)	Percentage content of sample (%)	Coordinates of the integral curve of granulometry
1.	>4,0	3,600	30,00	100
2.	4.0÷20=30,00 cm	4,400	36,66	70,0
3.	20÷10=15,00 cm	2,300	19,17	33,34
4.	10÷5=7,50 cm	0,900	7,50	14,17
5.	5÷2,5=3,75 cm	0,400	3,33	6,67
6.	2,5÷1,25=1,875 cm	0,100	1,13	3,34
7.	1,25÷0,63=0,94 cm	0,090	0,75	2,2

8.	0,63÷0,315=0,473 cm	0,070	0,58	1,46
9.	0,315÷0,14=0,227 cm	0,064	0,54	0,87
10.	0,14<	0,040	0,34	0,34
		$\sum = 12{,}00$ kg	$\sum = 100\% = 100$	

Table 2

Laboratory Tests (Sample II)

#	Sieve sizes	Weight of the sample (kg)	Percentage content of sample (%)	Coordinates of the integral curve of granulometry
1.	>4,0	2,000	1,6	100
2.	4.0÷20=30,00 cm	4,000	31,3	83,4
3.	20÷10=15,00 cm	3,500	28,3	52,10
4.	10÷5=7,50 cm	1,270	10,5	23,8
5.	5÷2,5=3,75 cm	0,700	5,8	13,3
6.	2,5÷1,25=1,875 cm	0,300	2,5	7,5
7.	1,25÷0,63=0,94 cm	0,050	4,1	5,0
8.	0,63÷0,315=0,473 cm	0,08	0,6	0,9
9.	0,315÷0,14=0,227 cm	0,03	0,2	0,3
10.	0,14<	0,02	0,1	0,1
		$\sum = 12{,}00$ kg	$\sum = 100\% = 100$	

Table 3

Laboratory Tests (Sample III)

#	Sieve sizes	Weight of the sample (kg)	Percentage content of sample (%)	Coordinates of the integral curve of granulometry
1.	>4,0	0,500	3,1	100
2.	4.0÷20=30,00 cm	2,500	18,8	96,9
3.	20÷10=15,00 cm	2,400	19,0	78,1
4.	10÷5=7,50 cm	3,200	20,6	59,1
5.	5÷2,5=3,75 cm	1,770	12,7	38,5
6.	2,5÷1,25=1,875 cm	0,200	14,6	25,8
7.	1,25÷0,63=0,94 cm	0,900	7,0	11,2
8.	0,63÷0,315=0,473 cm	0,500	4,0	4,2
9.	0,315÷0,14=0,227 cm	0,02	0,2	0,2
10.	0,14<	0,01	0	0
		$\sum = 12{,}00$ kg	$\sum = 100\% = 100$	

Using statistical indicators (see Tables 1-3), we construct integral curves of granulometry of debris flow sediments for all three samples, which are presented on the graphs (see Fig. 1, 2, 3).

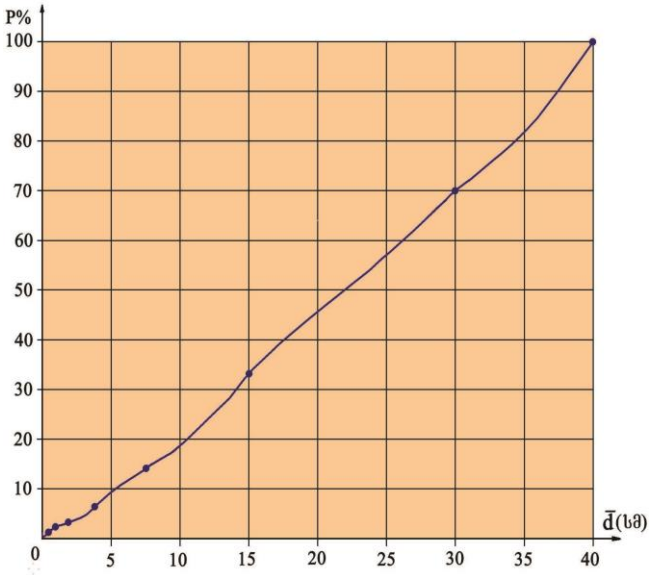


Fig. 1. Integral curve of granulometry of the first sample

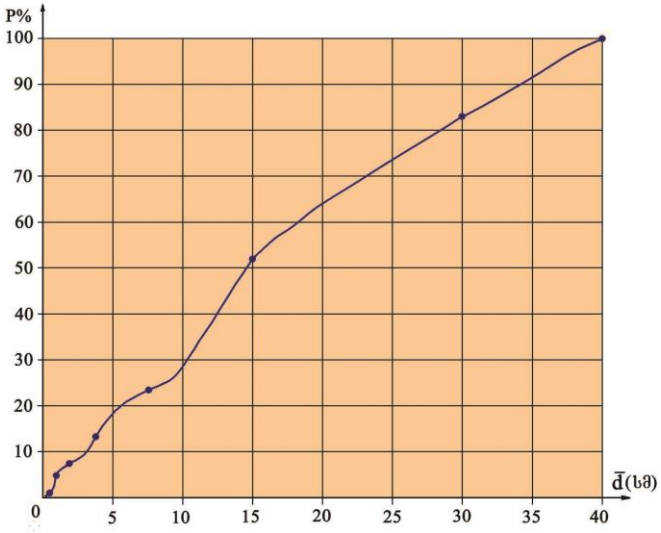


Fig. 2. Integral curve of granulometry of the first sample

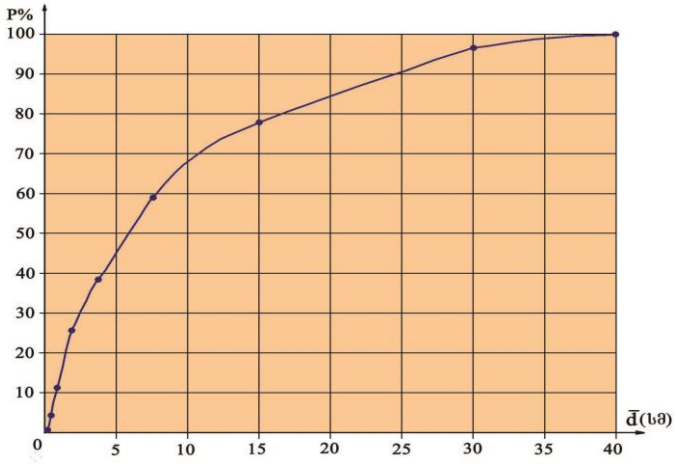


Fig. 3. Integral curve of granulometry of the first sample

Using the obtained data and the known empirical relationship, we calculate the average diameter of the output according to the following relationship:

For the I-st Sample: $\overline{d} = \sum_{i=1}^{n} \frac{P_i d_i}{100} \approx 26{,}5\text{mm} \approx 2.6\text{ cm}$

For the II-nd Sample: $\overline{d} = \sum_{i=1}^{n} \frac{P_i d_i}{100} \approx 14{,}8\text{ mm} \approx 1.5\text{ cm}$

For the III-rd Sample: $\overline{d} = \sum_{i=1}^{n} \frac{P_i d_i}{100} \approx 11{,}0\text{ mm} \approx 1.1\text{ cm}$

Thus, as a result of field studies, laboratory processing and mathematical calculations, the limits of variation in the average diameter of the samples were determined, and the average diameter of debris flow sediment in the Monastic ravine in the reporting section is:

$$\overline{D} = \frac{d_1 + d_2 + d_3}{3} = \frac{2{,}6 + 1{,}5 + 1{,}1}{3} = \frac{5{,}2}{3} = 1{,}73\text{ cm}$$

Using the average diameter of alluvial discharge, the average velocity of the alluvium, flow rate, transportability of solid sediments and specific flow of solid fractions of sediments are calculated at the next stage.

CONCLUSION

Based on the results of the passage of debris flow, reconnaissance work and field studies make it possible to calculate the magnitude of the dynamic force of the impact of debris flow on the structure, which allows us to assess the reliability of the structure and the risk of structural failure at the next stage.

REFERENCES

1. Dadiani K. "Sustainability of hyperconcentrated mudflow and possibilities of impact on the structure" (dissertation 2022, p. 139)
2. Tevzadze T., Shavlakhadze M., Dadiani Q. Problems of adaptation of natural-technogenic complexes and engineering structures in conditions of global warming. Collection of Works of the LEPL Institute Hydrogeology and Engineering Geology, vol. XVII, 2010. (*in Georgian language*).
3. Diakonidze R., Kharaishvili O., Charbadze Z., Dadiani Q., Nibladze N., Sukhishvili N., Lortkipanidze Ph. Elaboration of the sensitivity and risk assessment criteria of expected ecological problems caused by disasters, their use for the prevention of the mentioned problems (Georgia). Collected Works of the Ts. Mirtskhulava Water Management Institute of Georgian Technical University, #69, 2014, p. 78-83. (*in Georgian language*).
4. Natishvili O., Charbadze Z**.,** Dadiani K., Nibladze N. Numerical calculation of uneven traffic flow of hyper-concentrated sediment loaded mudflow with variable expenditures along its traffic. 4th International scientific and technical conference "Modern problems of water management, environmental protection, architecture and construction", September 27-30, 2014. Dedicated to the 85 Anniversary of the Water Management Institute.
5. Gavardashvili G., Kukhalashvili E., Kvirkvelia I. The danger of debris flows in the Stephantsminda region (Kazbegi) and ways to combat natural disasters. VI International Conference "Modern Problems of Water Management, Environmental Protection, Architecture and Construction", Tbilisi, 2016. (*in Georgian language*).

CLIMATE CHANGE-INDUCED DISASTERS AND THEIR PREVENTION

R. Diakonidze, J. Phanchulidze, L. Tsulukidze, I. Kvirkvelia,
K. Dadiani, N. Nibladze, M. Glunchadze
Ts. Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60b, 0179, Tbilisi, Georgia
E-mail: robertdia@mail.ru

INTRODUCTION

It is widely recognized that Earth is experiencing global climate change, resulting in frequent torrents and high-intensity precipitation events. Sometimes, rainfall within 1-2 days can equal the monthly norm. That's why excess water runoff leads to unpredictable ecological problems. Various regions of the world are affected by these challenges at different levels and results. Countries with mountainous terrain, such as Georgia, are particularly sensitive to this process.

MAIN PART

Since the turn of the century, the occurrence of natural disasters has increased significantly, particularly freshets, floods, erosion-debris flows, and landslides. Glaciers in mountainous regions are shrinking in size over time. On some mountains, the snow cover has disappeared completely. Mount Kilimanjaro is one example. The warm flow of the Gulf Stream is changing, and the ocean and sea levels are rising. In addition, vegetation has appeared in some deserts, such as the Atacama Desert in Brazil. In certain areas, there is a different process occurring where desertification is happening [1,2].

Due to humanity's inability to tackle climate change, it's necessary to conduct large-scale scientific research directly in the field.

The Tsotne Mirtskhulava Water Management Institute of the Georgian Technical University has been conducting research in the field of natural disasters for almost 100 years. Since the institute's establishment, the "Department of Natural Disasters and Environmental Protection" has been formed and functions as the only and oldest relevant department in the Republic. It is enough to enumerate the experts who are working in the mentioned above direction: Doctor of Science, Professor Mikheil Gagoshidze, Academician Otar Natshvili, Doctor of Science Vakhtan Tevzadze, famous scientists father and son Ilia and Yuri Sarkeulidze, Levan Sulakvelidze, Zaliko Iordanishvili, Dato Fruidze, Lia Sokhadze, Bedineir Kaladze. Scientists working today are successfully continuing the footsteps of the above-mentioned scientists: Academician Givi Gavardashvili, Dr. Eduard Kukhalashvili, and the article authors.

Scientists of the institute have been conducting field scientific research in nature for several decades. In addition to the thematic program research, they conduct research almost every year directly in the disaster zone, investigate the causes of the disaster, and present appropriate preventive measures.

Below are presented the field studies conducted in 2023 in Sighnaghi Municipality. The research objects were studying the causes and making relevant conclusions of the Bodbe St. Nino Nunnery flooding and the damaged section of the Sighnaghi-Dedoflistskaro highway.

The employees of the Tsotne Mirtskhulava Water Management Institute of the Technical University of Georgia Chief Scientist, Professor Robert Diakonidze, Head of the Natural Disasters and Environmental Protection Department, Jumber Phanchulidze, Levan Tsulukidze - Chief Scientists of the same department, and Irakli Kvirkvelia, the scientist of the innovative research group, to study the flood caused by the high-intensity rainfall in Sighnaghi municipality on June 20, 2023, and already mentioned ecological problems, were in the disaster zone.

First, we began to study the flooding of the Bodbe St. Nino Monastery, an outstanding monument of the spiritual life of Georgia. On the instructions of Igumenia Theodora, the monastery abbot nun Tamara

guided and consulted us during the familiarization with the problems caused by the natural disaster. We were shown a video recording of the flood (picture 1).

Picture 1. Flooded yard of Monastery

The flood caused damage to the waterdrainage system. The intense rainfall also damaged the nearby "Pilgrim" building. Some agricultural and decorative plants on the monastery grounds were also affected. In addition, the bypass at the back of the monastery (picture 2) has been damaged and requires rehabilitation work, especially as it is located in the landslide zone.

As the research showed, the disaster caused high-intensity heavy rain (according to nun Tamar, the rain fell for about 30 minutes), which led to the formation of a critical amount of surface water runoff. The road on the slope to the northwest of the monastery appeared as an artificial water-flow bed on which the water easily moved (the slope of the road is directed towards the entrance road to the monastery). The main part of the formed water rushed into the territory of the monastery. Despite the water drainage system at the entrance, it was unable to handle the water flow efficiently, resulting in a significant amount of water entering the monastery's territory and causing the aforementioned issues.

Picture 2. The damaged bypass at the back of the monastery

Based on all of the above, our goal was to determine the predicted values of the surface runoff of water formed on the monastery's surrounding area (the so-called catchment basin) for different percentage provisions (for repetition) so that additional drainage systems can be designed according to the obtained results.

Based on relevant studies and calculations, the recommended method of hydrological investigations (G. D. Rostomov - Technical instructions for reporting the maximum runoff of rivers in the Caucasus, Tbilisi, 1980, p. 71) was used to determine the prognostic values of surface water runoff expected in the territory of Bodbe Monastery (with 1000, 100, 50, 20, and 10-year recurrence) [3]. The obtained results are presented in Table 1.

Table 1

Bodbe Monastery territory surface water runoff prognostic values

#	Hydrological characteristics	Recurrence in years				
		1000	**100**	**50**	**20**	**10**
1	Water consumption (m^3/s)	4,67	1,95	1,49	1,05	0,81
2	Runoff volume (m^3/30 min)	8406	3510	2682	1890	1450
3	Drain layer height (mm)	65	27	21	14,5	11,2

The damaged road section is on the new road connecting Sighnaghi and Bodbiskhevi village along the Jabaantkhevi water channel bed. This water channel joins an unnamed ravine from the south, and the road sharply bends and the place of join. The water flow formed in these ravines damaged the embankment of the highway - a gabion of stone piles (Picture 3).

Picture 3. Damaged embankment of highway - stone pile gabion

It is important to note that the local population relies on drinking water from the mentioned ravines, where water intake wells are installed. A water catchment construction is located in the bed. In order to protect the mentioned structure from damage, the bed of Jabaantkhevi was redirected from the right side to the left side of the road by means of a bridge. We believe that the bridge in question was designed and constructed incorrectly. The stone pile gabion on the road connecting Sighnaghi-Dedoflistskaro failed to protect against excess water flow due to incorrectly settled parameters.

Even though the gabion protecting the road bank was built violating technical regulations, without support pads, causing its damage, we still calculated the predicted values of the maximum water consumptions expected on the ravines for a recurrence of 100 years i.e. 1% guarantee, because, in recent years, the surface runoff of water, formed in the background of climate change, reaches such high levels that in dry ravines (water channels) the formation of water flows of critical magnitude often occurs.

The maximum water consumptions for the above-mentioned ravines were determined by G.D. Rostomov method and compiled:

1. Jabaantkhevi $Q_{1\%}$ = 12.5 (m^3/s);
2. Unnamed ravine $Q_{1\%}$=12.3 (m^3/s).

CONCLUSIONS

- The Bodbe St. Nino Monastery experienced a water flow intrusion due to intense rainfall, which led to excessive surface runoff from the surrounding slope (it can be called a water catchment area). The water drainage system at the entrance of the monastery was unable to cope with the excess surface runoff, resulting in a significant amount of water entering the monastery grounds. The flow of water caused flooding in the courtyard, leading to damage to the sewage system, decorative plants, and a portion of the garden. At the bypass road at the back of the monastery, at the head of the dry valley, where the

landslide has developed, the road soil has moved from the reinforced concrete structure and the road support girders to become exposed. The Pilgrim Cafe bar, owned by the monastery and intended for visitors, was also damaged.

- To tackle the issues at hand, we have identified the anticipated predictive maximum values of surface water consumption for various percentages (recurrence in years). That will help us determine the parameters of the water drainage system for potential future rehabilitation projects (see Table #1 in the text).We believe that it is essential to install more water drainage collectors along the entrance road leading to the monastery grounds (ideally, in two places), and the water should be directed towards the ravine situated in the southeast of the monastery territory. Diverting the surface runoff into the ravine would help to reduce the risk of landslides.Regarding the water that entered the "Pilgrim" cafe bar, it was caused by heavy rainfall that exceeded the capacity of the pipes on the roof, possibly due to garbage clogging the pipes. With the onset of climate change, it is necessary to address the issue of frequent high-intensity precipitation events that produce almost as much precipitation as a typical month. Installing an additional drainage system on the roof of the building could solve the problem.

  The damaged section of the road is situated on the new road that connects Sighnaghi and Bodbiskhevi village. This particular section runs along the bed of Jabaantkhevi, a water channel that is joined by an unnamed ravine from the south. At the point where they converge, the road has a sharp bend. During the flood, the water flow formed in these ravines caused damage to the road's embankment - a stone pile gabion.

  It's important to note that the local population relies on drinking water from the ravines, where water intake wells have been installed. A water catchment construction is situated in the ravine bed. To avoid its damage, the bed of Jabaantkhevi was redirected from the right side to the left side of the highway by means of the constructed bridge. However, we believe that the bridge was poorly designed and built. Incorrectly set parameters for the stone pile gabion on the Sighnaghi-Bodbiskhevi village highway resulted in the road being vulnerable to excessive water flow.
- According to the research, the stone gabion embankment in the Sighnaghi-Bodbiskhevi village section of the highway was damaged. Due to heavy rain, a significant amount of runoff formed in the waterways at the junction of Jabaantkhevi and its right tributary - the unnamed ravine, which led to the damage. The main reason for the gabion's damage is a gross violation of construction regulations, specifically the absence of support pads.
- Adjacent to the mentioned highway, there is an incorrectly designed and built bridge, through which the bed of the Jabaantkhevi River is redirected from the right side of the road to the left side to protect the drinking water intake facility.
- Despite all the above, we take into account that in recent years, against the background of sharp changes in the climate, in a short period, there has been an increase in the frequency of high intensity and abundant precipitations, as a result of which large volumes of water runoff are formed in so-called dry ravines, and we considered it expedient to determine a 1% guarantee of the maximum water runoff prognostic values (100-year repeatability), which was $Q_{1\%} = 12,3$ (m/s) for Jabaantkhevi, and $Q_{1\%} = 12,3$ (m/s) for the unnamed ravine.

REFERANCE

1. R. Diakonidze, B. Diakonidze - Natural events, ecological disasters, and changes in the natural environment against the background of global warming. Geography of Georgia, Tbilisi University Publishing House, Tbilisi, 2006, pp. 82-85;
2. R.V. Diakonidze, I.V. Khubulava, Kh.L. Kiknadze, F.N. Lortkipanidze, M.Z. Navrozashvili, K.D. Dadiani – Climate change of the planet and hydro-ecological environmental problems. Ecological systems and devices, Publishing house "Nauchtekhlitizdat", Moscow, 2008, pp. 45-47;
3. G.D. Rostomov - Technical instructions for reporting the maximum runoff of rivers in the Caucasus. Tbilisi 1980 p. 71.

DEBRIS FLOW REGULATING ELASTIC BARRAGE (Innovation, modeling, design, construction)

G. Gavardashvili[1),2)], E. Kukhalashvili[1),2)], I. Iremashvili[1),2)]

[1)] Tsotne Mirtskhulava Water Management Institute of Georgian Technical University

[2)] Ecocenter for Environmental Protection the Organization in Category of Consultative Status with the Economic and Social Council (ECOSOC) of UN, Tbilisi, Georgia

E-mail: givi_ gava@yahoo.com

INTRODUCTION

The Georgian military road, starting from Tbilisi and running to Larsi for almost 170 km, is a mountainous and piedmont landscape where natural disasters such as floods, water erosion of mountain slopes, debris flows, landslides, snow avalanches, and mountain slope collapses are active every year (Fig. 1). This area is the catchment basin of the rivers Aragvi (Black Sea basin) and Tergi (Caspian Sea basin), which is often called the natural laboratory of origin of natural disasters.

The Aragvi River in the territory of Georgia flows as four different rivers: Tetri Aragvi, Shavi Aragvi, Pshavis Aragvi and Khevsuretis Aragvi. Presently, the catchment basin with most active natural disasters is the erosiove-debris flow basin of the Mleta River gorge, the right tributary of the Tetri Aragvi River. This very basin is the object of our scientific study (see Fig. 2), where floods occur at least 4 times a year.

Fig. 1. Geographic location of the study object

Fig. 2. View of the talus train filled with sediments of the Mleta River gorge

The debris flows formed in the Mleta River gorge channel often block the Tetri Aragvi Riverbed (Fig. 3), thus forming a natural barrier with a micro-reservoir. In case of critical parameters, the water mass disrupts this barrier and solid fractions, together with the debris flow mass, flows towards the Zhinvali reservoir thus reducing the lifetime of the Zhinvali HPP.

Besides, the debris flows formed in the Mleta River gorge channel put the St. Georgia Church of Mleta dated by 1876 to the risk of destruction (Fig. 4), and the local population of Kvemo Mleta (Dusheti Municipality, Georgia) are also in danger.

Fig. 3. Debris flow formed in the Mleta River gorge channel blocked the Tetri Aragvi Riverbed

Fig. 4. Yard of the Church of Mleta covered with debris flow mass and solid fractions

Following the above-mentioned, regulation of the Mleta gorge channel, the right tributary of the Tetri Aragvi, is of great strategic importance for Georgia, as sediment accumulation in the riverbed through the facility is the only engineering and technical solution for stabilizing the riverbed.

In order to determine the amount of solid sediment transported by a debris flow, field expedition studies were conducted and it was found that the average diameter of solid fractions transported by the flow varied between 15 and 45 cm (Fig. 5).

Fig. 5. General view of solid sediment transported to the Mleta River gorge channel by the debris flow

2. STRUCTURAL DESCRIPTION OF THE ELASTIC DEBRIS FLOW-REGULATING BARRAGE

Natural anomalies, debris flows in particular, are of a particular importance for designing efficient engineering solutions. Debris flow is a terrible phenomenon of the natural calamities and the regulation measures are associated with their genesis and dynamics.

The rigidity and structural solutions of the barrages used in practice fail to transform the flow on the pressure surface or redistribute the dynamic force.

By considering the above-mentioned, an innovative structure of the elastic debris flow-regulating barrage was designed by the joint efforts of the scientific workers of Ts. Mirtskhulava Water Management Institute of Georgian Technical University and NGO Ecocenter for Environmental Protection, with its Know-How approved by the Patent License of Georgia [2].

The sections of the elastic debris flow-regulating barrage are made of triangular prisms of the same height inserted in the bed, tight packed with their side faces. The base heights of the prisms increase along the debris flow current and form a springboard. The structure's top is directed against the current and there are elastic ropes stretched between the edges above the prisms connected with one another with the lateral ropes forming pockets between the edges to receive the debris flow mass. This type of barrage allows receiving debris flow smoothly (See Fig. 6).

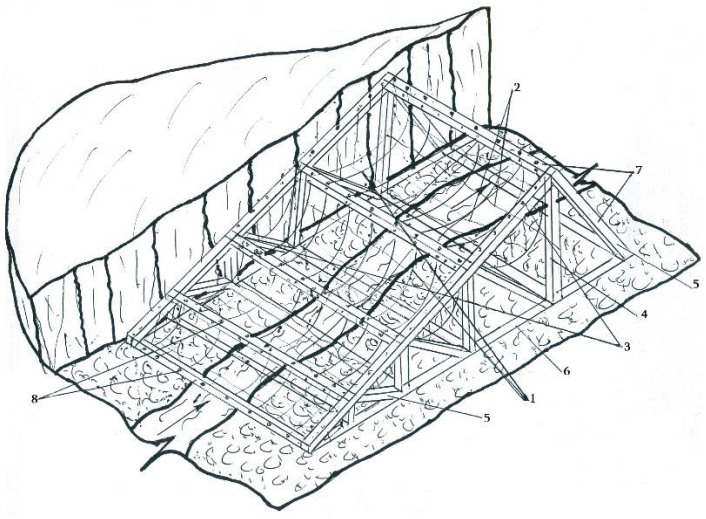


Fig. 6. General view of the elastic debris flow-regulating barrage

Elastic debris flow-regulating barrage (1) is made of sections connected to one another, which are made of triangular prisms of equal heights (2); the sections with side faces (3) are inserted in the bed in close sequence. The base heights of the prisms (4) increase in the debris flow direction and form a springboard. The top of the facility is directed against the current. The upper edges of the prisms have holes (5) or clamps to stretch elastic ropes (6) between them, while there are lateral ropes (7) stretched across the elastic ropes forming pockets between the sections to receive the debris flow mass. The ropes are attached at the bases with the openings (8) to fasten the ropes.

The sizes of the elastic debris flow-regulating barrage are calculated by considering the expected strength of debris flow and topographical properties of the location. When the structure is used as an elastic debris flow-regulating barrage, the current flows up the elastic surface and the impact force is distributed along its length as follows:

As the debris flow moves, the debris flow-retaining pockets in the first section of the facility receive the major dynamic impact force at the time of the flow passage, while the energy is further damped on the surface of the springboard, gradually and smoothly under the action of the elastic surface. The sizes of the

network of the debris flow-retaining pockets are designed by considering the diameters of the stones drifted by the expected debris flow.

The technical-economic advantage of the existing structures is the opportunity of removing the ropes of the facility and cleaning the facility making it possible to use it for many times.

Besides, the construction elements with less complex shapes are used to build the facility thus reducing the cost of construction. In addition to the above-mentioned, the technical-economic efficiency of the structure is high due to its trouble-free and long operation making it possible to avoid additional operational costs.

3. LABORATORY MODELING OF THE ELASTIC DEBRIS FLOW-REGULATING BARRAGE

For the sake of laboratory modeling of the elastic debris flow-regulating barrage, a hydraulic duct was selected at the hydraulic laboratory of Ts. Mirtskhulava Water Management Institute of Georgian Technical University with sizes: width: 0,36 m, height: 0,29 m, length: 12 m, duct gradient alteration: 0,01-0,06, [6-8].

Fig. 7. Laboratory model of the elastic debris flow-regulating barrage

Fig. 8. Model of the elastic debris flow-regulating barrage in the hydraulic duct

Fig. 9. Debris flow regulation elastic barrage during the laboratory tests

As for the model of the elastic debris flow-regulating barrage, by considering the parameters of the hydraulic duct, they are as follows: length of the model barrage: 0,60 m, width: 0,36 m, maximum height of the barrage: 0,15 m, number of steps: 3, step base length: 0,20 m, sizes of the open-end network to be installed in the elastic pockets: 5-7 mm with the first option, 4-5 mm with the second option and 2-3 mm with the third option.

By considering the above-mentioned, a laboratory model of the elastic debris flow-regulating barrage was made with its general view given in Fig. 7. Figure 8 shows the laboratory model of the structure in the hydraulic duct.

Experiments on the laboratory model of the elastic debris flow-regulating barrage will be done during the motion of the turbulent debris flow through the debris flow duct by observing the following parameters of modeling similarity[3,8]: the laboratory experiments will be done for debris flow motion through the hydraulic duct for dynamic similarity (*Fr = ident*), geometrical similarity (bed gradient: *i = ident*), drift motion ($V_{water} / V_{sediments}$ = *ident*), bed resistance coefficient (Chezy coefficient *C = ident*).

4. CONSTRUCTION DESIGN AND BUILDING

The dynamic impact of the flow on the innovative debris flow control structure is calculated with the following dependence:

$$P_1 = \frac{\gamma \omega V^2}{g} \sin \psi \; f(m) , \quad (\text{N/m}^2) \tag{1}$$

Where γ is the volume weight of the debris flow (N/m^3); ω is the area of the effective cross-section (m^2); V is the flow velocity (m/s); ψ is the gradient angle to the structure base (^{0}); ψ is the internal friction coefficient and equals to:

$$\psi = tg^2\left(45^0 - \frac{8}{2}\right) ; \tag{2}$$

Where h_0 is the equivalent depth of cohesiveness (m); H is the depth of current (m); a is the coefficient $(1-h_0/H)\psi$. $f(m)$ is the coefficient and depends on the rheological properties of the debris flow:

$$f(m) = \frac{16 - \left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2}{\left(\alpha^3 + 4\alpha\sqrt{\alpha}\right)\left(2+\sqrt{\alpha}\right)^2} \tag{3}$$

The innovative debris flow control structure is a bearing frame of a metal structure with steel details. Considering the technical characteristics of the structure, a point foundation was selected for it, and waterproof concrete W8, Class B25, made with Portland cement was used for the foundations. The structure, which is in contact with the ground and the river filtration current, is waterproofed with up-to-date insulating materials. The bearing structure of the anti-debris flow control barrage, as a single spatial system, is designed for permanent and temporary dynamic loads. The calculation was performed with software „Lira Sapr 2019" (License Number 1/7165).

The detail project is developed in accordance with normative documents effective in the territory of Georgia: Concrete and reinforced concrete structures (03.01.-09); Building Foundations (DN 02.01-08); Building climatology (DN 01.05-08); SNiP 2.01.07.85 Loads and Impacts; SNiP II-23-81: Steel structures; SNiP 2.03.11-85: Protection of structures against corrosion. The calculation results are given in Figure 10.

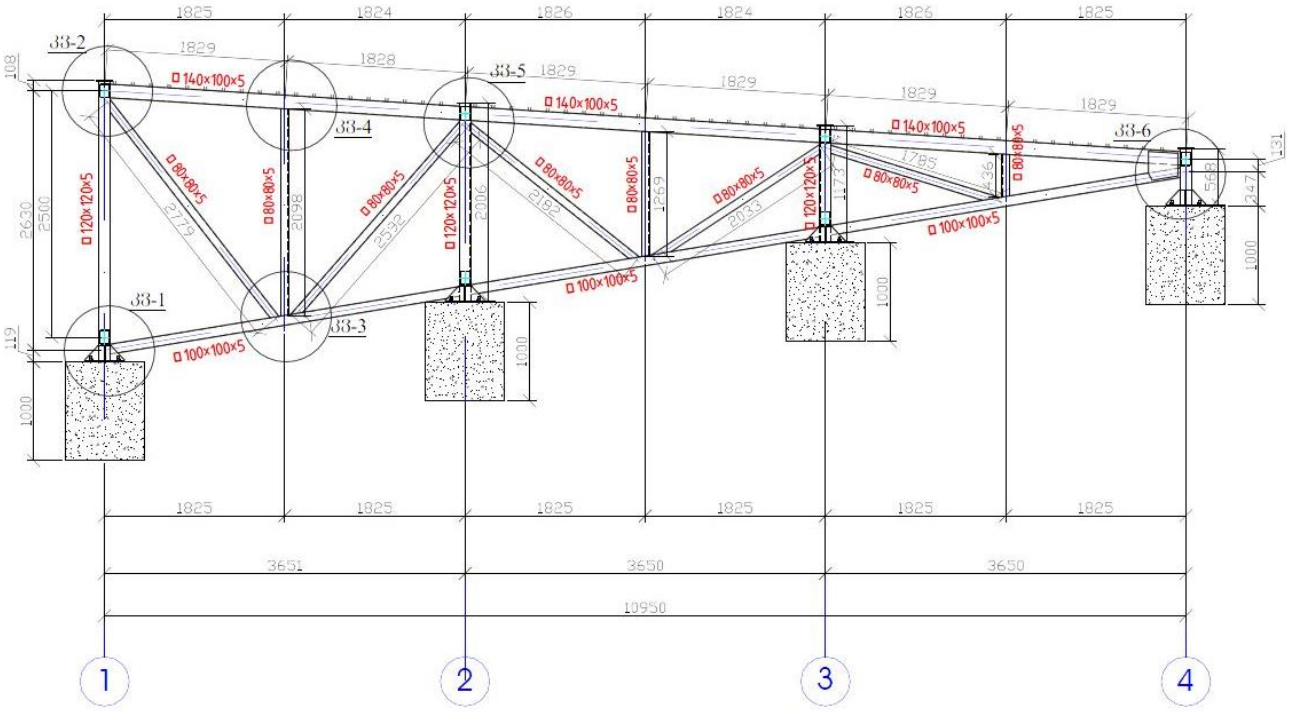


Fig. 10. Longitudinal section of the debris flow regulation structure

The volume of solid fractions accumulated in the headrace of the debris flow regulation elastic barrage is calculated as a function of time according to the following dependence:

$$W_t/W_T = \left[0{,}90 + 0{,}10\left(\bar{d}/\Delta\right)^{1{,}51}\right] (t/T)^{2{,}34}, \qquad (5)$$

Where W_t is the volume of solid fractions retained by the structure at a given moment of time (m^3), W_T is the total volume of fractions retained at the headrace of the structure (m^3); ($W_T = q_{sd}.B.T$), (m^3), B - width of the river bed (m); Δ is the permeability factor of the structure, t is the elementary time period (min), T is the time of complete filling of the structure with sediments in its headrace (min). There are metal cables suspended from the steps of the structure to make the barrage open-end by providing square holes (0.15 x 0.15 (m^2). According to the design data, the structure carries water mass with solid fractions less than 0,15 m to the tailrace, while the solid fractions greater than 0,15 m remain in the headrace of the structure.

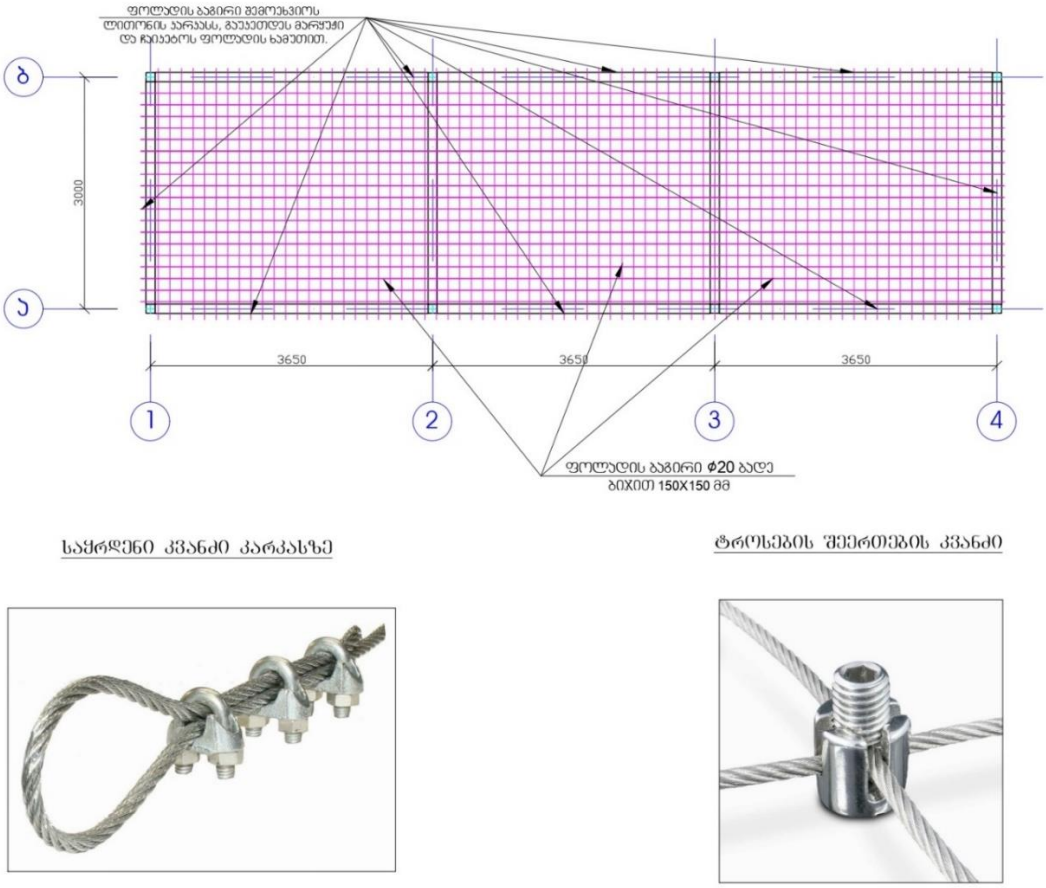


Fig. 11. Construction view in plan and nodes

Based on the conducted theoretical, laboratory and field studies, in order to regulate the solid fractions in the Mleta riverbed at 1600 m asl, in October of 2022 an experimental model of the debris flow regulation elastic barrage was built by us, and the debris flow formed in May of 2023 filled the first step of the structure with solid fractions. The general view is given in Figure 10.

View of the structure before the debris flow passage

View of the structure after the debris flow passage

Fig. 12. General view of the debris flow regulation elastic barrage regulating solid fractions

The expedition and field scientific studies and their analysis in the headrace of the elastic debris flow control barrage have yielded the following results: the structure contained the debris flow mass together with solid fractions in the headrace along a 30-m section, the volume of which is 112 m^3, and the height of the debris flow mass at the first step of the structure was 1.0 m (Fig. 11). The weight of the largest stone transported by the debris flow and retained in the headrace of the structure was 1.19 tons. The riverbed slope was 15° in the headrace of the structure before the debris flow passage in the riverbed, and the slope of the longitudinal profile of the surface of the debris flow mass accumulated in the headrace of the structure after the debris flow passage decreased by 4° to 11°.

Fig. 13. General view of the debris flow regulation elastic barrage

4. CONCLUSIONS

Based on the theoretical, laboratory and field scientific studies conducted under the financial support of the grant project of the Shota Rustaveli National Science Foundation of Georgia "Debris flow regulation elastic Barrage" in 2020 – 2023, the following basic conclusions can be made:

- An innovative design of an debris flow regulation elastic barrage, the priority of which is confirmed by a Georgian patent, has been developed to stabilize mountain riverbeds;
- In order to effectively regulate sediments in riverbeds, laboratory experiments were conducted on the model of the debris flow regulation elastic barrage, when two-phase flows loaded with sediment of different diameters were flowing in the hydraulic channel;
- Based on the conducted experiments, the methodology as well as hydrological and hydraulic calculations of turbulent debris flows were worked out and used to develop a working design of the debris flow regulation elastic barrage;

- By using the working design, an experimental structure of the debris flow regulation elastic barrage was installed in the Mleta riverbed in September and October of 2022;

- In May 2023, turbulent debris flow was formed in the Mleta River gorge bed, and the flow affected the experimental model of the debris flow regulation elastic barrage with a dynamic impact force. The structure did not collapse and is operable to date proving its reliability.

ACKNOWLEDGEMENTS

The research was financial supported by Shota Rustaveli National Science Foundation of Georgia, Grant # AR-18-1244 "Elastic debris flow-regulating barrage" Solid Sediments Movement Regulating Innovative Debris Flow Elastic Barrage.

REFERENCE

1. A. Armanini., M. Larcher & M. Odorizzi– Dinamic Impact of a Debris Flow Front Against a Vertical Wall. 5th International Conference on Debris-Flow Hazards (Mitigation, Mechanics, Prediction and Assessment). Padua, ITALY, 14-17 June, 2011, pp. 1041-1049.
2. G. Gavardashvili, E. Kukhalashvili, Sh. Kupreishvili, N. Gavardashvili - Elastic debris flow-regulating barrage. Georgian Patent #AP 2019 14656 A. Official, Bulletin of the Industrial Patent #15(523), SAKPATENTI, 12/08/2019, Tbilisi, 2019, p. 6.
3. G. Gavardashvili - Measures for the Safety of Mountain Landscapes During Natural and Tehnogenic Disasters. Tbilisi, Universal, 2011, 273 p. (In Georgian).
4. Gavardashvili G.V., 2022. Predicting Erosive and Debris Flow Processes and the Innovative Measures to Control Them. "Cambridge Scholars Publishing House" ISBN: 1-5275-8482-8; ISBN13: 978-1-5275-8482-2; Cambridge, UK, p. 245. https://www.cambridgescholars.com/product/978-1-5275-8482-2
5. Guide for adaptation to the climate change. Tbilisi, 2016, p. 266.
6. Natural Hazards in Georgia. SENN, Tbilisi, 2011, 65 p. http://drm.cenn.org/paper_atlas/RA-part-3. pdf;
7. O.G. Natishvili., G.V. Gavardashvili - Calculation of Impact Action of a Coherent Debris flow Current in the Wave Motion Mode on a Transverse Structure. 9th International Scientific and Technical Conference, Modern Problems of Water Management, Environmental Protection, Architecture and Construction". Tbilisi, 2019, pp. 210-214.
8. O.G Natishvili., G.V. Gavardashvili – Calculation of properties of the motion of the hear piece of a coherent debris flow. Collection of Scientific Works of the Ts. Mirtskhulava Water Management Institute of Georgian Technical University, №70, Tbilisi, 2015, pp. 138-143.
9. O. Natishvili, I. Kruashvili, G. Gavardashvili, I. Inashvili – Methodic Recommendations to design anti-debris flow structures (hydraulic calculations). Georgian National Academy of Science, Tbilisi, 2016, p. 48.
10. S.S. Chernomorets – Debris flow loci before and after catastrophes. Moscow: Nauchnyi Mir, 2005, p. 200.
11. M. Lin, K. Wang, T. Chen & S. Lin - The Case Study of Debris Flow Hazard Caused by Typhoon Morakot in TAIWAN, 2009. 5th International Conference on Debris-Flow Hazards (Mitigation, Mechanics, Prediction and Assessment). Padua, ITALY, 14-17 June, 2011, pp. 695-703.

FORMATION OF WATER QUALITY SELF-CLEANING PROCESSES IN THE ISANI-SAMGORI FILTER STATION OF THE TBILISI RESERVOIR

K. Iordanishvili[1)], I. Iordanishvili[1)], K. Bziava[1)], N. Kandelaki[1)], T. Supatashvili[2)], G. Omsarashvili[1)], E. Khosroshvili[1)], D. Potskhveria[1)], L. Bilanishvili[1)]

[1)] Ts. Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60[b], 0179, Tbilisi, Georgia
E-mail: k.iordanishvili@darialienergy.ge
[2)] University of Georgia
M. Kostava Ave. 77a, 0171, Tbilisi, Georgia
tamunasupatashvili@gmail.com

INTRODUCTION

Protection of the environment and maintenance of ecological balance is the primary task, for which it is necessary to rationally use natural resources, preserve and improve its components.

Among the components of the environment, the most common and important are water resources, which can be used by building reservoirs. We should consider the reservoir as a factor of human well-being and the development of the public economy, which depends on the impact of the environment. The creation and operation of water reservoirs leads to undesirable and inevitable changes in the environment, including the deterioration of water quality, which is caused by a sharp decrease in the speed of the river and the inevitable accumulation of pollutants; by reducing self-cleaning possibilities; with the increase of eutrophic processes, etc. [1,2,3,4].

The content of dissolved oxygen in water (O_2 mg/l) depends on two groups of processes taking place in the reservoir: water enrichment with oxygen and reduce oxygen in water. Oxygenation depends on photosynthesis of algae, which in turn depends on temperature and light. Therefore, the amount of oxygen in the upper layer of the reservoir water, which is illuminated and warmed, is greater than in the depth. Water enrichment with oxygen is also carried out by absorbing oxygen from the atmosphere, this process is enhanced by water currents and wind in the reservoir.

The reduction of oxygen depends on the respiration of aquatic organisms, the decay of organic matter, and the oxidation of inorganic and nitrogenous matter.

Carbon dioxide **(CO_2)** dissolved in the water reservoir is distributed free and in the form of ions, it is formed from the atmosphere by oxidation of organic residues in water and soil and respiration of aquatic organisms, during which the carbon dioxide formed joins water and is transformed into carbonic acid - $CO_2+H_2 \Leftrightarrow H_2CO_3$. The regime of CO_2 in the reservoirs is determined by the water flowing from the tributaries and the vitality of zooplankton, the temperature regime of the water and biochemical processes.

The active reaction of water in reservoirs depends on the ratio of different forms of carbon dioxide in it.

Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, HCO^{-}_3, SO_4^{2-} and Cl^{-} - ions play an important role in the formation of water quality in reservoirs.

In reservoirs, biogenic elements are formed from phosphorus and nitrogen compounds. Phosphorus is the most important element for the development of life in the reservoir. It exists in water as phosphate of phosphoric acid compounds. An increase in the amount of phosphate indicates the pollution of the reservoir. Nitrogen is one of the necessary and important biogenic elements. In reservoirs it is found in the form of ammonium nitrogen (NM^{-}_4), nitrates (NO^{-}_3) and nitrites (NO^{-}_2) ions. The increased amount of ammonium ions is explained by the discharge of domestic and industrial polluted water into the reservoir. Waters flowing from agricultural lands are also promoted.

The composition of the water in the reservoir depends on the self-cleaning ability of the reservoir, the

intensity of which is determined by a number of factors - the vital activity of bacteria, fungi, algae, animals and microorganisms, solar radiation, water acidity, temperature and intensity of water change. Self-cleaning of mountain water reservoirs is more intensive by diluting them multiple times with clean water. In the middle part of the mountain reservoirs (in deep water), the self-cleaning processes are sharply slowed down, these processes are more intense near the shores - in the area of the agora on the slope of the waves. The dynamics of self-cleaning processes in reservoirs depends on the mixing of water during storms, periodic emptying-filling of reservoirs, flushing of reservoirs, water falls, chemical and physical processes, precipitation, ion exchange of water, sorption of polluting substances, biological self-cleaning, generation of free oxygen, etc. There are two types of water exchange processes in reservoirs - external water exchange and internal water exchange. The value of the external water exchange coefficient of the full volume of the reservoir (K_{ful}^{out}) is determined by the relationship:

$$K_{ful}^{out} = W_{runoff} / V_{ful}, \quad (1)$$

where W_{runoff} is the volume of water flowing into the reservoir.

Accordingly, the value of the external water exchange coefficient of the useful volume of the reservoir (K_{useful}^{out}) is determined by the dependence:

$$K_{useful}^{out} = W_{runoff} / V_{useful}, \quad (2)$$

The present paper deals with the investigation of water quality and water change in reservoirs, in which the assessment of the hydro-ecological condition of one of the important reservoirs in Georgia - Tbilisi Isani-Samgori filter station.

MAIN PART

Tbilisi Reservoir is the main node in the Zemo Samgori irrigation system complex. The reservoir is of filling type, created at the base of three saline lakes - Avlabari, Kuki and Ilgunyan, and is fed by the river. Through the main channel of Iori Zemo Samgori - flow - 130 m3/s and from the Zhinvali reservoir - flow - 9.8 m^3/s, fig. 1,2. The depression formed by the lake basins stretches from the northwest to the southeast, 8 km long and up to 2 km wide, maximum depth - 35 m, average - 26 m. Its bottom is filled with deluvial-proluvial sediments, is represented by clay and is bounded by flat terraced elevations. The design total volume of the reservoir is 308.0 million m^3, useful volume - 155 million m^3. Due to the negative events that developed in the 70s of the last century (water filtration from the perimeter of two earth dams and flooding of Tbilisi residential district - TMC), the water level was reduced by 10.0 meters - from 548.0 m to 538.0 m. The maximum full capacity of the reservoir The volume has decreased and is 215.0 million m^3, and useful - 65.5 million m^3. The reservoir was created in the hollow of the former Lake Avlabari with two concrete dams 9 and 12 m high and two earth dams 10 and 12 m high. The structure includes sandstones and shale clays of Tertiary age. Its southern part is covered by Quaternary sediments. In the northern part, near the surface, there are karst rocks. The main rocks are represented by sandstones, argillite and siltstone rocks.

The Don mode is non-stationary. The processing depth is 13 m, fig. 2. The wind disturbance is directed along the reservoir. Wind speed is 23-24 m/s, wind speed - 2.55%, wave height - 1.2-1.4 m. Anxiety is characterized by strong irregularity. The intake of water in the lower irrigation main channel for irrigation is carried out in the south-eastern part of the reservoir, with a tower-type water intake. In the same area, water is taken for the drinking water supply of Tbilisi and Rustavi.

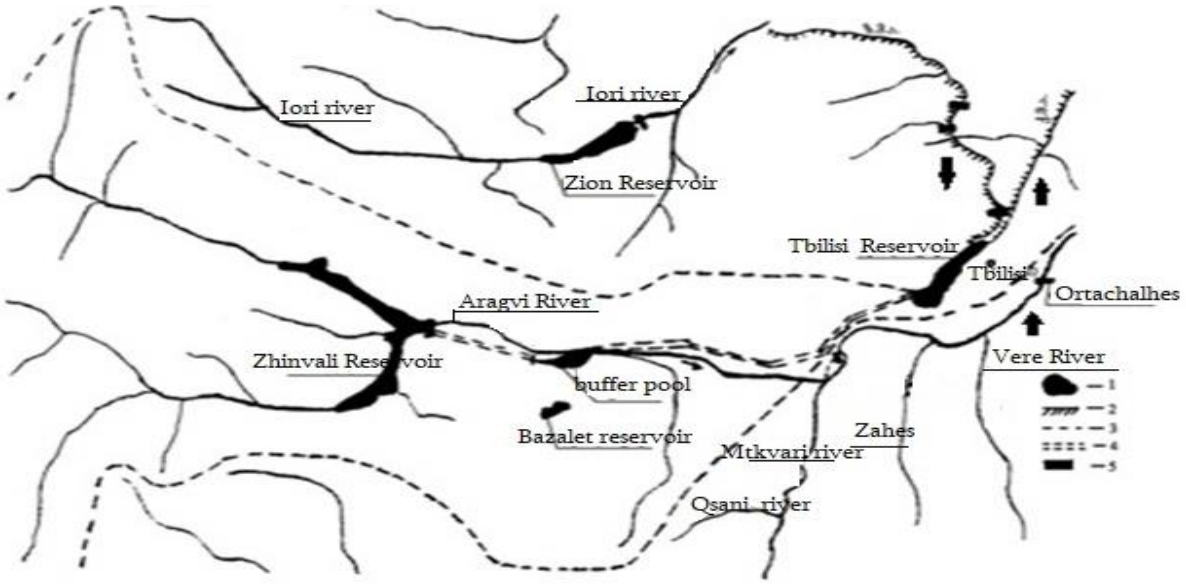


Fig. 1. Joint operation scheme of Sion, Tbilisi and Zhinvali reservoirs
1 - reservoirs; 2 - channels; 3-watershed of river basins; 4-aqueducts; 5 - Hydroelectric power station.

The curves of the Don regime, volume and mirror area of Tbilisi Reservoir are shown in fig. 2, and the morphometric and water change index of the reservoir in Table 1.

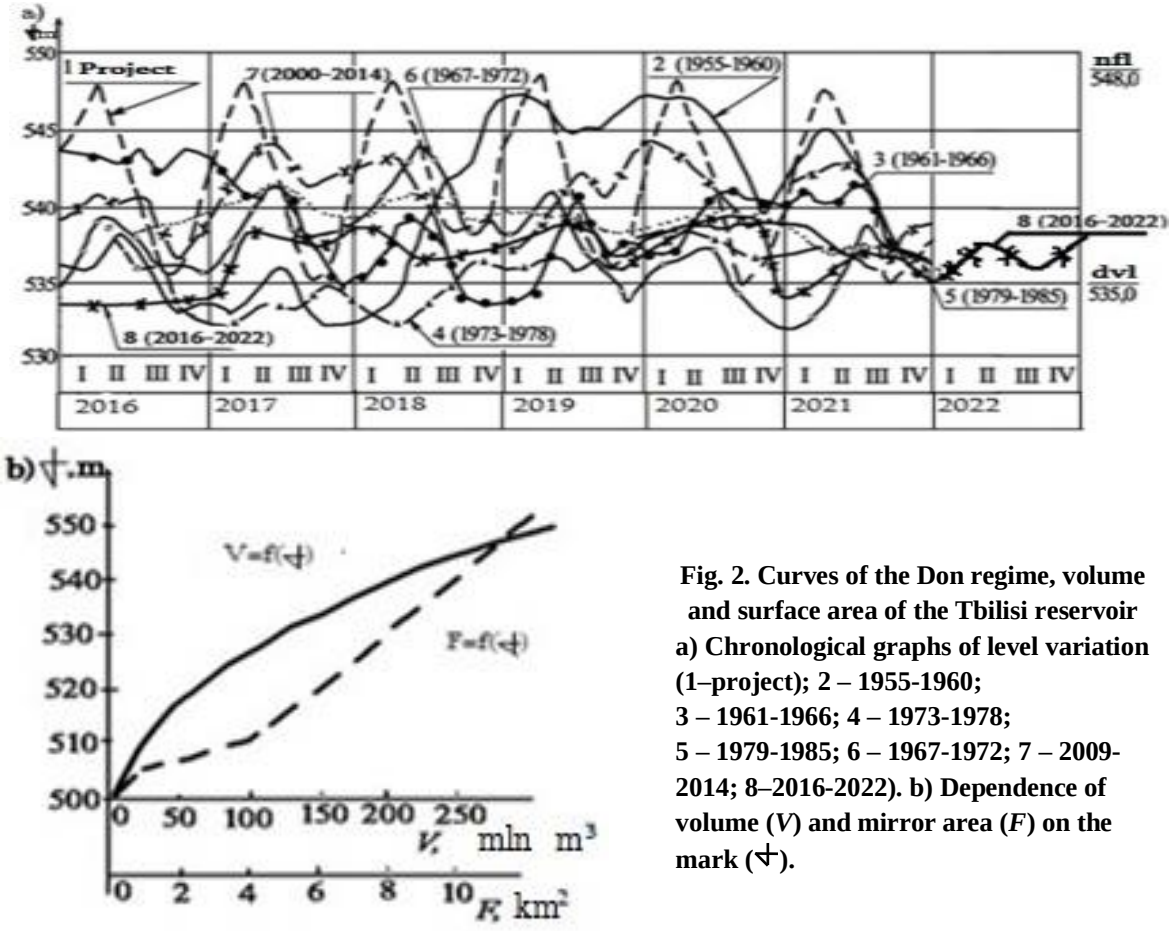


Fig. 2. Curves of the Don regime, volume and surface area of the Tbilisi reservoir a) Chronological graphs of level variation (1–project); 2 – 1955-1960; 3 – 1961-1966; 4 – 1973-1978; 5 – 1979-1985; 6 – 1967-1972; 7 – 2009-2014; 8–2016-2022). b) Dependence of volume (*V*) and mirror area (*F*) on the mark (▽).

Table 1

The main indicators of morphometric and external water change of the Tbilisi reservoir

№	Name of the reservoir	The volume of the reservoir		Reservoir level mark, ⊥ m		External water exchange coefficients				Reservoir type according to the tide
				nfl, ⊥ m	dvl, ⊥ m	Full volume		Useful volume		
		Full V_{ful}, mln m^3	Useful, $V_{use.}$, mln m^3			Water exchange coefficient, $K_{rez.ful}$	Number of water changes, per year, $n_{rez.}$	Water exchange coefficient, $K_{rez.useful}$	Number of water changes per year, $n_{rez.}$	
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	Tbilisi (Project)	308,0	155,0	548,0	535,0	1,69	0,59	5,61	0,18	III
1^1	Tbilisi (actual)	215,0	65,0	538,0	535,0	1,18	0,85	2,35	0,43	III

2022 to assess the **water quality** of Tbilisi Reservoir. Field studies were conducted in January and July, during which water samples were taken on the pre-planned profile (I-I) of the water reservoir, from which the city is supplied. Tbilisi and Rustavi with drinking water, Fig. 3. The results of chemical analysis of water from the Tbilisi reservoir are presented in Table 2.

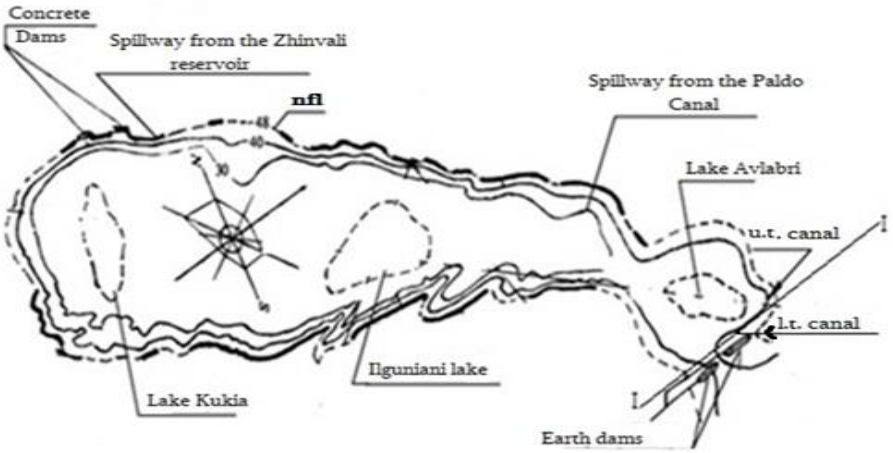


Fig. 3. Location of water sampling from Tbilisi Reservoir, I-I sampling profile

Table 2

Dynamics of the chemical composition of water in the Isani-Samgori filter station of the Tbilisi reservoir according to the period of the year (2022) (Profile I-I)

	№	Research indicator	Unit of measure-ment	Normative no more	Results obtained	Number of Normative document
1	**2**	**3**	**4**	**5**	**6**	**7**
Organoleptic indicators						
05.01	1	Smell 20°C, 60°C	**Ball**	1	0	3351-74
05.07	1^1			1	0	
05.01	2	Taste 20°C	**Ball**	1,0	0	3351-74
05.07	2^1			1,0	0	

05.01	3	Colorfulness in 20 cm	Degrees	15,0	<5,0	7887:2011
05.07	3[1]			15,0	<5,0	
05.01	4	Turbidity	მგ/ლ	-	1,33	7027-1:2016
05.07	4[1]				3,5	
General indicators						
05.01	5	Hydrogen index	pH	6,5-8,5	8,11	10523:2008
05.07	5[1]			8,5-8,5	7,78	
05.01	6	Permanganate oxidation	mg O_2/l	3	0,67	8467:1993
05.07	6[1]			3	0,64	
05.01	7	Dry balance	mg/l	1000	146,8	18164-72
05.07	7[1]			1000	217,2	
Inorganic substances						
05.01	8	Barium (Ba^{2+})	mg/l	0,1	0,02	11885:2007
05.07	8[1]			0,1	0,03	
05.01	9	Boron (B, total)	mg/l	0,5	0,21	11885:2007
05.07	9[1]			0,5	0,17	
05.01	10	Arsenic (As, total)	mg/l	0,05	0,002	11885:2007
05.07	10[1]			0,05	0,001	
05.01	11	Silver-water (Hg, inorganic)	mg/l	0,0005	0,0002	"AGILENT" method of the manufacturer
05.07	11[1]			0,0005	0,0002	
05.01	12	Cadmium (Cd, total)	mg/l	0,001	<0,001	11885:2007
05.07	12[1]			0,001	<0,001	
05.01	13	Manganese (Mn, total)	mg/l	0,1	0,002	11885:2007
05.07	13[1]			0,1	0,01	
05.01	14	molybdenum (Mo, Total)	mg/l	0,25	0,001	11885:2007
05.07	14[1]			0,25	0,001	
05.01	15	nickel (Ni, Total)	mg/l	0,1	0,001	11885:2007
05.07	15[1]			0,1	0,001	
05.01	16	Ammonia	mg/l	0,39	<0,08	7150-1:1984
05.07	16[1]			0,39	<0,08	
05.01	17	Nitrates (short exposure to NO_3)	mg/l	45	0,34	10304-1:2007
05.07	17[1]			45	0,36	
05.01	18	Nitrites (prolonged exposure to NO_2)	mg/l	3,3	<0,075	10304-1:2007
05.07	18[1]			3,3	<0,075	
05.01	19	Selenium (Se, total)	mg/l	0,001	<0,001	11885:2007
05.07	19[1]			0,001	<0,001	
05.01	20	Copper (Cu, total)	mg/l	1	0,001	11885:2007
05.07	20[1]			1	0,002	
05.01	21	Lead (Pb, total)	mg/l	0,03	0,001	11885:2007
05.07	21[1]			0,03	0,004	
05.01	22	Fluorides (F)	mg/l	0,05	0,09	10304-1:2007
05.07	22[1]			0,05	0,09	
05.01	23	Chrome (Cr^{6+})	mg/l	0,1	<0,001	11885:2007
05.07	23[1]			0,1	<0,001	

05.01	24	Stibium (Sb)	mg/l	0,05	<0,002	11885:2007
05.07	24[1]			0,05	<0,001	
05.01	25	Cyanides (CN)	mg/l	0,1	<0,005	HACH Method 8027
05.07	25[1]			0,1	<0,005	
05.01	26	Sulfates (SO_4^{2-})	mg/l	500	65,37	10304-1:2007
05.07	26[1]			500	58,75	
05.01	27	Chlorides (Cl)	mg/l	350	4,74	10304-1:2007
05.07	27[1]			350	5,05	
05.01	28	Overall stiffness	mg-equi/l	7	2,41	6059:1984
05.07	28[1]			7	3,95	
05.01	29	Alkalinity	mg-equi./l	-	1,31	9963-1:1994
05.07	29[1]			-	3,05	
05.01	30	Calcium (Ca)	mg/l	-	37,39	11885:2007
05.07	30[1]			-	65,5	
05.01	31	Magnesium (Mg)	mg/l	-	6,6	11885:2007
05.07	31[1]			-	8,28	
05.01	32	Sodium (Na)	mg/l	-	9,1	11885:2007
05.07	32[1]			-	10,73	
05.01	33	Zinc (Zn^{2+})	mg/l	1	<0,001	11885:2007
05.07	33[1]			1	<0,003	
05.01	34	Iron (Fe, total)	mg/l	0,3	0,005	11885:2007
05.07	34[1]			0,3	0,007	
05.01	35	Aluminum (Al^{3+})	mg/l	0,5	0,01	11885:2007
05.07	35[1]			0,5	0,18	
05.01	36	Silicon (Si, total)	mg/l	-	1,1	11885:2007
05.07	36[1]			-	1,0	
05.01	37	Polyphosphates (PO_4^{3-})	mg/l	3,5	<0,2	10304-1:2007
05.07	37[1]			3,5	<0,2	
05.01	38	Weighted particles	mg/l	-	<2,0	ISO 11923:1997
05.07	38[1]			-	2,2	
05.01	39	Dissolved oxygen	mg/l	-	9,1	HACH Method 8166 (ISO 5814)
05.07	39[1]			-	9,0	
05.01	40	COD (Chemical oxygen demand)	mg/l	-	1,21	HACH LCK500 The maker's method
05.07	40[1]			-	1,5	
05.01	41	BOD (Biochemical oxygen demand)	mg/l	-	0,81	ISO 5815-1 The maker's method
05.07	41[1]			-	0,93	
05.01	42	Electrical conductivity	µS/cm	-	321	ISO 7888
05.07	42[1]			-	338	
Organic substances						
05.01	43	Total pesticide content	mg/l	0,05	<0,0044	6468:1996
05.07	43[1]			0,05	<0,0044	
05.01	44	petroleum products, total	mg/l	0,3	<0,04	9377-2:2000
05.07	44[1]			0,3	<0,04	

05.01	45	Surfactant substances, anionic agents	mg/l	0,1	<0,1	7875-1:1996
05.07	45[1]			0,1	<0,1	
Microbiological indicators						
05.01	46	Total coliform bacteria	MPN 1 in l	10000	1652	9308-2:2012
05.07	46[1]			10000	1396	
05.01	47	Mesophilic aerobes and facultative anaerobes	1 in milliliter, 37°C	-	170	6222:1999
05.07	47[1]			-	50	
05.01	48	Mesophilic aerobes and facultative anaerobes	1 in milliliter, 22°C	-	290	6222:1999
05.07	48[1]			-	125	
05.01	49	Streptococcus faecalis	MPN 100 in milliliter	-	It was not found	7899-1:1998 ENTEROLERT E
05.07	49[1]			-	4,2	
05.01	50	Salmonella	1in l	Not allowed	It was not found	19250:2010
05.07	50[1]			Not allowed	It was not found	
05.01	51	Coliphages	1 in l	100	It was not found	4.2.1884-04
05.07	51[1]			100	It was not found	
Parasitological indicators						
05.01	52	Cysts of lamblia	Number of cysts in 25 l	Not allowed	It was not found	4.2.1884-04
05.07	52[1]			Not allowed		
05.01	53	Cysts of dysenteric amoebae	Number of cysts in 25 l	Not allowed	It was not found	4.2.1884-04
05.07	53[1]			Not allowed		

CONCLUSIONS

Thus, the gaseous regime in the Isani-Samgori filter station of the Tbilisi reservoir is determined mainly by the oxygen regime, which depends on the high amount of dissolved oxygen (0.2>9.1 mg/l), which is connected with the high value of **water exchange** of the reservoir water (the water exchange coefficient of the full volume is $K_{rez.}^{ful.}$ =1.2 and of useful volume – $K_{rez.}^{use.}$=2.35 - times/year). **A high value of oxygen** determines the decomposition of anaerobic products (ammonia, hydrogen sulfide) and the redistribution and accumulation of chemical elements (iron, phosphorus, zinc, manganese, etc.) at the bottom of the reservoir.

Mineral and organic substances enter the Tbilisi reservoir mainly from river and surface runoff - from agricultural fields and industrial areas. Water samples of the Tbilisi reservoir, which were taken on the profile, from which water is supplied to St. In the drinking water supply of Tbilisi and Rustavi, the chemical indicators of a number of elements do not exceed the norm, except for the fluoride (F) indicator, the amount of which is 0.09 mg/l in winter and summer (normative <0.05 mg/l) and the total coliform bacteria, the indicator of which , both in winter and summer exceed the norm - 1659 - in January, in winter - 1396 (normative - 1000).

The amount of some elements increases in the summer, but is within the normative limits, such as: nitrates - 0.34 mg/l in winter, 0.36 mg/l in summer; copper 0.001 mg/l in winter, 0.002 mg/l in summer;

Lead - 0.001 mg/l in winter, 0.004 mg/l in summer; barium - 0.02 mg/l - in winter, 0.03 mg/l - in summer; magnesium 0.002 mg/l - in winter, 0.01 mg/l - in summer; Chlorides - 4.74 mg/l in winter, 5.05 mg/l in summer; total hardness index - 2.41 mg-eq/l in winter, 3.95 mg-equi/l in summer; Alkalinity index - 3.05 mg-equi/l in winter, 1.31 mg-equi/l in summer; Calcium - 37.39 mg/l in winter, 65.5 mg/l in summer; magnesium - 6.6 mg/l in winter, 8.28 mg/l in summer; sodium - 9.1 mg/l in winter, 10.73 mg/l in summer; iron - 0.005 mg/l in winter, 0.07 mg/l in summer; Aluminum - 0.01 mg/l in winter, 0.18 mg/l in summer; The amount of weighted particles - 2.0 mg/l in winter, 8.2 mg/l in summer.

On the contrary, the amount of some elements is higher in winter than in summer, these are: boron - 0.21 mg/l in winter, 0.17 mg/l in summer; Arsenic - 0.002 mg/l in winter, 0.001 mg/l in summer; Stibium - 0.002 mg/l in winter, 0.001 mg/l in summer; sulfates - 65.37 mg/l in winter, 58.75 mg/l in summer; zinc - 0.001 mg/l in winter, 0.003 mg/l in summer; silicon 1.1 mg/l in winter, 1.0 mg/l in summer; dissolved oxygen - 9.1 mg/l in winter, 9.0 mg/l in summer; Coliform bacteria - 1652 MPN - in winter; 1396 MPN - in summer; Aerobes and anaerobes at 37 ºC - 170 kc/ml - in winter, 50 kc/ml - in summer, and at 22 ºC respectively - 290 kc/ml in winter, 125 kc/ml - in summer. As for the parasitological elements in the intersection of the Tbilisi reservoir, from which water is taken in St. It was not found in the drinking water of Tbilisi and Rustavi.

REFERANCE

1. Iordanishvili K., Iordanishvili I., Mghebrishvili M., Kuparashvili I., Kandelaki N., Khosroshvili K., Bilanishvili L. Processes of water quality formation and self-cleaning in the Zhinvali reservoir. Collected Papers of the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, №75, Publishing House “Universali”, Tbilisi, 2022, p. 108-116;
2. Iordanishvili I., Iremashvili I., Itriashvili L., Iordanishvili K., Natroshvili G., Khosroshvili E., Potskhveria D., Bilanishvili L. Dynamics of water quality of the main reservoirs of Georgia. 9th International Scientific-Technical Conference "Contemporary problems of water management, environmental protection, architecture and construction". Proceedings of the Conference, Tbilisi, Publishing House “Universali”, Tbilisi, 2019, p. 95-107 (*in Russian*);
3. Hygienic requirements for water composition and quality, limits of permissible concentrations of harmful substances in the drinking-household and cultural water facilities (LPC). 16/08/2001 – Order of the Minister of Labor, Health, and Social Affairs of Georgia - №297/ნ - "About approval of norms of the qualitative state of the environment". The official printing authority of Georgia. "Legislative Herald of Georgia" (Journal of Laws), No. 90, 24.08.2001, p. 91-93.

REASONS, PREDICTIONS AND PROBLEMS OF EXTREME EVENTS AND PREVENTION

L. Itriashvili[1)], E. Khosroshvili[1)], G. Kighuradze[2)]

[1)] Ts. Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60[b], 0179, Tbilisi, Georgia

[2)] Ilia State University
32 Ilia Chavchavadze Ave., Tbilisi, Georgia

E-mail: itriashvili@mail.ru

INTRODUCTION

Human civilization thrives during challenging periods, such as global climate changes and microclimatic shifts, which directly impact the sensitivity of territorial regions and the population density. These phenomena intensify geophysical processes and lead to a substantial increase in population.

According to the United Nations, more than 10% of the Earth's land surface is affected by various extreme events. At the same time, their number, intensity and repetition are increasing and they appear where they have never been before.

Considering that around a billion people inhabit extremely sensitive areas, it becomes evident that extreme events significantly impact their lives. These events are more frequent and intense, and their recurrence is more pronounced, leading to considerable socio-economic consequences. To illustrate, densely populated urban centers, numerous major metropolitan areas, and expansive agricultural regions suffer losses equivalent to 10-15% of their national income. In the last 30 years, extreme events have been documented to have surged fourfold in the United States.

This underscores the reality that, despite escalating investments in infrastructure development and improved preparedness for extreme events, the frequency and severity of such occurrences continue to grow. There is no guarantee that human populations will be better equipped to withstand these challenges.

MAIN PART

The primary cause of extreme events is the convergence of multiple geophysical factors, including force and velocity, in practical terms, which leads to a heightened level of vulnerability.

In the context of emergencies, this becomes one of the causes of the unexpectedness of these extreme phenomena is inadequate consideration of physically grounded models of fluctuations of runoff, evaporation and rainfall, in particular, the beat-and-moisture exchange instability of evaporation from the surface of river basins, leading to auto fluctuations of moisture reserves in the basin and river runoff [1].

At present for standard treatment of time hydrological series use is made of distributions from the family of exponentials [5]. In other words, according to the central limit theorem of the probability theory, the water level in rivers assumes values conformably to the Gaussian distribution. And in this case in more than 99.7% of occurrences the random value (tails of distribution) deviates from the mean value less than by 3s (standard deviation), and rarer from the limit 5s in one case in a million. This means that one may disregard very great events when the random value reaches values sufficiently higher than average, as practically impossible, i.e. the tail of distribution corresponds to the so-called hypothetical floods, the possibility of whose occurrence is not taken into consideration in practice [2].

The above approach means that from the standpoint of the thermodynamics of irreversible processes, description of long-term fluctuations of river runoff by linear equations presupposes steady stability of the hydrological system over the entire range of its parameters, and does not take into consideration the

specificity of hydro physical processes in the catchment area, which under definite conditions may lead to extreme phenomena [3].

At the same time, an overwhelming majority of hydrodynamic systems, at a definite distance from the state of thermodynamic equilibrium, represent instabilities with essentially nonlinear effects and they do not vanish at averaging. Even small nonlinearities in a dynamic system appreciably alter precisely the tails of distributions, and the assessment of the probability of catastrophic phenomena.

A river basin constitutes a complex system whose state depends on inter-influence of many, also interdependent, climatic and hydrological factors. The runoff depends on the moisture reserve; moisture reserve itself depends on precipitation and water-permeability of the soils of the basin, which in turn depends on porosity, composition, heat conductivity, heat capacity, humidity, etc.; in their turn, these factors affect the temperature of the earth surface and the close-lying layer• of air, and accordingly the value and intensity of evaporation, etc.

The mechanism of the interinfluence of moisture reserve and evaporation is connected with the considerable difference of the thermophysical properties of water and the dry components of the soil.

The heat conductivity of dry porous soils totals 0.24-0.40 J, heat capacity 0.80 J, and for water 0.60 J and 4.19 J, respectively.

At humidification, air of small heat capacity and small heat conductivity is ejected by water, the land layer heats up slowly and cools slowly. Hence the land temperature depends directly on the moisture reserve of its active layer, the depth of which in turn depends on the depth of penetration' of heat waves, on the average amounting to 10m. Therefore, at humidification of soils, their thermodynamic condition changes: the considerable difference between the thermophysical properties of water and dry soils tells on the mechanism of the influence of moisture reserve on the rate and magnitude of evaporation. Numerous experimental investigations of the dependence of evaporability on the degree of humidification of the territory (moisture reserve) confirm the above said. It has been established also that evaporation from a unit of surface of earth saturated with moisture is 50% greater, on the average, than from a reservoir situated on this territory [4].

As is known, the elasticity of water vapors depends exponentially on temperature and the effects of heating are more important than of cooling, while the elasticity of water vapors is an increasing function of the amplitude of temperature fluctuations. As is known, the elasticity of water vapors depends exponentially on temperature and the effects of heating are more important than of cooling, while the elasticity of water vapours is an increasing function of the amplitude of temperature fluctuations. An analogous picture is observable for evaporations as well. Therefore, the greater the differences in temperature, the stronger the evaporation of water from land surface; the increase of evaporation in turn leads to a still ,greater temperature difference, i.e. a positive feedback is observable, leading to a temperature instability of evaporation. Physically this means that at a definite reserve of humidity the river basin may progressively accumulate water, at unchanged quantity of precipitation.

Water permeability of unsaturated soils also grows exponentially with the increase of humidity.

The so-called "soil paradox" is known, connected with a different mechanism and specific peculiarities of movement of moisture in dry and moist soil.

According to the general phenomenological law, transfer of substances and energy occurs in a direction opposite to the gradient of the motive force that is directed from smaller value to greater.

In application to dispersive media, to which soils belong, the motive forces constitute the pressure gradient of soil moisture, which causes the transition of water in the soil – from point of greater pressure to that of lower and on which the coefficient of moisture conductivity depends, i.e. the capacity of soils to conduct moisture, which in its turn is a characteristic of the material state, composition and saturation of soils.

In the course of movement of water the pressure gradients between the moist and dry pats of soil are almost equal for both less dense and more dense soil. Absorption of moisture is primarily determined by the

capacity of the soil to conduct the flow (coefficient of moisture conductivity). In dry soil, in an area of a higher pressure of moisture (pressure is a negative value) the coefficient of moisture conductivity of dense

soil is several times higher (and occasionally by orders) higher than of a loose one. This coefficient is not constant for each soil, but depends on the pressure of moisture in the soil, this dependence being of nonlinear character. It is this coefficient that determines the well-known soil effect: the drier the soil the lower its moisture conductivity; at the same time moisture conductivity increases with increased compactness [4].

Therefore water moistens a compact soil quicker, and moves slowly along a loose one. In soil already moistened the movement of moisture has a reverse dependence. Thus, the specific dependence of moisture conductivity on water pressure leads to specific effects, which are of major practical value, in particular the rates of moisture saturation of water basins with which the formation of runoff and its magnitude is directly connected.

The larger the volume of a river basin the longer the process of its moistening over time. In application to large basins this process may be drawn out over months and more.

Naturally, the movement of maximum moisture capacity (maximum reserve moisture) will also be extended in time. At the same time, the more compact the soils the quicker this process passes. How much heat arrives in the atmosphere in latent (evaporation) or overt (turbulent stream of heat) form depends on the extent of moistening of soil, as well as on the temperature of the soil itself. Experiments in which the influence of soil moistening on the microclimate of the territory showed that great evaporation from soil exerts a direct influence on the circulation of the atmosphere and rainfall. At the same time, humidity, once arisen, is capable of preserving itself in definite conditions at the expense of precipitation, formed at the expense of evaporation and in this case major rainfall may lead both to explosive accumulation of moisture and to an increase of runoff at the expense of surface waters.

Even under a small change of the random value, the amplitude of fluctuations of the process near an equilibrium state may reach very large values. Consequently, river runoff and moisture reserve of the river basin may change also with a wide range under the influence of many variable random factors. At the same time it is natural to presume that there exists a reverse interrelationship. In the aggregate, the above-said exerts a substantial influence on the formation of the climatic characteristics of the basin. The physical mechanism of this may be accounted for by the fact that if there is a small quantity of rainfall for a number of years, the moisture reserve of the active layer will fall drastically, while its heating will accordingly considerably increase because of the reduction of effective heat volume. This will lead to still greater diffusion of moisture in the atmosphere, and the strongly heated surface of land may turn the falling rain into vapor while still in the atmosphere. Naturally enough, such mutual influence must be of nonlinear character. The wide range of change of the thermophysical properties of catchment areas is one of the causes of fluctuations of moisture reserves; at cyclic change of the amount of precipitation the amplitudes of variations of moisture reserves and runoff may grow drastically. A large amount of precipitation will increase the reserve of moisture and reduce the intensity of evaporation, i.e. both factors act jointly, which may lead to an explosive accumulation of moisture in the basin [5].

The growth of moisture reserve increases the heat capacity and heat conductivity of the catchment area. Therefore, at an unaltered arrival of heat the catchment heats up weaker, evaporation reduces and the water saturation of the catchment increases, i.e. evaporation may decrease with the growth of moisture reserve, as a considerable part of solar heat will be spent not only on evaporation but on heating the increasing volume of water.

Thus, the two major factors entering the equation of the balance of a river basin: increase of moisture reserve and decrease of resistance to movement of water in the basin, as well as all other numerous factors, are not independent but are interconnected and in active mutual influence. Obviously, the random process of runoff fluctuations cannot be Gaussian. Naturally, if precipitation follows the Gaussian law, then the "heavy tails" of distribution, in the emergence of which many interconnected factors take part, are formed by

mutually influencing processes at the catchment. The behavior of moisture reserves river runoff, evaporation, temperature fluctuations of the surface of soils are of auto fluctuation character. Therefore, description of long-term fluctuations of the river runoff by linear equations cannot be satisfactory from the physical point of view, as their solutions, according to the thermodynamics of irreversible processes presuppose that a hydrological system never loses its stability over • the entire range of change of its parameters.

At the same time, the overwhelming majority of physical systems, at a definite departure from the state of thermodynamic equilibrium, constitute instabilities with substantially nonlinear effects, and at averaging they do not disappear; while the hydrogeological system (including the river basin) correspondingly is also in a constables state. Therefore, the behavior of the average values of moisture reserves, amplitudes of temperature actuations, evaporation and other parameters have an autofluctuation character. In view of this, from the physical standpoint, description of long-term fluctuations of river runoff and prediction of extreme floods cannot be carried out on the basis of linear equations (laws).

Even nonlinearities in a dynamic system appreciably alter precisely the tails of distributions, and consequently, the assessment of the probability of catastrophes. Increase of the potential energy of water and decrease of resistance to its movement in aggregate lead to a nonlinear increase of discharge, i.e. increase of moisture reserve and decrease of the resistance of water movement in the basin are mutually dependent, and the random process of runoff fluctuation is not Gaussian. In the period of heavy rainfall resistance to water movement may diminish so much that the runoff will be formed not only at the expense of the last precipitation but at the expense of preceding rains that had not entered the river because of great resistance. Naturally enough, in this case too only precipitation follows the Gaussian law, while extreme phenomena must be subject to step-by-step distribution.

Thus, a river basin obviously constitutes an oscillator generating fluctuations of moisture reserves and river runoff, by which the asynchronous and synchronous fluctuations of river runoff may be accounted for. The physical cause of this is the strong dependence of the coefficient of resistance of the river basin on moisture reserves.

Numerous full-scale studies have demonstrated that the extreme of moisture reserve in a river basin lag by one to two years from the extreme of runoff, while river waters constitute a mixture of various age, primarily underground waters, aged 10-12 years. The formation of river runoff is also closely linked to the magnitude of precipitation (frequency and volume) and the regime of evaporation from the surface of its basin.

The complexity of the variability of hydrological processes and the mutual influence of the numerous factors participating in them should be really taken into account in physic-mathematical models rather than applying them as formal statistical characteristics (average dispersions, correlation functions, etc). In order to give a correct description of hydrological items one should bear in mind the non-equilibrium of the thermodynamic processes of heat exchange and moisture and their nonlinear character.

An anomalously large number of extreme have been discovered in the time series of runoff. It is by this effect that V. Naidenov accounts for the phenomenon of the drastic rise of the level of the Caspian Sea. On the basis of an analysis of over 50 stations, he has ascertained that over decades the content of moisture in the active layer of soil in the river basin of the Caspian is constantly increasing, with simultaneous decrease of evaporation. Having accumulated moisture the Caspian basin began to give it away to the sea, which found expression in a drastic increase of the runoff of rivers and rise of the water level [6].

The American statistics of catastrophic phenomena (tornadoes, earthquakes, floods, hurricanes) shows that the data obtained practically exactly obey stepwise statistics, which is distinguished for the fact that major phenomena taking place at the tail occur much more frequently than at normal distribution, i.e. catastrophic floods are not extraordinary events but have a sufficiently high probability.

The table 1 presents some catastrophic floods the recurrence of which took place over the past one hundred years, and the probabilities of their recurrence, calculated by gamma and stepwise distributions [7].

table 1

Name of river	Probability of flood (years)		Name of river	Probability of flood (years)	
	By gamma dist.	By stepwise Distr.		By gamma distr.	By stepwise distr.
1	2	3	4	5	6
Neva	3000	256	Terek	406	106
Yangtze	667	367	Kuma	28000	85
Missouri	121	38	Podkumok	8800	102
Western Dvina	526	88	Elbe	1000	100
Kuban	1000	70	Volga	260	46

Thus, in designing hydraulic engineering structures consideration should be made of statistics that is described by stepwise distribution; the more so that the expenditure on the building of structures becoming more expensive cannot compare with the possible future damage.

However, even optimally designed for maximum possible high waters, engineering structures cannot ensure reliable protection from floods. The cause of this is the growing rates and scale of anthropogenic impact on the natural environment.

The psychological factor is of special importance in this. After the construction of these or those hydrotechnical systems and structures, in people living in the immediate vicinity or on territories subject to floods there arises confidence of security. It is in such areas that new lands are developed, residential buildings and industrial enterprises are erected, roads are built, etc. Attention is not given to the possibility of a new, greater flashflood, the rise of which they themselves contribute to with their activity.

Constant enhancement of the reliability of engineering flood control measures, with all its attractiveness, has its limit, for it is connected with a drastic increase of its size, volume of work, complexity of technological processes, which in the final analysis leads to such an increase of expenditure that are unaffordable even to the majority of developed countries.

Therefore, such combination of engineering and non-engineering methods should become an optimum solution in whose selection maximum account is taken of the natural and economic peculiarities of the territory and which are implemented not at local sections of the catchment but throughout the territory.

CONCLUSIONS

The multifaceted nature of water-related disasters is predominantly influenced by various factors and typically results from the confluence of different extreme events (floods, landslides, hailstorms, and others). This complexity adds to the challenges associated with the overall impact of these disasters, including infrastructure damage, vertical and horizontal displacement, plasticity, casualties, internal displacement, critical vulnerability, and others. In addition, these disasters are compounded by significant contributors such as earthquake, storm, drought, etc.

It is worth noting that predicting the timing, speed, and intensity of extreme events constitutes a formidable challenge. Even in the realm of non-precise mathematical models, the accuracy of forecasting remains within the range of 50-60% in practice.

As for the present day, the practical possibility extends to the recording of only two facts - the occurrence of sensitive areas and extreme processes' identification. Georgia is situated in an area characterized by a particularly sensitive location, closely monitoring extreme events such as floods, avalanches, landslides, and similar occurrences, especially in the regions of Samegrelo, Svaneti, Gurjaani, Racha, and Gori.

To prevent and respond effectively to extreme events and related emergencies, establishing comprehensive databases and a geoinformation system (GIS) with accessibility for the public is imperative.

An important detail should be considered here: the current approach, which involves the investor drawing up the project, financing it and preparing an expert opinion, which hides the danger of adapting the project to the client's interests. Examples of such an approach are - imposition of taxation on the private investor, processing and subsequent approval by the private investor.

In the context of maximum risk, it is imperative to enforce legislation that prohibits any commercial activities, including land sales, on sensitive territories, regardless of the ownership, the type of construction, or any other activities.

As Academician Tsotne Mirtskhulava aptly pointed out, "There is no guarantee of safety after any extreme event" [8].

REFERENCES

1. Naidenov V.I. Shveikina V.I. Terrestrial causes of water cycles. 1/Priroda , 1999, No. 5, pp. 19-30.
2. Osipov, V.I. Vestnik RAN, v. 71, No. 4, 2007.
3. Naidenov V.I., Kozhevnikova, I.A. Doklady RAN, v. 386, No. 3, 2002.
4. Itriashvili L., Some aspects of moisture movement in soils of the aeration zone, VI International Scientific and Technical Conference, collected papers, Tbilisi, 2016.
5. Polyushkin Yu, V, Larionov N.V., Martinov V.D. Long-term forecasts of natural phenomena. Novosibirsk, 2010.
6. Itriashvili L. Water cycles and extreme events. Water Management Institute of Georgian Technical University, collected papers, No 68, Tbilisi, 2013.
7. Embrecots P., Klupperberg, C., Mikossch, T. Modeling extreme events for insurance and finance, Berlin, 2009.
8. Mirtskhulava Ts. (1987), Floods, combating them, Tbilisi, 53 p.

DETERMINING THE WATERREQUIREMENTS OF AGRICULTURAL CROPS FORTAMARSI VILLAGE OF MARNEULI MUNICIPALITY IN KVEMO (LOWER) KARTLI REGION

O. Kharaishvili[1)2)], P. Sichinava[1)], N. Mebonia[2)], M. Kikabidze[1)2)], L. Baidauri[2)], N. Sukhishvili[2)], L. Toklikishvili[1)]

[1)] Tsotne Mirtskhulava Water Management Institute of Georgian Technical University
Chavchavadze Ave. 60-b
2) Faculty of Agricultural Science and Biosystems Engineering, Georgian Technical University,
Guramishvili 17, 0192
Email:xaraishviliolga@gmail.com; n.mebonia@gmail.com

INTRODUCTION

Kvemo (Lower) Kartli region is located on the borders of semi-desert, dry subtropical and high mountain alpine zone. The landscape is mainly represented by fields and forest-fields. The Kvemo Kartli region is located between the temperate and subtropical zones; the climate in the Kvemo Kartli region is quite dry, which is determined by the peculiarity of the terrain.

Marneuli municipality is located on the bank of Algeti River and is bordered by Bolnisi municipality to the west, Tetri Tskaro municipality to the north, Gardabani municipality to the northeast, Azerbaijan and Armenia to the south.

Table 1

Agroclimatic Indicators of Marneuli Municipality

№	Agroclimatic Characteristics	Months											
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1	Duration of sunlight (hours)	147	144	192	216	256	287	312	288	230	188	141	119
2	Average air temperature	0.0	1.9	6.0	11.5	16.8	20.6	22.9	23.5	19.0	13.4	7.0	1.9
3	Absolute maximum air temperature	20	23	27	31	34	37	39	40	37	33	27	24
4	Absolute minimum air temperature	-25	-19	-15	-7	-1	4	7	7	-1	-7	-10	-21
5	Total atmospheric precipitation (mm)	21	26	38	56	75	73	37	30	40	41	40	19
6	Number of days with ≥0.1 mm atmospheric precipitation	5.1	7.0	8.9	10.5	13.2	11.2	7.6	6.1	7.4	8.0	7.6	6.3
7	Number of days with strong wind (≥15 m/s) during the warm period				2.3	2.2	1.9	2.1	1.7	1.4	1.1		

Marneuli municipality is characterized with moderately dry subtropical warm steppe climate. The average annual temperature is 12°C, and 0-0.3°C in January, 23.9°C in June, an absolute minimum is 10.3°Cand an absolute maximum is 40°C. The average amount of precipitation per year is 490-550 mm. The maximum amount of precipitation falls in May and minimum - in December.

MAIN PART

As a result of the summary of climatic and soil conditions, the irrigation requirement for the municipality was determined. For evaluation of irrigation water supply in the municipality, G. Selianinov's method is used [1]:

Where

ΣP is the sum of atmospheric precipitation for three summer months;

$\sum t$ – the sum of temperatures of three summer months. G. Selianinov emphasizes eight zones in Georgia according to the value of the water balance coefficients:

1. Dry, especially the irrigation zone, when the water balance $K < 6$;
2. Very drought, when the water balance fluctuates within 0,6–0,8;
3. Droughty – 0,8–1,0;
4. Insufficiently humid– 1,0–1,2;
5. Moderately humid – 1,3–n1,6;
6. Humid – 1,6–2,0;
7. Excessively humid – 2,0–2,4;
8. Highly humid– >2,4.

The Water Balance Coefficient, which was processed by G.T. Selivanov's method for Marneuli Municipality of Kvemo Kartli region, was determined using the following equation:

$$K = \frac{\sum P}{\sum t{:}10} = \frac{140}{2325{:}10} = 0.6 \quad (1)$$

According to the obtained data, the municipality of Marneuli belongs to the Highly humid zone.

On the meadow brown soils of the Tamarisi village, the irrigation indicators of soil were studied and determined, and the irrigation rate was determined (see Table 2), which have been studied at the Agricultural Land Reclamation Laboratory of Agro-Engineering Department of the Faculty of Agricultural Science and Biosystems Engineering of Georgian Technical University**(**maximum molecular moisture of the soil, seepage coefficient, maximum retentive capacity and 80% of it), on the basis of which the irrigation rates and the values of the water duty were established, and an uncompleted graph of the water duty was built, after completing which, the water demand curve was built taking into account the relevant conditions.

Table 2

Irrigation indicators of the meadow brown soil in village Tamarisi

Depth of sample, cm	Volumetric weight, g/cm^3	Maximum molecular humidity,percentage weight	Maximumretentive capacity, %	Seepage coefficient	maximum retentive capacity, 80%
0-16	1.08	12.01	40,36	0.004300	32.29
16-32	1,30	13.64	34,39	0.000700	27.51
32-48	1.34	14.40	32.28	0.000610	25,83
48-64	1.40	14,09	30.25	-	24.20
0-80	1.28	13.53	34.1	-	27,28

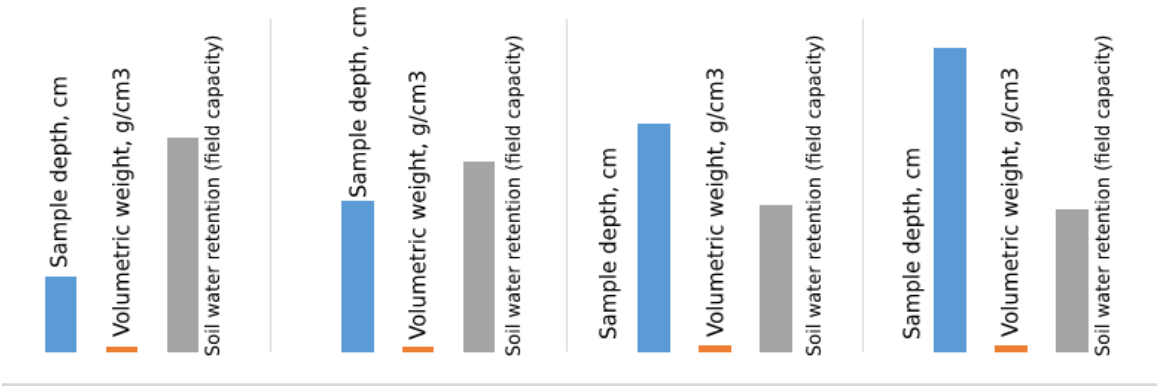


Fig. 1. Irrigation indicators of meadow brown soil (village Tamarisi, Marneuli Municipality)

The area occupied by the agricultural fields of Tamarisi village is 720 ha. The percentage of occupied area by each agricultural crop was determined:

$$\alpha = \frac{\omega_1}{\omega}\% \quad (2)$$

Where

α is an area occupied by each crop, %;

ω_1 - area occupied by agricultural crops, ha;

ω - the whole area occupied by agricultural crops, ha.

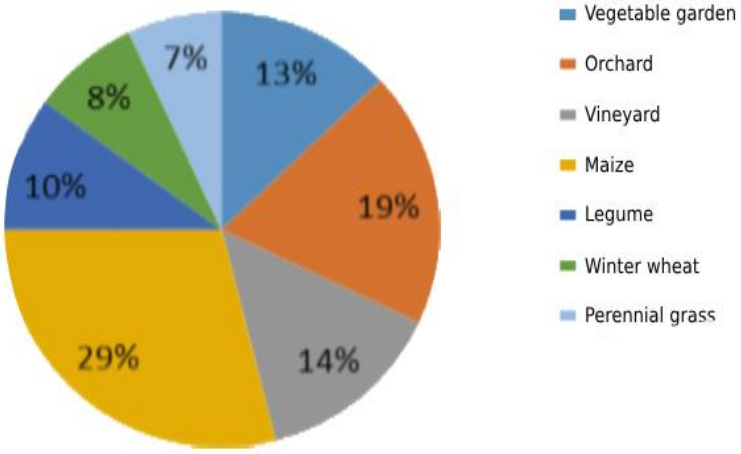


Diagram. 2 Areas occupied by agricultural crops of the village Tamarisi, %

The irrigation rate has been determined:

$$m = 100H\alpha(r_L - r_{L\ 80\%})M^3/\text{ha} \quad (3)$$

Where

*m*is an irrigation rate, m^3/ha;

H- soil active layer, cm;

α- soil volumetric mass, g/cm^3;

r_R-soil water retention (field capacity) by weight percentage;

$r_{R\ 80\%}$ - lower soil water retention capacity before irrigation.

The volumetric mass of the soil is obtained - α=1,28g/cm^3.The soil water retention (field capacity)r_R =34,1. The lower soil water retention (field capacity) before irrigation for the plant - r_R = 34,1×0.8=27.28.

The water duty for each plant (vegetable garden, orchard, vineyards, maize, legumes, winter wheat, perennial grass.) is determined:

1. (vegetable garden) $m_1=100\times0,51,28\times(34,1-27,28)=436,48\approx400$, m^3/ha;
2. (orchards) $m_2=100\times0,8\times1,28\times(34,1-27,28)=698,368\approx700$, m^3/ha;
3. (vineyards) $m_3=100\times0,8\times1,28\times(34,1-27,28)=698,368\approx700$, m^3/ha;
4. (maize) $m_4=100\times0,7\times1,28\times(34,1-27,28)=611,072\approx600$, m^3/ha;
5. (legumes) $m_5=100\times0,6\times1,28\times(34,1-27,28)=523,776\approx500$, m^3/ha;
6. (winter wheat) $m_6=100\times0,7\times1,28\times(34,1-27,28)=611,072\approx600$, m^3/ha;
7. (perennial grass) $m_7=100\times0,7\times1,28\times(34,1-27,28)=611,072\approx600$, m^3/ha.

The water duty, i.e. the amount of water to be supplied per unit of time (l/s per ha), for irrigating one hectare, is calculated by the following equation:

$$q = \frac{m\ X1000}{TX86\ 400}\alpha\ \%, \text{l/s per ha}, \quad (4)$$

Where

q is water duty, l/s per ha;

m – irrigation rate, m^3/ha;

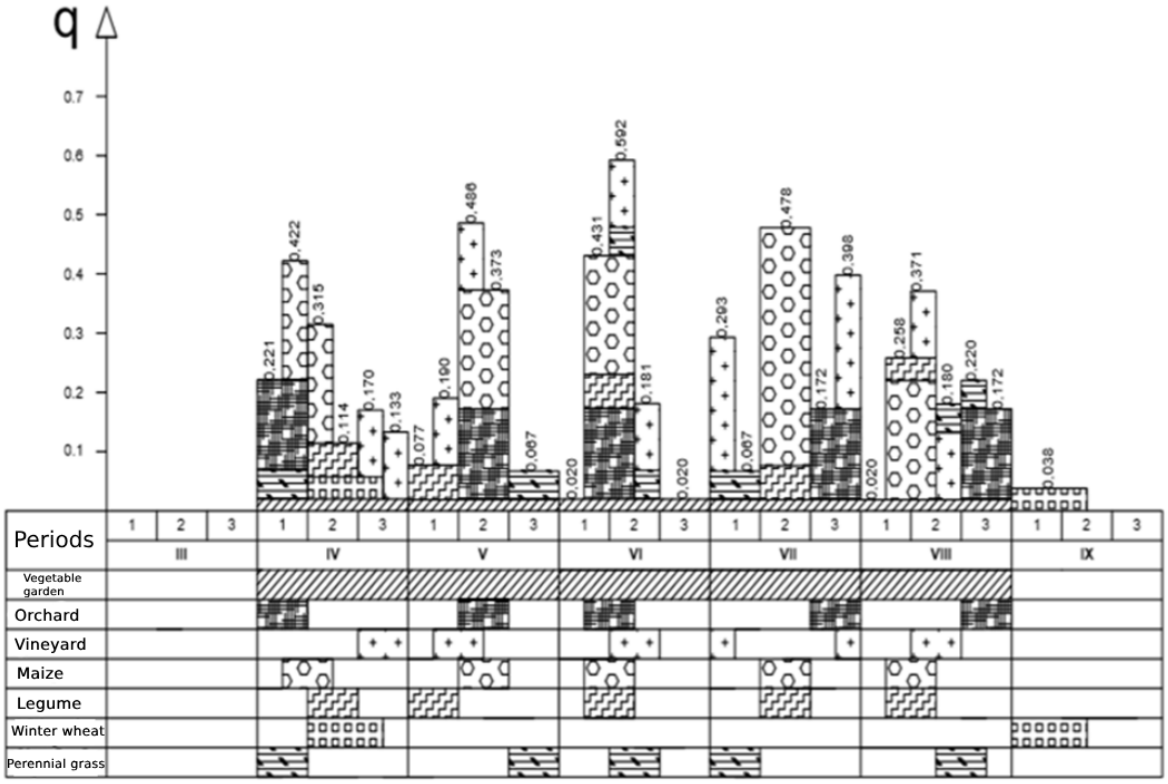
T – crop watering period per day;

α - % of area occupied by each crop out of total area, where the sum of percentages of the area occupied by

86400-number of seconds per day;

1000 –metric conversion coefficient, $m^3$to litters.

The data obtained as a result of the water duty's calculation are inserted into Table 3 and, accordingly, an uncompleted water duty graph has been built. If the same crop is irrigated on the same day, then an uncompleted graph is created by summing the water duties of the specified crops (see Table 3 and Graph 3).



Graph 3. Water duty's uncompleted graph

Table 3

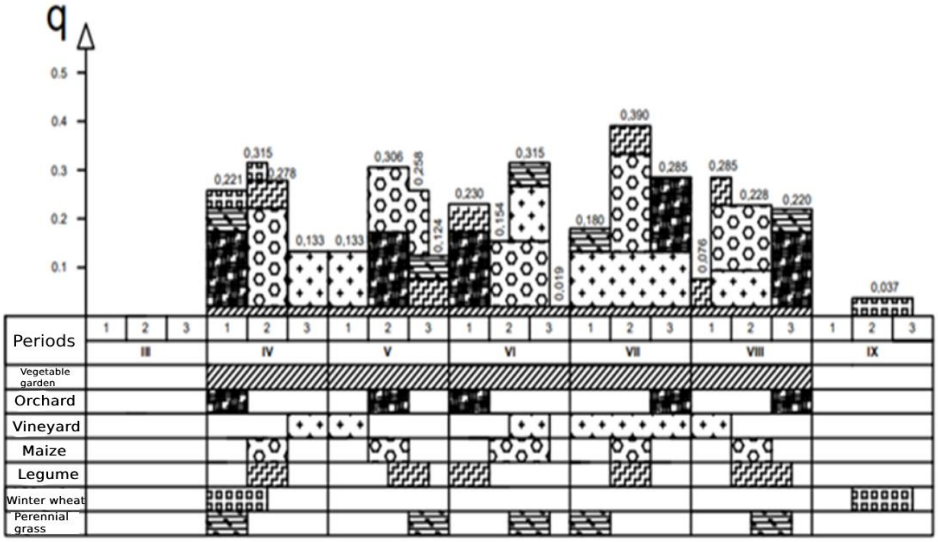
The Initial Data of uncompleted water duty's graph

Crops		area		Irrigation number	Irrigation periods		Duration of period (days)	I Irrigation rate, m^3/ha	Total irrigation rate, m^3/ha	Water duty value	
		ha	%		starting	ending				Per ha	% of total area
1.	**Vegetable garden**	90	0,13	1.	1-IV	30-IV	30	400	2 000	0,154	0,020
				2.	1-V	31-V	31			0,149	0,019
				3.	1-VI	30-VI	30			0,159	0,020
				4.	1-VII	31-VII	31			0,149	0,019
				5.	1-VIII	31-VIII	31			0.149	0.019
2.	**Orchard**	140	0,19	1.	1- IV	10- IV	10	700	3 500	0,810	0,153
				2.	10-V	20-V					
				3.	5-VI	15-VI					
				4.	20-VII	30-VII					
				5.	20-VIII	30-VIII					
3.	**Vineyards**	100	0,14	1.	20-IV	30-IV	10	700	4 200	0,810	0,113
				2.	5-V	15-V				0.810	0.113
				3.	10-VI	20-VI				0.810	0.113
				4.	1-VII	5-VII	5			1,620	0,226
				5.	25-VII	30-VII					
				6.	10-VIII	20-VIII	10			0,810	0,113
4.	**Maize**	210	0,29	1.	5-IV	15-IV	10	600	3 000	0,694	0,201
				2.	10-V	20-V	10			0.694	0,201
				3.	5-VI	15-VI	10			0.694	0.201
				4.	10-VII	20-VII	10			0.694	0.201
				5.	5-VIII	15-VIII	10			0,694	0,201
5.	**Legumes**	70	0.10	1.	10-IV	20-IV	10	500	2 500	0,578	0,057
				2.	1-V	10-V					
				3.	5-VI	15-VI					
				4.	10-VII	20-VII					
				5.	5-VIII	15-VIII	10			0.578	0,057
6.	**Winter wheat**	60	0,08	1.	10-IX	25-IX	15	600	1 200	0,463	0,038
				2.	1-IV	15-IV					
7.	**Perennial grass**	50	0,07	1.	1-IV	10-IV		600	3 000	0,694	0,048
				2.	20-V	30-V					
				3.	10-VI	20-VI					
				4.	1-VII	10-VII					
				5.	15-VIII	25-VIII					
8.	**Total**	**720**	**100 %**								

An uncompleted water duty's graph shows the amount of water available for Tamarisi farm, per hectare per time unit in l/s per ha. The graph describes which crop was irrigated in what amount of time. It is clear from the uncompleted graph of the water duty that the water requirement during the vegetation period is uneven. Since the irrigation network is calculated on the maximum consumption of water, during a certain period of time the system operates with incomplete load, in order to avoid unprofitability of the system, it is necessary to align and complete the water duty's graph (aligning the ordinates of a graph) (see Table 4 and Gr. 4).

Table 4. The Initial Data of completed water duty graph

Crops		area		Irrigation number	Irrigation periods		Duration of irrigation (days)	Irrigation rate, m^3/ha	Total irrigation rate,m^3/ha	Water duty	
		ha	%		starting	ending				Per ha	% of total area
1.	**Vegetable gardens**	90	0,13	1	1-IV	30-IV	30	400	2 000	0,154	0,020
				2	1-V	31-V	31			0,149	0,019
				3	1-VI	30-VI	30			0,154	0,020
				4	1-VII	31-VII	31			0,149	0,019
				5	1-VIII	31-VIII	31			0.149	0.019
2.	**Orchards**	140	0,19	1	1-IV	10-IV	10	700	3 5.00	0,810	0,153
				2	10-V	20-V					
				3	1-VI	10-VI					
				4	20-VII	30-VII					
				5	20-III	30-VIII					
3.	**Vineyards**	100	0,14	1	20-IV	30-IV	10	700	4 200	0,810	0,113
				2	1-V	10-V					
				3	15-VI	25-VI					
				4	1-VII	10-VII					
				5	20-VII	30-VII					
				6	5-VIII	20-VIII	15			0,540	0,075
4.	**Maize**	210	0,29	1	10-IV	20-IV	10	600	3 000	0,694	0,201
				2	10-V	25-V				0,462	0,134
				3	10-VI	25-VI	15				
				4	10-VII	20-VII	10			0,694	0,201
				5	5-VIII	20-VIII	15			0,462	0,134
5.	**Legumes**	70	0.10	1	15-IV	25-IV	10	500	2 500	0,578	0,057
				2	10-V	20-V					
				3	1-VI	10-VI					
				4	10-VII	20-VII					
				5	1-VIII	10-VIII					
6.	**Winter wheat**	60	0,08	1	10-IX	25-IX	15	600	1 200	0,462	0,037
				2	1-IV	15-IV					
7.	**Perennial grass**	50	0,07	1	1-IV	10-IV	10	600	3000	0,694	0,048
				2	20-V	30-V					
				3	15-VI	25-VI					
				4	1-VII	10-VII					
				5	20-VIII	30-VIII					
8.	**Total**	**720**	**100 %**								



Graph 4. Completed water duty graph

The mentioned graph generally shows the required amount of water per unit of time for the entire area of Tamarisi village and its variation throughout the vegetation period. The amount of water (l/s per ha) needed for Tamarisi farming was determined based on the completed graph of the water duty and a water demand curve was created.

The amount of water supplied for farming was determined as follows:

$$Q_{net}=q\times\omega \quad (5)$$

where Q_{net} is the water flow supplies to the irrigation area;

q – maximum ordinate of the completed water duty graph, l/sec per ha;

ω – irrigation area of the farm, ha.

The total area of the farm, in turn, consists of the irrigated plot, which is directly occupied by agricultural crops, including an unused area, which contains canals, roads, hydraulic engineering, civil and industrial structures, windbreaks, gullies, etc. The area given in the article represents the irrigated area.

Crop Water Requirement (CWR) calculated by all ordinates of the water duty graph (equation 6) is the net water flow, which must be directly supplied to the irrigated area. The water requirement calculated for the entire vegetation period will be applied to the completed graph of the water duty. The gross flow from the water source of irrigation water takes into account all losses (seepage, evaporation, etc.) that reduce the volume of water supplied. These losses are taken into account by the so-called irrigation efficiency for the irrigation system. η (ie), which depends on the type of irrigation system and its technical efficiency:

$$Q_{gross}=\frac{Q_{net}}{\eta} \text{ l/s ha} \quad (6)$$

where

Q_{gross} are losses of irrigation waters from canals of irrigation system due to see page, evaporation and etc.;

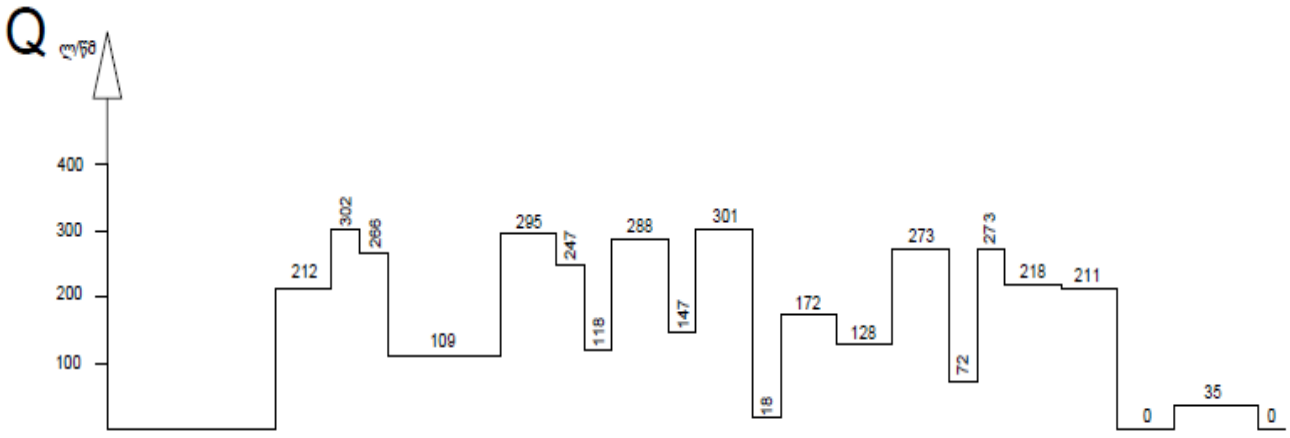
η-is irrigation efficiency (ie) of internal farmin system.

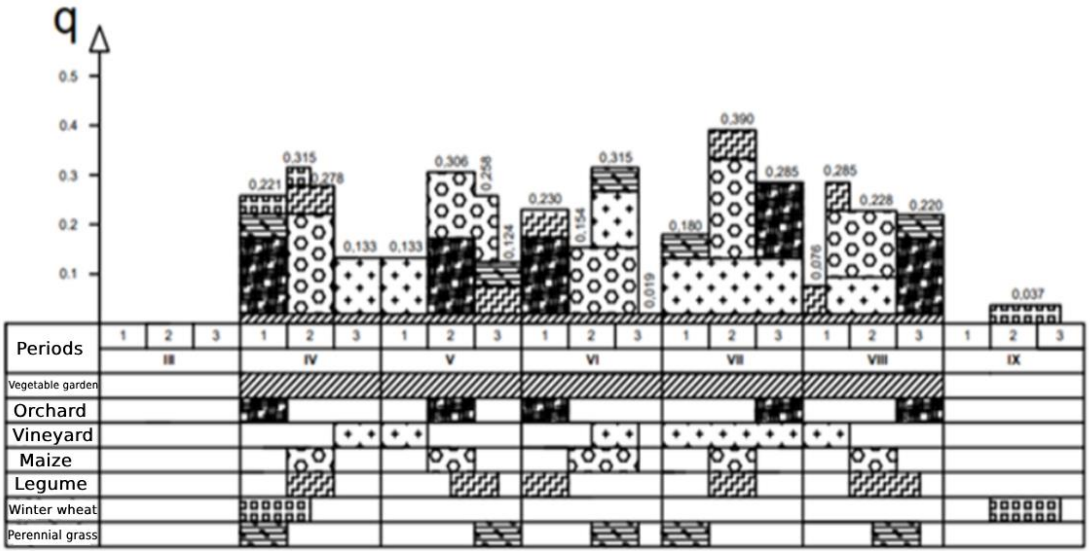
Since the irrigation network is lined, therefore the system's irrigation efficiency is equalled to η= 0.75. Table 5 represents the net and gross water flow values required for Tamarisi farming, and a water demand curve is created accordingly (see graph 5).

Table 5

Irrigation water flow required for farming

Irrigation period	Maximum ordinate of water duty	Farm area, l/s per ha	Net water flow, l/s per ha	i.e.	Gross water flow, l/s per ha
1/ IV -10/IV	0.221	720	159	0.75	212
10/ IV -15/IV	0.315		226		302
15 /IV -20/ IV	0.278		200		266
2 0/IV- 30IV	0.113		82		109
1/V-10/V	0.113		82		109
10/V-20/V	0.308		221		295
20/V-25/V	0.258		185		247
25/ V-30/V	0.124		89		118
1/VI-10/VI	0.230		216		288
10/VI-15/VI	0.154		110		147
15//VI-25/VI	0.315		226		301
25/VI-30/VI	0,019		14		18
1/VII-10/VII	0.180		129		172
10/VII-20/VII	0.132		96		128
20/VII-30/VII	0.285		205		273
1/VIII-5/VIII	0.076		54		72
5/VIII-10/VIII	0.285		205		273
10/VIII-20/VIII	0.228		164		218
20/VIII-30/VIII	0.220		158		211
10/IX-25/IX	0.037		27		35





Graph 5. Completed water duty graph including water demand curve

CONCLUSION

As a result of the summary of climatic and soil conditions, the need for irrigation was determined. In order to evaluate water supply, Prof. c. Selyaninov's method was used.

It was determined that Marneuli municipality belongs to a severe drought zone.

The percentage ratio of the area share occupied by individual agricultural fields in the village of Tamaris of Marneuli municipality in relation to the total area, was determined. Irrigation indicators of the soil of Tamaris village were determined; the irrigation rate for each agricultural crop was defined water demand was determined according to the irrigation periods, the values of which differ significantly from the existing ones.

REFERANCE

1. G. Gavardashvili, Irrigation, Drainage, Erosion, Tbilisi, Publishing House “Universal”, p.413, 2018, Central Library of GTU.
2. D. Gubeladze, O. Kharaishvili - „Agricultural Hydromelioration”, Textbook, p.650, http://dspace.nplg.gov.ge/handle/1234-/320999, Tbilisi, 2020, GTU Central Library.
3. D. Gubeladze, O. Kharaishvili „Workshop of Agricultural Melioration”, 2018, p..322. ISBN978-9941-8-0713-8 GTU Central Library 631.6. p-921.
4. G. Tugushi, P. Tugushi , O. Kharaishvili - „Agricultural Hydraulic Engineering Amelioration. Special types of land irrigation, dewatering and water supply". Tbilisi, 2000, p. 78. GTU Central Library
5. I. Kruashvili, I. Inashvili - „Management of Water Recourses in Agriculture”. GTU, Tbilisi, 2009 p.184.GTU Central Library: http://www.gtu.ge/publishing house/ ISBN 978-9941-14-759-3.
6. O. Kharaishvili, N. Mebonia, L. Akhvlediani. Determining the irrigation indicators of the irrigated regions of Georgia and the need for irrigation according to municipalities (Monograph) [Book] – Tbilisi: Sachino, 2023. p. 459.
7. I. Inashvili, K. Bziava. Water resources regulation in agriculture - Environmental problems. LAP Lambert Academic Publishing (2021-01-26), ISBN-13: 978-620-3-30625-5, ISBN-10: 6203306258, EAN: 9786203306255, 2021, 120 p.

AMELIORATIVE INDICATORS OF SOILS IN THE IRRIGATION ZONE OF THE CASPIAN AND MTSKHETA MUNICIPALITETS OF THE SHIDA KARTLI PLAIN OF GEORGIA

O. Kharaishvili, E. Kechkhoshvili, F. Lortkipanidze
Ts. Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60[b], 0179, Tbilisi, Georgia
E-mail: xaraishviliolga@gmail.com

INTRODUCTION

The main task of agriculture is to increase the production of products to meet the needs of the population and raw materials for the light and food industries. Fulfillment of this task from farms requires, in order to increase soil productivity on developed and new areas, to outline and implement a set of agrotechnical measures that will sustainably ensure the obtainment of high yields. In addition to agrotechnics, an important factor is the correct selection of irrigation regime.

Recently, irrigation systems have been rehabilitated in Georgia, however, meeting the demand for agricultural products depends not only on the scale of irrigation construction; it requires proper operation of the systems, rational use of the received water based on appropriate irrigation techniques and irrigation regime.

Irrigation regime, unlike irrigation technique, requires specification for each irrigation district and microdistrict. If the natural-climatic conditions of irrigated areas are not taken into account when planning reclamation measures, irrigation can reduce soil fertility to such an extent that crop yields fall to the minimum.

MAIN PART

The purpose of the article is to determine ameliorative indicators of soils of Mtskheta and Kaspi municipalities for the purpose of correct selection of irrigation regime elements.

We do not provide all those indicators that should be determined during soil ameliorative study. We mainly consider those of them, which are necessary for selection of irrigation regime elements: ultimate water holding capacity, maximum molecular water holding capacity, volumetric mass and character of water absorption into soil.

For determination of soil ameliorative indicators, samples (4 samples at each point) in the form of monoliths in natural state with height of 16 cm and diameter of 12 cm were taken at the depth of 64 cm from the ground surface with gradation of 16 cm. The samples were investigated in the laboratory of agricultural melioration of the Georgian Technical University. According to the obtained data, the irrigation rate was calculated (taking into account the investigated soil depth, the irrigation rate was determined for field crops).

The following soil categories can be distinguished in the irrigation zone of Mtskheta and Kaspi municipalities:

- Forest brown carbonate clayey soil;
- Forest brown carbonate loamy soil;
- Forest brown carbonate heavy to medium loamy soil;
- Gray-brown carbonate heavy loamy soil;
- Gray-brown carbonate heavy to medium loamy soil;
- Sod-alluvial carbonate heavy to medium loamy soil;
- Complex of sod-carbonate saline and sodic soils.

The forest brown carbonate clayey soils are distributed on the northern slopes of Kvernaki Mountain, in the upper strip of areas of Tezi-Okami irrigation system, in the southern part of Mukhrani valley, on both sides of Tbilisi-Gori highway. In the upper horizons these soils are characterized by dusty-compact structure.

Humus content in the upper soil layers varies within 2.44 - 3.16 %. By mechanical composition the soil is clayey throughout the depth (amount of physical clay 65,05 - 86,50 %). The exception are soils in the southern part of Mukhrani valley, which are close to heavy loams. In them the amount of physical clay in the upper layers reaches 62.25 % and at the depth of 70-80 cm decreases to 51.65 %.

Table 1

Ameliorative indicators of forest brown carbonate clayey soils

Sample location	Sampling depth cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Qvemo Rene	0-16	1,01	15,30	47,60	0,001944	682	38.08	-
	16-32	1,12	17,01	46,03	0,001380	500	36,82	-
	32-48	1,29	16,17	33,92	0,001980	716	27,14	-
	48-64	1,36	16,16	31,79	0,001339	482	25,43	-
	0-70	1,19	16,16	39,83	-	-	31,86	663
vill. Okami	0-16	1,00	16,01	47,19	0,001888	680	37,75	-
	16-32	1,12	16,44	42,04	0,002768	996	33.63	-
	32-48	1,57	16,73	33,32	0,000837	30	26,66	-
	48-64	1,43	16,80	31,02	0,000858	308	24,82	-
	0-47	1,23	16,40	38,39	-	-	30,71	664
vill. Chardakhi	0-16	1,09	16,24	50,71	0,002281	821	40,47	-
	16-32	1,12	18,32	44,79	0,001494	538	35,83	-
	32-48	1,26	15,41	31,23	0,002251	810	24,98	-
	48-64	1,27	15,33	31,41	0,002455	884	25,13	-
	0-70	1,18	16,50	39,53	-	-	31,62	653

As can be seen from Table 1, these soils are loose from the surface and slightly compacted in depth. Volumetric weight of 0 - 32 cm layer is equal to 1.00 - 1.12, lower layers 1.26 - 1.43.

Among water properties, due to heavy mechanical composition of soil, high values of maximum molecular moisture capacity should be noted, which can be misleading when visually assessing the moisture content of the soil to determine the timing of irrigation. This is explained by the fact that in such cases the soil looks sufficiently moist, although most of the soil moisture is in a form inaccessible to the plant.

According to the given data these soils retain moisture well - the ultimate water holding capacity is 31.02 - 50.71 weight percent. Such an indicator of ultimate water holding capacity requires a high irrigation rate. For these soils for 1 ha of crops for each irrigation approximately 650 m^3 of water is required.

The table shows values of 80 % water holding capacity, which is the lower limit of the optimum amount of soil moisture for the plant. According to this, watering should be carried out when the water holding capacity drops to 31%.

Physical and water properties of these soils fully correspond to the value of their filtration coefficient. According to the table, at the whole investigated depth the filtration of these soils is rather high, numerically - 0.00276 - 0.000837 cm/sec, which corresponds to 996 - 301 m^3/hour per 1 ha.

The forest brown carbonate loamy soils are distributed in the upper strip of the southern part of the Caspian region. Table 2 shows that the upper 0-32 cm layer of these soils is loose (volume mass 1.04-1.18

g/cm^3); with increasing depth due to strong compaction, the volume mass increases to 1.53 g/cm^3. The exception is the soil of Telatgori village, which remains loose throughout the profile, due to which its volume mass does not exceed 1.47 g/cm^3.

Table 2

Ameliorative indicators of forest brown carbonate loamy loamy soils

Sample location	Sampling depth cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Doesi	0-16	1,04	13,48	40,18	0,012476	446	32,14	-
	16-32	1,18	14,77	35,24	0,000767	276	28,19	-
	32-48	1,40	13,89	36.61	0,000052	19	29,29	-
	48-64	1,53	13,85	30,77	0,000006	2	24,62	-
	0-70	1,29	13,02	35,09	-	-	28,56	589
vill. Kavtiskhevi	0-16	1,04	15,04	43,43	0,011985	4314	37.74	-
	16-32	1,16	15,68	39,09	0,006678	2403	31,27	-
	32-48	1,58	13,91	28,11	0,000150	54	35,14	-
	48-64	1,63	14,28	26,38	0,000073	25	21,10	-
	0-70	1,35	14,73	34,38	-	-	27,50	650
vill. Telatgori	0-16	1,04	13,00	44,50	0,004303	1549	55,63	-
	16-32	1,31	14,66	36,44	0,000722	260	29,15	-
	32-48	1,37	15,45	34,33	0,000515	221	27,46	-
	48-64	1,47	15,10	31,37	0,000039	14	25,10	-
	0-70	1,20	14,55	33,65	-	-	26,92	662

As it is evident from the data of maximum molecular moisture, these soils are characterized by lighter mechanical composition in comparison with the above described soils. Indices of maximum molecular moisture in 0.7 m layer range from 13.92 to 14.77 %. Also these soils have lower values of ultimate water holding capacity, although the average value of this indicator in 0.7 m layer is rather high - 34.38%.

When irrigating these soils, due to high water holding capacity, irrigation rate should be 650 m^3/ha, and watering should be done when soil moisture decreases to 28 - 29 %.

As for the filtration properties of these soils, according to the table, the upper horizons are characterized by strong filtration - 0.012476 - 0.004303 (per ha 446 - 1549 m^3/hour), and from the depth of 0. 32 m (for Telatgori 0.48 m) filtration decreases significantly - in the layer 32 - 48 cm to 0.000052 cm/sec (per ha 19 m^3/hour), 32 m (for Telatgori 0.48 m) filtration decreases significantly - in the layer 32 - 48 cm to 0.000052 cm/sec (per ha 19 m^3/hour), and in the next layer 48 -64 cm - 0.000006 s/sec (per ha 2 m^3/hour). On this basis, the elements of irrigation technique should be selected in such a way that the water on the area for a long time stagnated to moisten the active layer of soil to the required depth. Horizontal filtration irrigation with a small irrigation flow gives good results, and on high gradients - the use of oblique furrows.

The forest brown carbonate heavy to medium loamy soils are found in the northern part of the Mukhrani valley and in the upper strip of the Saghuramo massif. They are characterized by fine lumpy structure; humus amount is 3.78 - 2.24 %. The mechanical composition is heavy and medium loams - the quantity of physical clay (particles <0.01mm) in the whole profile is 45.65 - 55.22 %. Such mechanical composition causes characteristic relatively small value of maximum molecular moisture.

Table 3

Ameliorative indicators of forest brown carbonate heavy to medium loamy soils

Sample location	Sampling depth, cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity, %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate, m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Dzalisi	0-16	0,20	12,19	40,52	-	-	32,42	-
	16-32	1,30	12,13	30,13	0,000516	103	24,10	-
	32-48	1,46	12,21	30,28	0,000377	125	24,22	-
	48-64	1,50	11,35	20,63	0,000436	137	16,50	-
	0-70	1,33	11,97	32,39	-	-	25,91	603
between vill. Misakcieli and vill. Natakhtari	0-16	1,16	13,65	32,65	0,001078	388	46,85	-
	16-32	1,31	12,05	32,17	0,001122	403	25,75	-
	32-48	1,47	12,65	28,84	0,000659	237	23,07	-
	48-64	1,49	13,63	28,46	0,000622	224	22.77	-
	0-70	1,36	12,99	30,83	-	-	24,42	581
vill. Saguramo	0-16	1,06	14,46	40,54	0,001100	396	32,43	-
	16-32	1,17	13,83	36,32	0,001355	488	29,06	-
	32-48	1,45	14,22	29,33	0,000385	139	23,46	-
	48-64	1,47	14,53	22,69	0,000505	182	18,15	-
	0-70	1,29	14,23	32,22	-	-	25,78	582

In the whole profile the maximum molecular moisture is 11.35-14.53 %. These soils, in comparison with the above-described brown forest soils, are characterized by lower ultimate water holding capacity, which does not exceed 32.39 % in 0.7 m layer. The irrigation rate should not exceed 600 m^3/ha, and it is necessary to irrigate when soil moisture decreases to 25 - 26 %. According to the data of Table 3, these soils have approximately the same filtration properties in the whole profile. The data of layer 16 - 32 cm are of special interest. Mainly these soils are spread on slopes with large gradients, therefore, horizontal filtration irrigation along oblique furrows is a good result for them.

The gray-brown carbonate heavy loamy soils are spread along both banks of the Tedzami River in the Kasp district, up to the border of forest brown carbonate heavy loamy soils. They have gray chestnut color, humus content 0,48 -1,65 %, carbonates - 13,33 - 15,91 %. The structure in the upper 10 cm is fine-grained, in the next 10 cm - finely lumpy-grained. In water extract dry residue is high - 0,043 - 0,053 %, total alkalinity at the depth of 70 - 80 cm is rather high - 0,466 %, that is explained by 0,0023 % presence of soda in this layer. These soils are loose from the surface: volume mass of layer 0-32 is approximately 1 g/cm^3 and at the depth of 0,7 m - 1,19 g/cm^3.

As for maximum molecular moisture, the average values in the 07 m layer are 12.61 - 15.93 %. Soils on the left bank of the Tedzami River have higher values of maximum molecular moisture than on the right bank, which indicates their heavier mechanical composition. These soils are characterized by high water-holding capacity. Its average value in 0,7 m layer is 38,58 - 40,48 %. This determines the necessity of rather high irrigation rate, approximately equal to 650 m^3/ha, and it is necessary to irrigate when soil moisture in 0.7 m layer decreases to 31 - 32 %.

Filtration indices are of special interest. As can be seen from Table 4, these soils are characterized by the best indicators. Filtration coefficient of soils on the right bank of Tezami river is higher, which can be explained by inclusions of mineral rock particles. In the 0-32 cm depth layer the value of the coefficient is 0,008449 - 0,008871 cm/sec, which in recalculation per hectare gives 3042 - 3134 m3/hour. The filtration coefficient decreases with depth, but still remains significant. Due to the large filtration, in order not to increase the irrigation rate, irrigation should be carried out by furrows with flowing water. At the same time, the flow rate of the furrow should be maximal, so that the water on the field did not stagnate for a long time.

Table 4

Ameliorative indicators of gray-brown carbonate heavy loamy soils

Sample location	Sampling depth, cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity, %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate, m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Doesi	0-16	1,09	15,61	42,10	0,001766	634	33.68	-
	16-32	1,09	17,36	45,03	0,004272	1538	36,02	-
	32-48	1,22	14,41	38,90	0,000836	301	31,12	-
	48-64	1,34	16,33	35,91	0,000082	30	28,73	-
	0-70	1,19	15,93	40,48	-	-	32,38	674
between vill.Akhalqa laqi and vill. Metekhi	0-16	1,00	13,51	43,84	0,008449	3042	35,04	-
	16-32	1,01	14,40	42,81	0,008871	3134	34,25	-
	32-48	1,31	11,42	36,48	0,001413	489	29,18	-
	48-64	1,39	11,11	31,20	0,001145	412	24,96	-
	0-70	1,18	12,61	38,58	-	-	30,86	637

The gray-brown carbonate heavy to medium loamy soils are distributed in the Caspian region along the left bank of the Kura River on the massif of western and eastern Ashuriani. Soils are characterized by gray-brown color, humus content 3.51 - 1.54 %; mechanical composition is heavy and medium loams.

Table 5

Ameliorative indicatorsof gray-brown carbonate heavy to medium loamy soils

Sample location	Sampling depth, cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity, %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate, m^3/ha
					cm/sec	average m^3/ha per hour		
East Ashuriani	0-16	1,25	13,68	35,91	0,006228	2242	28,73	-
	16-32	1,35	13,65	33,91	0,006281	2261	27,13	-
	32-48	1,55	12,43	26,05	0,000109	39	20,84	-
	48-64	1,53	11,76	26,00	0,000259	93	20,80	-
	0-70	1,39	12,88	30,67	-	-	24,54	597
Vest Ashuriani	0-16	1,22	11,76	34,83	0001364	401	27,86	-
	16-32	1,27	14,02	36,69	0,000091	23	29,35	-
	32-48	1,57	12,73	25,83	0,000723	260	20,66	-
	48-64	1,55	13,55	25,88	0,000616	185	20,70	-
	0-70	1,40	13,02	30,81	-	-	24,65	604

These soils are compacted from the surface and are characterized by high values of volumetric mass. At the depth of 0 - 32 cm this indicator is equal to 1.22 - 1.27 g/cm^3, and in the underlying layers it reaches 1.53 - 1.57 g/cm^3.

Accordingly, the indicators of ultimate water holding capacity also change. If at the depth up to 0.32 m it is equal to 33.91 - 36.69 %, then below it decreases significantly to 25.83 - 26.00 % due to soil compaction and easier mechanical composition.

On these soils irrigation rate should not exceed 600 m^3/ha, and irrigation should be carried out when the soil moisture in the layer up to 0.7 m will be 24 - 25%.

As for filtration, different indices were recorded in these soils, in particular, soils of eastern Ashuriani in 0 - 32 cm layer are characterized by high index (2261 m^3/hour per ha), which sharply decreases with increasing depth to 0.000109 - 0.000259 cm/sec (39 - 93 m^3/hour per ha). Filtration in soils of western Ashuriani is more uniform - 0.001364 - 0.000516 cm/sec (491 - 186 m^3/hour per ha). The exception is the layer of 16-32 cm, in which, due to weak solonetization, the indicators of maximum molecular moisture and limit moisture are increased, while the filtration coefficient is sharply reduced.

When irrigating these soils, for uniform moistening of the entire active layer, irrigation should be carried out in furrows with flowing water with a low water flow rate.

The sod-alluvial carbonate heavy to medium loamy soils are spread in a narrow strip on both banks of the Kura River in Kaspi district, on the Tezi-Okami massif, on the right bank of the Ksani River, on the Mukhrani valley south and east of the villages of Ksovrisi, Dzalisi, Tsilkani, Natakhtari up to the Georgian military road in a strip 2 - 4 km wide and on the Saguramo massif in a narrow strip 0.5 - 4 km wide along the Aragvi River. The color is gray, dark gray and gray-yellow; the amount of humus in the 0.5 m thick layer is 1.86 - 3.21 %, carbonates in the upper layer 19.28 - 26.65 % increase with increasing depth and at a depth of 1 m reach 32.90 %.

Table 6

Ameliorative indicators of sod-alluvial carbonate heavy to medium loamy soils

Sample location	Sampling depth, cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity, %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate, m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Mukhrani	0-16	1,22	11,15	34,32	0,002640	950	27,46	-
	16-32	1,24	10,98	30,11	0,000551	199	21,97	-
	32-48	1,39	11,20	28,10	0,000251	94	22,48	-
	48-64	1,49	12,01	27,78	0,000144	52	22.22	-
	0-70	1,33	11,33	30,08	-	-	24,06	560
vill. Saguramo	0-16	1,17	10,02	33,16	0,004222	1520	26,53	-
	16-32	1,41	11,76	30,60	0,000296	109	24,48	-
	32-48	1,01	11,41	28,09	0,000251	90	22,47	-
	48-64	1,45	11,36	28,09	0,000569	203	22,47	-
	0-70	1,36	11,14	29,99	-	-	23,99	561

As it is evident from Table 6, these soils in the whole profile have rather significant volumetric mass: in the 0-16 cm depth layer - 1.17-1.22 g/cm^3, and in the 48-64 layer - 1.49 g/cm^3. The ultimate water holding capacity in the 0-32 cm layer is 30.11-34.32 %, and later it decreases to 27.78 %

Together with small value of ultimate water holding capacity these soils are characterized by low values of molecular moisture, which does not exceed 10,02 - 12,01% in the whole profile. Irrigation norm for these soils should not exceed 550 m^3/ha and watering should be done when soil moisture decreases to 24%. Filtration characteristics of these soils are rather high - in the upper horizon the filtration coefficient is 0.002640 - 0.004222 cm/sec (950 m^3/hour per ha), with increasing depth it decreases, but still remains quite significant.

The Complex of sod-carbonate saline and sodic soils are mainly spread in the halves and depressions of the central part of the Mukhrani plain. Their overwatering, sometimes turning into water logging, is a result of high groundwater table as a result of excessive irrigation rates or improper irrigation. According to the results of water extraction in saline soils total alkalinity in soil layer 38 - 46 cm is high (0,61%), which is explained by the presence of 0,0063 % of soda in it. Dry residue in the upper layer of 10 cm is 0.099%, with increasing depth it increases and reaches 1.83% below 1.0 m. Both overwatered and sodic soils are carbonate. Soils of the central part of Mukhrani plain are heavy loams by mechanical composition, and soils of the southern and south-eastern part are medium loams.

These soils are loose in the upper arable horizon. Volumetric mass of 0.32 m layer is 0.99 - 1.17 g/cm^3 and below it increases up to 1.55 g/cm^3. The 0.5 m thick layer has a high water-holding capacity. The maximum water holding capacity on horizonts is 30.77 - 40.73% (average in 0.7 m layer is 33.85 %). Irrigation rate should not exceed 600 m^3/ha, and irrigation should be carried out when the moisture content

of the soil layer 0.7 m deep decreases to 26 - 27 %. As for the coefficient of filtration, in the upper horizons it is rather high, and with depth, it decreases significantly.

Table 7

Ameliorative indicators of sod-carbonate saline and sodic soils

Sample location	Sampling depth, cm	Volumetric mass, g/cm^3	Maximum molecular moisture content weight %	maximum water holding capacity, %	Filtration coefficient		80% of maximum water holding capacity	Irrigation rate, m^3/ha
					cm/sec	average m^3/ha per hour		
vill. Agaiani	0-16	1,10	15,81	31,75	-	-	25,40	-
	16-32	1,15	13,80	36,92	-	-	29,54	-
	32-48	1,49	14,28	30,77	-	-	27,69	-
	48-64	1,55	14,77	26,94	-	-	21,55	-
	0-70	1,32	14,66	31,59	-	-	25,27	503
Mukhrani plain	0-16	1,10	12,12	37,04	0,001166	420	29,63	-
	16-32	1,17	11,26	35,14	0,001006	362	28,11	-
	32-48	1,47	10,51	33,37	0,000609	219	26,70	-
	48-64	1,48	12,34	29,61	0,000048	17	23,69	-
	0-70	1,30	11,62	33,79	-	-	27,03	606
Mukhrani plain	0-16	0,99	16,59	40,73	0,00346	1233	32,58	-
	16-32	1,09	15,81	33,78	0,003705	1334	27,02	-
	32-48	1,41	15,16	32,53	0,000414	149	26,02	-
	48-64	1,52	14,51	28,37	0,000219	79	22,70	-
	0-70	1,25	15,51	33,85	-	-	27,08	592

Special attention at irrigation of these soils should be paid to the size of irrigation rate and correct selection of irrigation technique elements. They should be selected so that water on the area did not stagnate for a long time and the soil did not receive water, more than the calculated norm. It is also necessary to control irrigation of neighboring, especially overlying areas, because excessive water received by them, in the considered soils can cause rise of groundwater table and increase overwatering.

CONCLUSION

Based on the conducted research and relevant calculations, it was established that in Kaspi and Mtskheta municipalities of Shida-Karli Plain 600-650 m^3/ha should be accepted as irrigation norms for field crops; similarly, compared to the existing irrigation norms, irrigation norms for perennial plantations (650-700 m^3/ha) and vegetable crops (400-450 m^3/ha) should be changed. The proposed irrigation rates differ significantly from the current ones, which will save water and help farmers in proper selection of irrigation regime for stable generous yields.

REFERANCE

1. O. Kharaishvili, M. Kikabidze, N. Mebonia, M. Lomishvili, K. Rokva. DETERMINE THE MARGINAL WATERSHED AND VOLUMETRIC WEIGHT INDICATOR OF MUKHRANI-SAGURAMO VALLEY SOIL IN LABORATORY CONDITIONS. Tsotne Mirtskhulava Water Management Institute, Collected Papers №74, 2019 pp 130-135;
2. O. Kharaishvili, T. Darsavelidze, T. Gogishvili, M. Meladze, G. Natroshvili. Irrigation efficiency during sowing and growing season. «World Scientific Reports» (November 17-18, 2022). Paris, France; 5 p. ISBN978-1-8628-5741-4 DOI10.5281/zenodo.7338607;
3. D. Gubeladze, O. Kharaishvili, Sh. Shamatava. Influence of acid reaction of the soil area on the physical-chemical processes in the soil. Input of increased amounts of lime into acid soils for chemical soil modification. BULLETIN of Georgian Academy of Agricultural sciences №2(48), Tbilisi, 2022 pp. 61 -70.

EFFECT OF SHEAR FORCE ON THE STABILITY OF VULNERABLE SLOPES

N. Kvashilava, I. Khubulava, I. Kvirkvelia
Tsotne Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60-b, 0179, Tbilisi, Georgia
E-mail: kvashilavanugzar@gmail.com

INTRODUCTION

The problems related to maintaining the stability of slopes are so relevant that researches related to this issue are often conducted. In some cases, the situation is catastrophic and requires radical measures, while in other cases, the danger is less severe.

Recently, due to the deterioration of the ecological situation around Tbilisi, which is caused by the activation of erosive processes, landslides and mudslide events, and all this is due to the presence of a water catchment area around the capital, which includes more than 50debris flow ravines, up to 60 small rivers and more than 60 landslide zones, and all this poses a threat to the city's population and infrastructure [1].

From the ecological point of view, one of these small rivers is important. Gldaniskhevi, which has a high risk of natural disasters. In our case, the object of consideration is the river. A rolling slope, the stability of which requires the determination of appropriate parameters. Based on the laboratory processing of the samples taken as a result of the field work, the values of the search parameters were determined.

Internal friction angle $\varphi = 18^0$; porosity n = 0.4; mineral density $\rho_ə$ = 2,71 t/m^3; liquid density $\rho_ს$ = 1t/m^3; density c = 2.1 t/m^2.

Let's use the formula we know [2,3,4]

$$1/\bar{z} \leq \frac{c}{\rho g z} = \sin\alpha - tg\varphi \cdot \cos\alpha, \qquad (1)$$

where $\bar{z} = \frac{\rho g z}{c}$ is the relative thickness of the sloppe layer, α – is the slope angle. This image is from elementary soil equilibrium analysis:

$|\tau_{x^2}| > |\sigma_z| tg\varphi + c$, where σ_z = ρgzcosα and τ_{xz} = ρgzsinα there are normal and shoulder stresses respectively.

In case of saturation with water, we have the following image:

$$1/\bar{z}_1 \leq \frac{c}{\rho g z_1} = (1-\frac{\rho}{\rho})(\sin\alpha - tg\varphi\cos\alpha) + \frac{\rho_ს}{\rho_ə}\sin\alpha \cdot \frac{1}{1-n} \qquad (2)$$

where $\bar{z}_1$–is the relative thickness of the slope layer in the case of soil saturated with water.

Taking formulas (1) and (2) into account, we obtain the following expressions based on our parameters:

$$1/\bar{z} \leq \frac{c}{\rho g z} = \sin\alpha - 0.32\cos\alpha \quad (3)$$

$$\frac{1}{\bar{z}_1} \leq \frac{c}{\rho g z_1} = 1.25\sin\alpha - 0.2\cos\alpha \qquad (4)$$

Let'sbuild a graph according to the relations (3) and (4) between the critical relative depths of the slope and the slope.

Table 1

α	20^0	30^0	40^0	50^0	60^0	70^0	80^0	90^0
$1/\bar{z}$	0	0.22	0.39	0.56	0.7	0.83	0.93	1

Table 2

α	9^0	30^0	40^0	50^0	60^0	70^0	80^0	90^0
$1/z_1$	0	0.45	0.65	0.33	0.98	1.1	1.2	1.25

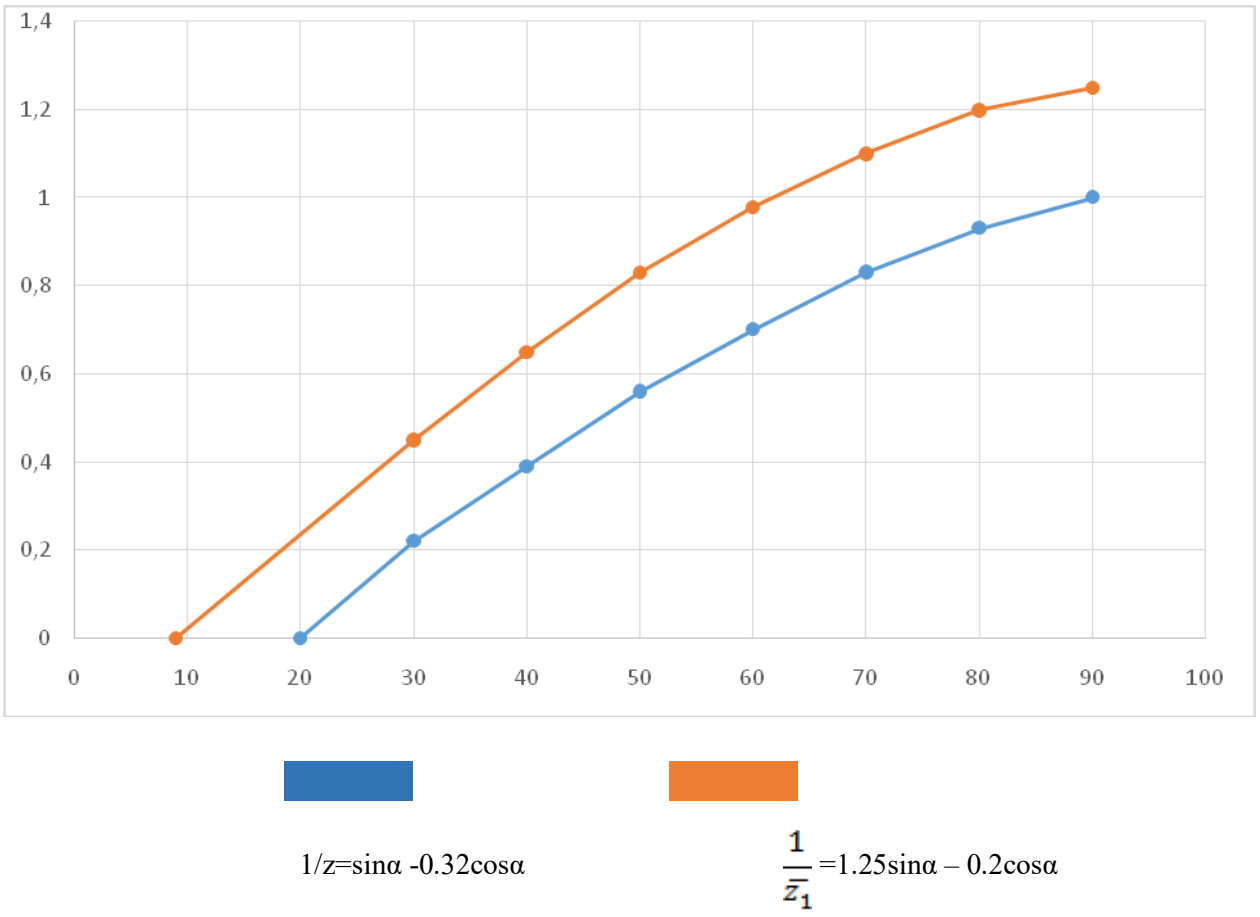


Fig. 1. A graph of the relationship between the critical relative depths of the slope and the slope

The graph is constructed using the given tables. The solid line corresponds to the critical condition of "dry" soil, and the dashed line to saturated soil. Area I in the figure corresponds to the steady state of the slope, z.m. – is the limit state, and the II area is the boundary state, that is, when the slope is moved.

For "dry" soil, we get for $\alpha = 30^0$ from formula (3) $\frac{c}{\rho g z} \leq 0{,}215$, from which follows $z \geq 6.1$m.

for $\alpha = 40^0 z \geq 4{,}0$ m, for $\alpha = 50^0 z \geq 2{,}7$m.

In case of saturation with water for $\alpha = 30^0 c/\rho(1-n)z_1 \leq 0.447$, from where $z_1 \geq 2.8$ m,

for $\alpha = 40^0 z_1 \geq 2.3$ m, but for $\alpha = 50^0 z_1 \geq 1.8$ m.

As we can see in this case it is possible to climb the slope.

It can be seen from the figure that water reduces this critical slope angle (when movement starts) by approximately $11\div25^0$.

Cohesive strength is known to be low in sandy soils; It's shaking in the interval $0\div0.8$ t/m^2, and in clay soils it is important and fluctuates in the interval of $0.5\div9.4$ t/m^2.

To simplify the calculation, for comparison, let's take the tension of 0,21 t/m^2, while $\alpha= 30^0 z\geq0.61$ m; when $\alpha = 40^0$, $z\geq0,40$m, and $\alpha = 50^0$, $z\geq0.27$ m; for all these cases, "dry" soil will be moved.

In case of soil saturated with water when $\alpha = 30^0$, $z_1\geq0.29$ m; when $\alpha = 40^0$, $z_1\geq0.23$m; And when $\alpha = 50^0$, $z_1\geq0.18$ m – ground shaking will occur.

As we can see, in the case of a small compressive force (especially in the case of water saturation), a layer of the ground only a few tens of centimeters thick can move and form a landslide.

Now, also for comparison, let's take a hypothetical density of 21 t/m^2. We take ten times more to simplify the account.

"Dry" soil for $\alpha = 30^0$ will move when $z\geq61$ m; for $\alpha = 40^0$ when $z \geq 40$ m; and for $\alpha = 50^0 z\geq18$ m.

After saturation for $\alpha = 30^0 z_1\geq29$ m; for $\alpha = 40^0$ $z_1\geq23$ m and for $\alpha = 50^0$ $z_1\geq18$ m.

As we can see, in this case, practically impossible to climb a slope saturated with water.

CONCLUSION

Based on the above calculation, it can be concluded that the mentioned slope is prone to landslides, because in the case of a slope of about 40^0, the presence of a ground mass of about 2 m is enough to move this mass in case of saturation with water.

In the article, we also saw how important a role the ground grip plays.

In the case of a small grip, the slope can be moved even in the "dry" state, while in the case of a large grip force, even its saturation with water is not a danger.

REFERENCE

1. http: //www.nplg.gov.ge/dlibrary/ collect/0002/000689/ G.N. disertacia-10.07.2013.pdf;
2. The influence of water saturation on the conditions of flood formation// Bulletin of the Academy of Sciences of Georgia, vol. 106, No. 2, Vol., 1982, p. 353-356;
3. Liatkher, N. Kvashilava. A mechanical model of flood formation // Water Resources, No. 3, 1984, p. 96-108;
4. https://dspace.nplg.gov.ge/handle/1234/274275

ARTIFICIAL INTELLIGENCE AS AUTOMATION AND ROBOTISATION TOOL IN CONSTRUCTION PROCESSES

J. Niemiro-Maźniak, M. Major, I. Major

Czestochowa University of Technology
Czestochowa, Poland
E-mail: maciej.major@pcz.pl

1. INTRODUCTION

At the present time, artificial intelligence is becoming ever more widely used tool in various human activities. Today's construction industry is also increasingly impacted by artificial intelligence, which is based on the technology of implementing construction processes by using numerical tools that enable the creation of digital twins in BIM technology [1], and effectively seeks to implement the construction process autonomously, i.e. without direct human involvement. This issue is discussed in paper [2], in which the automation of the design process is reviewed, with a particular focus on its application in the design of building structures. The authors presented examples of its application, its advantages and associated challenges. When we consider the high-tech manufacturing process used in prefabrication plants or material factories, where artificial intelligence also makes it possible to conduct manufacturing process on the basis of an automated, digitally controlled production line with the use of industrial robots, we can see that we are facing another challenge: the robotisation of the construction process itself. This process that has been used in line construction is slowly becoming a solution that is gaining importance in the road construction process. Already today, many earthmoving works and road constructions are carried out with self-driven machines that use GPS to locate the position of the machine performing a specific task at a given time. This enables the construction process to be carried out according to the design specifications continuously, without any necessary work breaks for the operators. The autonomous process is characterised by the accuracy of machineries' positions while the works are carried out, which results in accuracy of the work in progress, unattainable by skilled operators. For concrete pavements, automatic pavers lay not only the pavement but also the expansion joints, using a dedicated automatic system. Machines operating with the Real Time Kinematic system constitute here a good example.

Automation and robotisation are processes which, in the construction industry, boil down to replacing humans with machines. Such a process improves work efficiency and significantly reduces the costs of building projects [3]. Presently, automation and robotisation in construction processes is mainly used to carry out heavy work which would be difficult or dangerous for people. In the field of civil engineering, these are currently mainly earthworks and underground works, as well as assembly works with large and heavy components. However, in the future the construction process will be based on autonomous machines using artificial intelligence to oversee the execution of work and to eliminate potential difficulties arising from the robotic building construction process itself. This is due to the effectiveness of the very concept of automating and robotising the construction process using artificial intelligence. Such a process, in turn, results from the need for continuous and dynamic economic growth. It is therefore necessary to further develop automation and robotisation in the construction industry and to look for new solutions which would significantly increase the efficiency of construction process. This can be effectively achieved by further developing and using artificial intelligence in various areas of construction industry, using appropriate technology dedicated to the implementation of the intelligent construction process.

The paper addresses the issue of the use of technology in automation and robotics processes in the building construction industry. It is shown how these processes contribute to the development of the construction sector. As an example of the robotisation of construction processes, the paper presents the continuously developing 3D printing technology. The characteristics of machine learning, including deep

learning, are also presented as well as, based on a literature review, examples of the use of deep learning in the construction industry.

2. ARTIFICIAL INTELLIGENCE AND NEW TECHNOLOGIES IN BUILDING CONSTRUCTION

Nowadays, a major revolution is underway in the construction industry, which is changing the way buildings and infrastructure are made, and also the dynamics of the construction process. Its development is supported by innovative technologies such as: Building Information Modelling (BIM), Artificial Intelligence (AI), Digital Twin (DT), Smart Vision (SV) and Internet of Things (IoT), increasing efficiency, accuracy and productivity [4]. Innovative tools for the design, visualisation and realisation of buildings also include: augmented reality (AR), Virtual Reality (VR), 3D printing and intelligent robotics. All of these technologies raise new standards in the design, construction and management of new facilities and support more efficient and safer completion of projects.

Building Information Modelling (BIM) technology is an advanced approach to the management of the entire building cycle, which integrates information about, inter alia, its construction parameters, materials, costs and work schedules. The ability to create three-dimensional models, integrating all project-related data, improves communication among project teams, reduces the possibility of errors and collisions and enables cost and energy efficiency analysis. Thanks to the digital twins, that is virtual models of real-life structures, it is possible to monitor, simulate and conduct an ongoing analysis of building's performance. The Internet of Things, on the other hand, enables continuous control, monitoring and optimisation of building's fixtures and systems, thus increasing efficiency and reducing operating costs.

Digital transformation is generating huge amounts of data. Their systematic and continuous analysis and creation of predictive models can lead to innovative structural and architectural designs, minimise construction costs, enhance safety on construction sites, automatise physical work, speed-up construction processes and increase durability. Analysing such huge amounts of data and recognising patterns by standard computer programmes and humans is becoming impossible. Artificial intelligence (AI) plays a key role here. It has the ability to create and process huge databases, recognise patterns, make predictions, automatise tasks and optimise construction processes. The phrase Artificial Intelligence (AI) was coined by John McCarthy at a conference at Dartmouth College in 1956. It was to distinguish it from the concept of cybernetics [5]. The phrase was to describe the idea of creating machines performing tasks requiring human intelligence. Thus, the emergence of artificial intelligence has initiated attempts to make tools recreating the abilities assigned to the human brain, responsible for understanding and problem solving [6]. The continuous development of new and more complex algorithms is intensifying interest in artificial intelligence and the need to increase its areas of application. This progress is related to machine learning and its subset, deep learning, which uses advanced neural networks for data processing and learning. Figure 1 shows a diagram of machine learning in an AI context, with widely used algorithms: Convolutional Neural Networks (CNN), Multi-Layer Perceptron (MLP), Radial Basis Function Network (RBFN), Recurrent Neural Network (RNN), Generative Adversarial Network (GAN) and Long Short-Term Memory Network (LSTM).

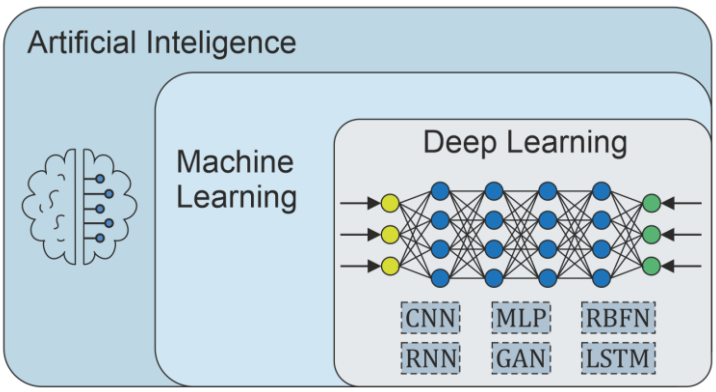


Figure 1. Deep learning in artificial intelligence and its algorithms

Machine learning, a major focus of artificial intelligence, has become an important tool in the construction industry. With its ability to process large amounts of data, detect patterns, memorise them and predict subsequent events, it minimises time, maximising the use of computing resources [7]. This leads to more effective project management, risk reduction as well as increased safety and efficiency in construction processes. Machine learning is being applied in many sectors of the construction industry, starting with the design stage all the way through implementation and then maintenance of buildings. Based on a dataset, machine learning algorithms can predict costs, required time and resources for a given construction project [8] as well as risks [9]. Deep learning in computer vision supports the construction industry especially in the area of site safety [10-13], improving quality, optimising work and detecting structural damage [14,15].

The impact of machine learning on the construction industry continues to grow, increasing efficiency, quality and sustainability. Artificial intelligence is becoming an integral part of progress in the construction industry, providing more efficient resource management and safety.

3. DEEP LEARNING

Deep learning is a branch of artificial intelligence, a subfield of machine learning (Fig.1). It focuses on creating neural networks which are capable of learning from data. The models, which are to replicate the functioning of human brain, consist of multiple layers, hence the learning process is referred to as deep. These models are trained on large datasets, gradually improving their capabilities through identifying features, pattern recognition and decision-making. They can be used for prediction, classification, image segmentation as well as content generation and speech recognition.

The basic deep learning techniques used in the construction industry are: Convolutional Neural Network (CNN), Feedforward neural networks (FNN), Recurrent Neural Network (RNN), Generative Adversarial Network (GAN) and Variational Autoencoder (VAE).

4. APPLICATION OF DEEP LEARNING IN CONSTRUCTION INDUSTRY

Deep learning based on advanced neural networks makes it possible to monitor the progress of works, detect defects and faults, analyse structures and materials, and also optimise the use of resources. Over the recent years, there has been a growing interest in the use of deep learning in construction industry. Many scientific publications and research papers focus on the application of the potential of artificial intelligence in various fields of construction, among others for predicting construction costs, object detection, that is detection, recognition and identification of objects.

a. Predicting construction costs

Accurate construction costs estimation is a key element of successful management of construction projects. The use of artificial intelligence in this sector of activity significantly improves the precision and accuracy of predictions. The methods used so far, which consist of construction cost estimation based on analysis of data from other projects and experts' experience have limited capabilities, whereas the capability of machine learning algorithms to analyse huge amounts of data offers the possibility of considering concurrently multiple factors affecting construction costs. By using artificial intelligence techniques such as neural networks and regression analysis, construction companies can make more effective decisions right from the project planning stage and successfully manage their financial resources.

The paper [8] presents a new approach to forecasting the Construction Cost Index (CCI) in developing countries, a measure for tracking changes in the cost of construction materials and overall construction-related costs. Three techniques were used in this work: a modified artificial neural network (ANN), time series and linear regression. Additionally, the swish activation function was introduced to increase the accuracy of the interrelated algorithms. The analyses showed that the use of regression and time series models had high error rates. They gave unrealistic predictions. The use of the ANN technique gave the best results in forecasting CCI, with the lowest error rates and the most effective predictions. Accurate forecast of the CCI enables correct estimation of the project budget.

b. Detection of objects during construction works

Detecting objects during construction works is a key element in ensuring site safety and quality control of the construction process. Advanced vision systems based on machine learning and image detection are increasingly used on construction sites. Many research papers are dealing with to this topic. The work [16] focuses on the issue of using a deep learning method to eliminate construction site accidents and enhance surveillance on the construction site. The research encompassed the use of the high-precision Faster R-CNN method, a technique for detecting objects in images, which achieves very good results by utilising deep neural networks. In this case the database consisted of randomly selected still images from video recordings of workers, from visually different construction sites. The still images were classified according to their visual characteristics. Studies have shown that the rapidity of this method, as well as its reproducibility, offers the possibility of effectively detecting workers without hard hats/safety helmets under different conditions on construction sites.

Object detection can also be used to identify building elements and components. The paper [17] compares three machine learning techniques for detecting three common building materials: concrete, red brick and OSB boards. Multilayer Perceptron (MLP), Radial Basis Function (RBF) and Support Vector Machine (SVM) were used. The results showed that for all the materials, the SVM method turned out to be the best in terms of accurate detection of material textures in images. It was also concluded that commonly used algorithms for material detection perform best for materials with distinct colour and appearance (e.g., red brick) , while less accurate results are obtained for materials with colour and appearance similar to other elements and materials that differ in colour and texture (concrete).

The use of deep learning can also be effective for identifying construction objects and equipment in a monitored location. They can be successfully used to analyse construction equipment activity, monitor the number and density of vehicles on construction sites [12] and detect uncertified work [10].

c. Object detection and image segmentation

During the service life of a building structure, its quality and parameters can be affected by a number of factors leading to wear, damage and cracking. Nowadays, the possibility of automatising the detection of defects and anomalies becomes a key element for maintaining optimal condition of building structures. The state-of-the-art deep learning approach is discussed in the paper [18], which presents a method for automatically identifying damage to asphalt pavements caused by moisture. Based on ground penetrating radar (GPR) surveys of various asphalt bridges, three databases with different image resolutions were created. Convolutional neural networks (CNNs) were used to determine features of asphalt layers and detect any damages. To prepare the input data, an incremental random sampling (IRS) technique was proposed to generate the corresponding GPR images, which were then fed into the convolutional neural networks (CNNs). Promising results have been obtained on the effectiveness of identifying and locating damages to asphalt pavements caused by moisture.

Machine learning techniques are also used in image segmentation, used to delineate areas in images enabling detection of possible defects or damages. In the construction industry, image segmentation is used to visually detect problems, such as bridge structural damage [14] or potholes in the road surface [19].

5. AUTOMATION AND ROBOTISATION PROCESSES IN THE CONSTRUCTION INDUSTRY

The automation and robotisation process in the construction industry is gaining more and more importance since it increases efficiency of investment in a construction project and reduces the necessary human labour in its implementation. The use of automation and robotisation improves the company competitiveness in the construction services market because it can provide more attractive offers in relation to the competitors. An example of the automation of construction processes of underground works is a tunnel drilling machine the use of boring machines that, while drilling a tunnel, remove the excavated material and

at the same time is lining the tunnel using the supplied prefabricated elements thanks to the system of automatic guidance of the cutting shield and the whole boring equipment. This solution is currently being used for tunnelling subway lines, and in the highway industry for the construction of traffic tunnels. Tunnelling for high-speed railways is discussed in the work [20], in which the authors analysed several problems concerning the efficiency and safety of implementing such projects.

Due to natural demand of the modern labour market, the process of automating construction work is becoming more and more advanced, slowly moving to the robotisation of construction work [2, 21]. Nowadays, mobile robotic arms are increasingly used for lifting heavy materials, which indirectly contributes to human safety. Such a solution is currently being used in the construction of cubic structures for delivery od building materials and gradually in assembly and construction processes. The experience of the precursors, the Japanese, has shown that the peculiarities of construction work do not allow the application of universal solutions, and the robotisation of construction processes still requires human presence. Advances in the robotisation of construction processes also include 3D printing, which has undoubtedly ushered in a new phase in the transformation of construction processes [22, 23]. Objects made in Contour Crafting technology developed at the University of Southern California, conduct a construction process based on rapid placing of successive layers of concrete mixture, which effectively shortens the construction process. The 3D printing technology based on a properly prepared concrete mixture also includes the printing of individual structural components, which takes place in a robotic prefabrication factory. In this way we can print walls, stairs and roofs. Such prefabricated elements are prefabricated elements are transported to the construction site and assembled there, but it should be remembered that the reinforcement in this process is still made by traditional methods which are still necessary to ensure the appropriate strength parameters of the structure. The efficiency of such a construction process can be clearly seen when comparing the time, it takes to complete the job, which is 50 to 70% shorter compared to the traditional construction method [24]. It includes ever more efficient solutions for print heads and the concrete mixture itself, and continuously improving methods and processes of erecting various objects with concrete mix-based 3D printing technology.

The robotic 3D printing process is also applied for metal objects and structures. Using this technology, it is possible to print large 1:1 scale metal object with parameters corresponding to traditional metal structures. This can be achieved with MX3D industrial robots using Wire Arc Additive Manufacturing technology, which can create 3D objects from ferrous alloys. An example of such a structure is a footbridge over one of Amsterdam's canals [25]. Carbon steels, stainless steels and non-ferrous bronze and aluminium alloys can be used in this process. MX3D declares that, based on the technology they have developed, it is possible to build a bridge structure 10 to 1,000 times faster than using traditional methods [25].

6. CONCLUSIONS

Artificial intelligence as a tool in the processes of automation and robotisation of construction works is a factor that effectively improves the efficiency of the investment implementation process. In the near future, with the use of artificial intelligence, there will be an increase not only in the automation of construction processes but also, or especially, robotisation enabling autonomous construction implemented without human labour. As in the case of autonomous vehicles, there is still unresolved problem of legal responsibility for works of artificial intelligence. However, from a technical point of view, there is no other way to enhance the efficiency of construction process while at the same time reducing its cost, than with the use of artificial intelligence. The future of artificial intelligence in construction is therefore promising, covering many areas of application. The increasing integration of advanced artificial intelligence technologies with traditional construction processes will create a number of opportunities affecting the efficiency and development of the construction industry.

REFERANCE

1. Abanda F. H., Byers L., An investigation of the impact of building orientation on energy consumption in a domestic building using emerging BIM (Building Information Modelling), Energy 2016, 97, 517–527, https://doi.org/10.1016/j.energy.2015.12.135
2. Khairulzaman H.A., Usman F., Automation in civil engineering design in assessing building energy efficiency, International Journal of Engineering & Technology 2018, 7, 722-727, DOI:10.14419/ijet.v7i4.35.23096
3. Dadhich S., Bodinyand U., Andersson U., Key challenges in automation of earth-moving machines, Automation in Construction 2016, DOI: 10.1016/j.autcon.2016.05.009
4. Sharafi P., Teodosio B., Shringi A., Mendis P., Artificial intelligence and smart vision for building and construction 4.0: Machine and deep learning methods and applications, Automation in Construction, 2022, 141, 104440.
5. McCarthy J., Review of the question of artificial intelligence, Ann. Hist. Comput., 1988 (10), 224-229.
6. Brooks R. A., Intelligence without representation, Artificial Intelligence, 1991 (Volume 47, Issues 1-3), 139-159.
7. Xu Y., Zhou Y., Sekula P., Ding L., Machine learning in construction: From shallow to deep learning, Developments in the Built Environment, 2021, 6, 100045.
8. Aslam B, Maqsoom A, Inam H, Basharat Mu, Ullah F. Forecasting Construction Cost Index through Artificial Intelligence, Societies, 2023, 13(10):219. DOI:10.3390/soc13100219
9. Poh C. Q., Ubeynarayana C. U., Goh Y. M., Safety leading indicators for construction sites: A machine learning approach, Automation in Construction, 2018, 93, 375-386.
10. Fang Q., Li H., Luo X., Ding L., Rose T. M., An W., Yu Y., A deep learning-based method for detecting non-certified work on construction sites, Advanced Engineering Informatics, 2018, 35, 56-68.
11. Fang W., Zhong B., Zhao N., Love P. E., Luo H., Xue J., Xu S., A deep learning-based approach for mitigating falls from height with computer vision: Convolutional neural network, Advanced Engineering Informatics, 2019, 39, 170-177.
12. Guo Y., Xu Y., Li S., Dense construction vehicle detection based on orientation-aware feature fusion convolutional neural network, Automation in Construction, 2020, 112, 103124.
13. Nath N. D., Behzadan A. H., Paal S. G., Deep learning for site safety: Real-time detection of personal protective equipment, Automation in Construction, 2020, 112, 103085.
14. Deng W., Mou Y., Kashiwa T., Escalera S., Nagai K., Nakayama K., Matsuo Y., Prendinger H., Vision based pixel-level bridge structural damage detection using a link ASPP network, Automation in Construction, 2020, 110, 102973.
15. Dorafshan S., Azari H., Evaluation of bridge decks with overlays using impact echo, a deep learning approach, Automation in Construction, 2020, 113, 103133.
16. Fang Q., Li H., Luo X., Ding L., Luo H., Rose T. M., An W., Detecting non-hardhat-use by a deep learning method from far-field surveillance videos, Automation in Construction, 2018, 85, 1-9.
17. Rashidi, A., Sigari, M.H., Maghiar, M. et al. An analogy between various machine-learning techniques for detecting construction materials in digital images, KSCE J Civ Eng 20, 2016, 1178–1188, https://doi.org/10.1007/s12205-015-0726-0
18. Zhang J., Yang X., Li W., Zhang S., Jia Y., Automatic detection of moisture damages in asphalt pavements from GPR data with deep CNN and IRS method, Automation in Construction, 2020, 113, 103119.
19. Hangbin W., Lianbi Y., Zeran X., Yayun L., Xinran A., Qichao C., Zhengning L., Bin M., Road pothole extraction and safety evaluation by integration of point cloud and images derived from mobile mapping sensors, Advanced Engineering Informatics, 2019, 42

20. Zhang H., Sun J., Ma H., Chen S., Huang M., Development and application of mechanized matching equipment for high-speed railway tunnel construction, Procedia Manufacturing 2019, 32, 952–959, https://doi.org/10.1016/j.promfg.2019.02.308
21. Vähä P., Heikkilä T., Kilpeläinen P., Järviluoma M., Gambao E., Extending automation of building construction - Survey on potential sensor technologies and robotic applications, Automation in Construction 2013, 36, 168–178, https://doi.org/10.1016/j.autcon.2013.08.002
22. Major M., Minda I., Zastosowanie technologii druku przestrzennego w budownictwie, Zeszyty Naukowe Politechniki Częstochowskiej 2016, 172, Budownictwo z. 22, 238-247, DOI: 10.17512/znb.2016.1.23
23. Tan K., The framework of combining artificial intelligence and construction 3D printing in civil engineering, MATEC Web of Conferences 2018, 206, 01008, https://doi.org/10.1051/matecconf/201820601008
24. https://3dprint.com/38144/3d-printed-apartment-building/ [access on 26.11.2023]
25. http://www.dezeen.com/2015/10/19/joris-laarman-3d-printed-canal-bridge-amsterdam/ [access on 26.11.2023].

ANTROPOGENIC IMPACTS TO RIVERBED DEFORMATIONS – CASE STUDY AGHSUCHAY RIVER

A. Nuriyev
Baku State University, Baku, Azerbaijan
E-mail: anar_nuri@yahoo.com

INTRODUCTION

Riverbed deformations are a set of phenomena associated with the impact of water flows on the banks and bottoms of rivers, with the movement and deposition of sediments, leading to their erosion, and seasonal, multi-year, and historical changes in riverbeds. Riverbed formation determines the conditions of life and economic activity of people on the banks of rivers, the use of water resources, etc. Active factors of river channel formation processes are water flow and sediment transport. The bottom and bank of the river guide the movement of the flow, but they themselves depend on the structure of the flow. With the change in the hydraulic characteristics of the stream, the forms of the channel change as well as time passes. Some of them are destroyed, and other forms of relief appear. The stronger the rocks that make up the banks and bottom of the river, the more time is required to change the forms of the channel.

As a result of the interaction of the river flow with the bed, the riverbed deforms and transformations in its shape take place over the years. These changes that occur depend on multiple factors which can include hydrological parameters of the river, the geological structure of the area, changes in climate, landscape, and other natural factors. In modern days there is another factor, or group of factors that can pose a significant effect on riverbed deformations. This group of factors is composed of anthropogenic factors.

It is important to note that the specific impacts of these anthropogenic factors on riverbed deformation can vary depending on local conditions, river characteristics, and the scale and intensity of human activities.

The sediment budget and riverbed deformation of the Azerbaijan rivers have attracted global concern as they can threaten channel stability and security of hydrotechnical constructions. Anthropogenic disturbances, including dredging, and engineering projects, will aggravate the changes in the natural process of sediment budget and bed morphology in mountain rivers.

Sediment reduction leads to channel down cutting, coastal restoration, and alteration of riverine depositional environments. Under natural conditions, rivers address sediment reduction via self-adaptive adjustment of the bed morphologies, however, this process may take years to decades. Recent studies have demonstrated that the upstream channel provides sediment for downstream reaches of alluvial rivers via riverbed deformation.

However, knowledge of the contribution of various types of reaches to downstream sediment is lacking due to changes in local river patterns, riverbed sediment, slopes, and other hydrological and geological factors. Therefore, regarding sediment transport, understanding riverbed deformation in the different river reaches has great significance for channel stability, as well as the prediction of coastal erosion.

STUDY AREA

For this research selected study area is the Aghsuchay River. Aghsuchay is one of the rivers that has been affected by anthropogenic impacts and yet the construction of a new water reservoir is planned to be built in the near future.

Our study area is located in the Shirvan Plain which is part of the southern foothills of the Greater Caucasus. The relief of the region mostly consists of mountainous areas, foothills, and plains with slopes. The mountainous part is located at an altitude of 700-1000 meters above sea level. Agsuchay basin is located

on the southern slope of the Greater Caucasus. In terms of hydrological zoning, the river belongs to the eastern (Shirvan rivers) hydrological region of the southern slope of the Greater Caucasus.

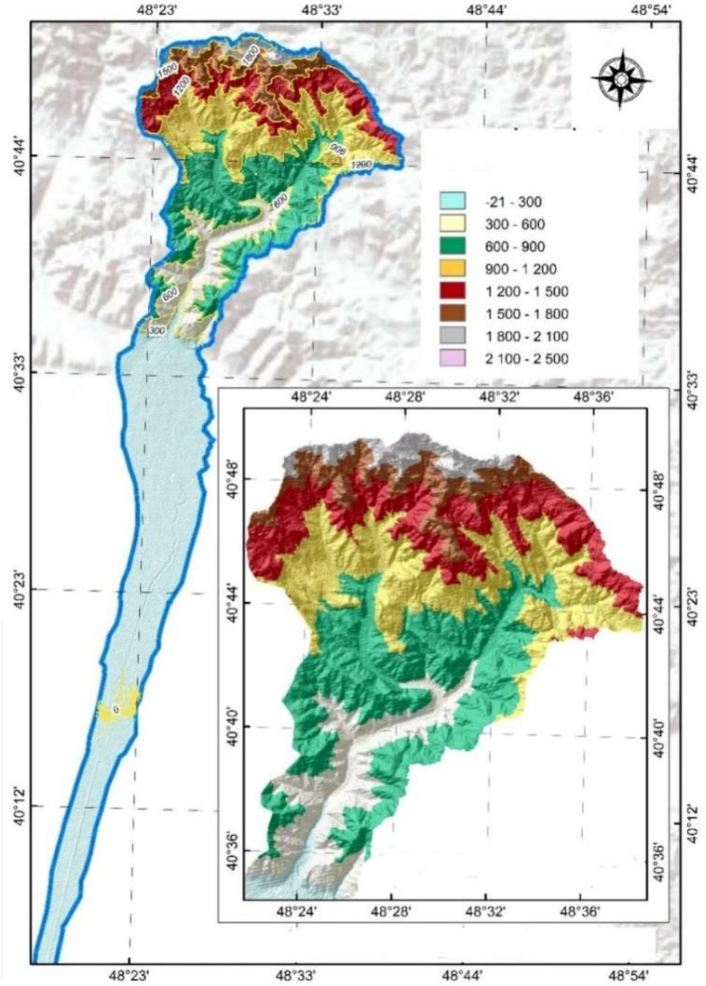


Figure 1. Aghsuchay river basin

Agsuchay river is formed by the confluence of springs flowing from the slope of the Sari-Bulag (2268 m) mountain. the confluence zone of tributaries is located in the Langebiz mountain range. The main part of the downstream of the river is located in the plain area. Depending on the changes geological composition of the rocks at its mouth and near it, filtration, and annual characteristics of the flow, the Aghsuchay River flow might not reach the Kura River. However, in recent times, by opening an artificial channel from the mouth of the river, its flow was connected to the Girdimanchay River which joins the Kura River.

The average width of the Agsuchay basin is 6.7 km, and the average height is 666 m. The forest area in the basin covers 130 km^2. The average slope of this river is 24.7‰, and the density of the river network is 0.46 km/km^2.

The geological structure of the Agsuchay basin includes sedimentary, magmatic, and metamorphic lithological complexes with a wide stratigraphic range. The rock complexes that form the foundation of the natural landscape in the study area are very rich and diverse, either according to their age or formation, composition, and structure. Just as the mountainous and plain areas differ sharply from each other in terms of their geological structure, individual mountainous provinces themselves also differ greatly in the nature of the sediments that make them up. As a general rule, rock layers of older geological periods are spread in the mountainous areas, and sediments of the youngest periods are spread in the plains. Lowlands and foothills form a transition between them.

MATERIALS AND METHODS

In the study, the dynamics of the perennial flow of the Aghsuchay river and their annual changes were analyzed using archival materials, data from a hydrological observation point located in the area, and the results of previous studies conducted by researchers. Based on the collected data, the trend analysis of the water discharge series was performed according to the linear regression method, as it is both simple and visual. By performing trend analysis of observational data of regional rivers, multi-year fluctuations of flow were analyzed. Furthermore, field trips were conducted to research area and topographical measurements were compared to identify riverbed deformations.

RESULTS AND DISCUSSION

According to the results of research conducted on the southern slope of the Greater Caucasus, it was observed that the average annual temperature in the area increased by 1.0^0C in 1991-2020 compared to 1961-1990. This indicator was 0.9^0C for the Aghsuchay River basin. Compared to 1961-1990 (norm), the seasonal trend of temperature in 1991-2020 has a unique feature. As a result of the analysis, the most changes are observed in the parts of the basin with 1500-2000 m altitude. The average annual temperature index at this altitude increased by 0.9^0C and increase in temperature in summer was 1.3^0C. It was determined that the average seasonal temperature for the entire basin increases more in summer and winter.

The analyses show that, compared to the norm, there were noticeable fluctuations in the seasonal amount of precipitation in 1991-2020. If we take close look at the vertical distribution of precipitation over the basin, it is possible to see a significant (34%) decrease in precipitation in the lower parts of the lowlands and mid-altitude (500-1500 m) in all seasons. The middle and lower flow of Aghsuchay corresponds to this area. If the average multi-year temperature was 12.0^0C in 1961-1990, this indicator was 12.8^0C in 1991-2020. The amount of precipitation decreased from 507 mm to 410 mm, respectively.

The multi-year average water discharge for each month based on observation on Aghsuchay River, Aghsu station is shown in table below.

Table 1

Average water discharge in Agshuchay (m^3/sec)

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
1,33	1,53	2,39	3,56	3,18	2,03	1,41	1,04	1,46	1,77	1,65	1,55

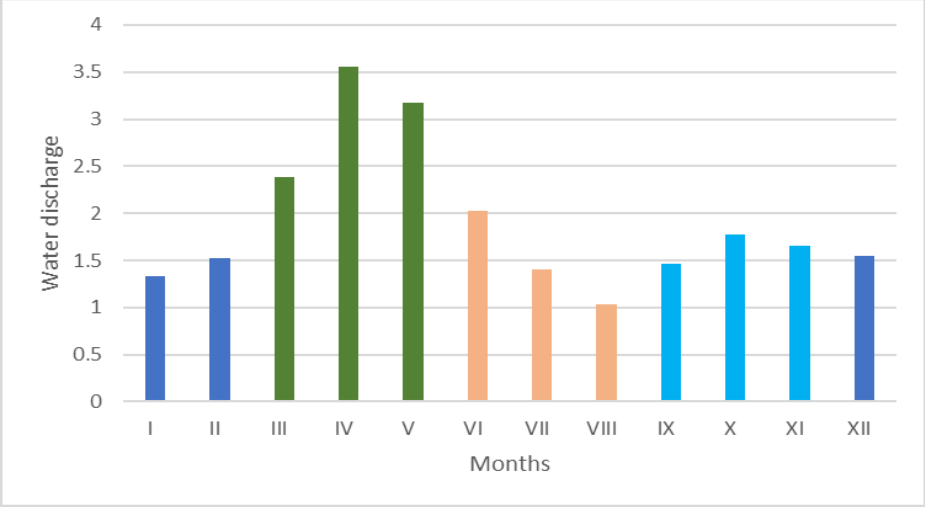


Figure 2. Distribution of average monthly flow in Agsuchay River, Aghsu station

The distribution of sedimentation flow in Aghsuchay depends on the proportion of snow and rainwater that feeds the river. This ratio varies depending on the elevation in the river basin. The main part of the flow of suspended sediments in the river passes in the spring-summer period, making up 70-90% of the annual flow volume of sediments. This is mainly due to the melting of snow accumulated in the cold period of the year and the rains that fall in the spring.

Since the clay shales and sandstones that make up the basin of Aghsuchay are quickly eroded and crushed, the content of suspended sediments in the river mainly consists of small fractions (less than 0.05 mm) and increases to 80-90%. As you go further downstream, the size of suspended sediments decreases. Mostly large particles move upstream and small particles the downstream. However, large particles moving upstream of the river are gradually crushed and the amount of small particles increases. Small and large-sized mountain rocks, soil particles, plant and animal particles form the basis of the formation of sediment flow in the Aghsuchay catchment.

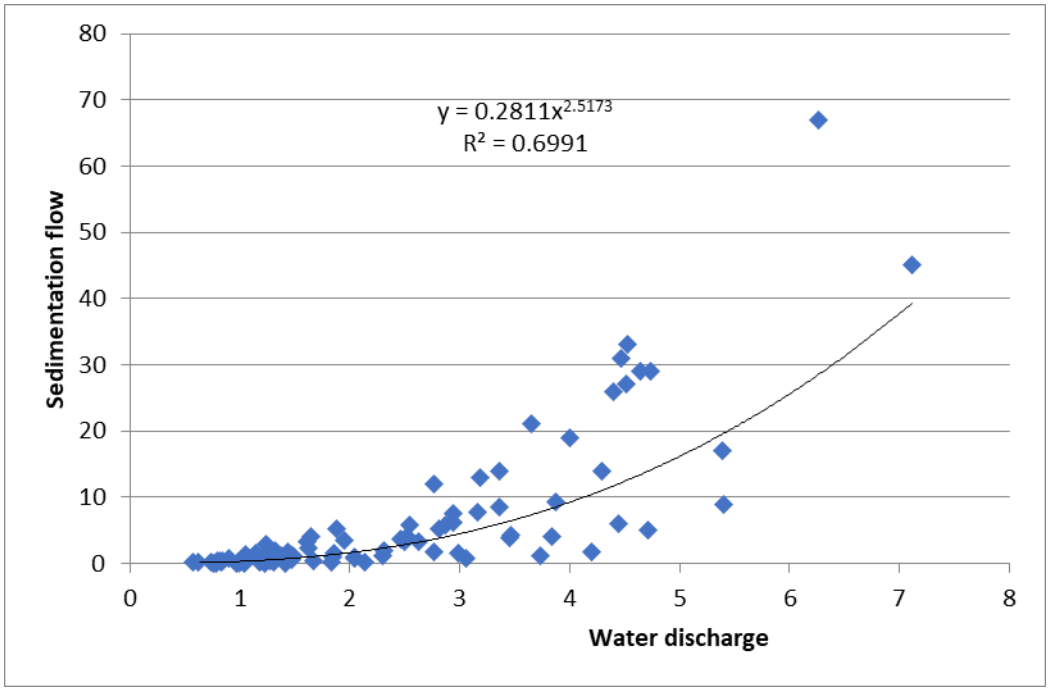


Figure 3. Relationship between water and suspended sediment discharge (Aghsuchay River – Aghsu station)

Table 2

Monthly distribution of water and suspendent sediment flow (%)

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Q, m^3/s	5.7	6.68	10.46	15.62	13.84	9.08	6	4.49	6.36	7.88	7.12	6.76
R, kq/s	1.48	2.93	12.12	27.06	22.95	5.45	6.68	5.46	6.34	4.42	3.52	1.59

The annual suspended sedimentation flow of the river is 6.6. kg/sec, average turbidity is 3530 g/m^3.

Field trips were conducted to identify yearly riverbed changes. Field investigation determined all types of impact that led to riverbed deformation. Anthropogenic impacts can significantly contribute to riverbed deformation, altering the natural morphology and dynamics of river systems.

Here are some key anthropogenic factors that can affect riverbed deformation:

1. Channelization: Channelization involves modifying the natural course of a river by straightening, deepening, or widening its channel. This can be done for navigation, flood control, or water diversion purposes. Channelization alters the flow patterns and sediment transport, leading to changes in riverbed morphology.

2. Dams and Reservoirs: Construction of dams and reservoirs can have significant impacts on riverbed deformation. Dams can trap sediment, reducing downstream sediment supply and altering the natural erosion and deposition processes. The altered sediment regime can result in erosion or deposition downstream of the dam, leading to changes in the riverbed profile.

3. Sand and gravel mining: Extraction of sand and gravel from river channels for construction purposes can cause riverbed deformation. Removal of sediment from the riverbed disrupts the natural equilibrium between sediment supply and transport, leading to erosion, channel incision, and changes in the riverbed morphology.

4. Urbanization and land-use changes: Urban development and land-use changes in the river catchment area can increase the volume and velocity of storm water runoff, leading to increased erosion and sediment transport. This can result in channel widening, bank erosion, and overall changes in the riverbed topography.

5. River engineering and flood control measures: Construction of levees, embankments, and flood control structures alters the natural floodplain dynamics. These structures can confine the river within a narrower channel, increasing flow velocities and causing erosion. As a result, the riverbed can deform over time, leading to changes in the cross-sectional shape and profile.

6. Climate change: While not directly anthropogenic, climate change induced by human activities can have significant impacts on riverbed deformation. Altered precipitation patterns, increased frequency of extreme weather events, and changes in the hydrological cycle can affect river flows, sediment transport, and erosion rates, leading to riverbed deformation.

An observation point was selected to analyze channel processes in the river. Bathymetric and cross-sectional data were collected from 2013 to 2021 and were analyzed to address the changes in the depositional environment. In this section, horizontal channel deformations are mainly observed (Figure 4). However, after the construction of the hydrotechnical facility, it was observed that the vertical channel processes were rapidly progressing in the river. This process was also influenced by the quarry operating in the area.

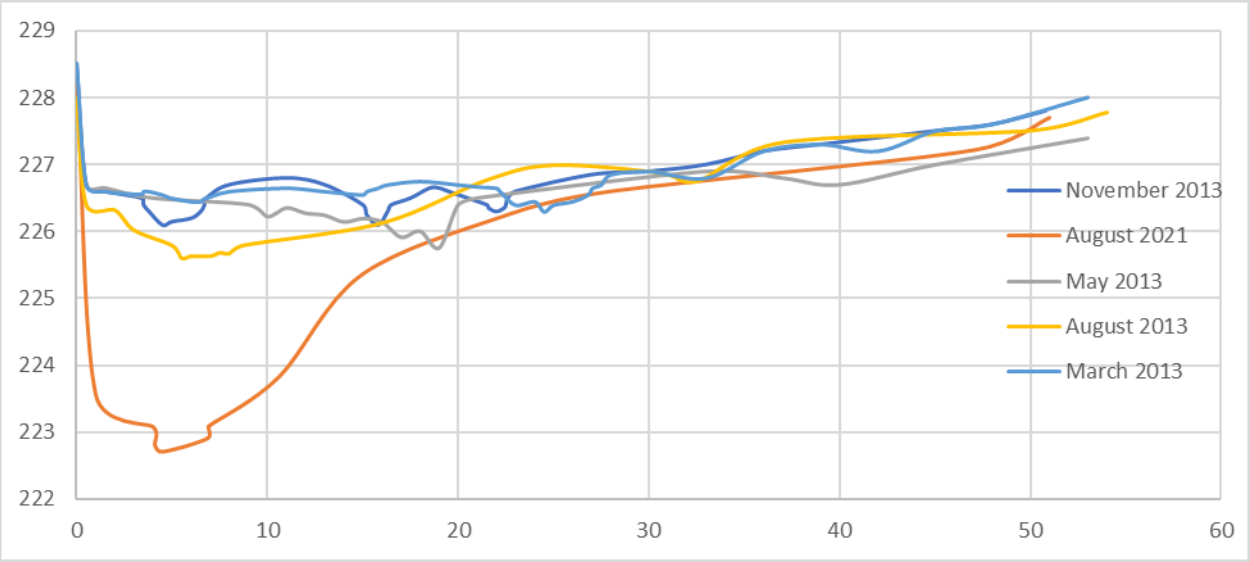


Figure 4. Cross section of the river

The hydrotechnical facility built on the river has led to the imbalance of sediments. After that, intensification of vertical channel deformation is observed in the river. Due to water abstraction after main settlements, there is no water in the downstream of the river.

CONCLUSIONS

Bathymetric and cross-sectional data were collected from field were analyzed to address the changes in the depositional environment. The results indicate that the whole riverbed in the Aghsuchay River has been scouring after the construction of the intake facility of the irrigation canal and this trend is expected to continue in the future due to decreasing sediment supply from the upper watershed. Based on observations approximately 3 m of vertical deformation occurred in the riverbed. Due to water abstractions river dried in downstream of the river basin. Thus, riverine channel deformation in response to anthropogenic disturbance is dynamic in different reaches, and this finding has both scientific and practical significance in terms of understanding channel stability and its response to external stressors.

REFERANCE

1. Mahmudov R.N. Modern climate changes and hazardous hydrometeorological events. Baku, 2018, 232 p.
2. Mammadov M.A. Hydrography of Azerbaijan. Baku, 2002, 265 p.
3. Rustamov S.H. Rivers of the Azerbaijan SSR and their hydrological characteristics. Baku, 1960, 196 p.
4. Alexandr G. Obodovsky, The assessment of Ukrainian riverbed deformation, Sediment Transfer through the Fluvial System (Proceedings of a symposium held in Moscow, August 2004) IAHS Publ. 288, 2004, 253-260.
5. Shuwei Zhenga, Huanlong Luoa, Jiayue Zhanga, Heqin Chengb, Zijun Lia, Yugai Mac, Shuaihu Wud, Enfeng Liu. Sediment budget and riverbed deformation in the uppermost part of the lower Yangtze River China, March 2022, International Journal of Sediment Research 37(3–4), pp 484-492.

AGRICULTURAL LANDS POLLUTEBLY CHLORPYRIPHOS – CONTAINING PESTICIDES IN GEORGIA

M. Shavlakadze[1)], G. Natroshvili[2)], L. Itriashvili[3)], K. Didebulidze[4)], A. Gujabidze[5)], Kh. Kiknadze[6)]

[1),2),3),6)] Tsotne Mirtskhulava Water Management Institute of the Georgian Technical University,

[4),5)] Agricultural University of Georgia

E-mail: marishavlakadze@gmail.com

INTRODUCTION

Permanent breach of hygiene norms of pesticide u se in Georgia caused the soil intensive pollution in the regions of agricultural product production. Today 684 ton of pesticides of 19 trade names are imported and actively used in Georgia (see table 1).

Table 1

Pesticides permitted for use in Georgia (hazard-class pesticides for human consumption)

#	Trade name of pesticide products, preparation form	Active substance, concentration	Class of hazard
1	Grandd, EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
2	Dursban, EC	Chlorpyriphos(480g/L)	II
3	Dursban,450TM	Chlorpyriphos(480g/L)	II
4	Epdalposetrin550EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
5	Valsarel,EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
6	Loksli	Chlorpyriphos(450 g/L)	II
7	Nurel-D,EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
8	SuperpirineksEC420	Chlorpyriphos+Bifentrin(400+20g/L)	II
9	Pyriphos,EC	Chlorpyriphos(480g/L)	II
10	Piroelectra48EC	Chlorpyriphos(480g/L)	II
11	Priban4,EC	Chlorpyriphos-Methyl(480g/L)	II
12	Priban25EC	Chlorpyriphos-Ethyl(250g/L)	II
13	Sairen,EC	Chlorpyriphos(480g/L)	II
14	Sarban48,EC	Chlorpyriphos(480g/L)	II
15	Serban4EC	Chlorpyriphos(480g/L)	II
16	Tenchant,EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
17	Chlorpyrivat-agro, EC	Chlorpyriphos+Cypermethrin(500+50g/L)	II
18	Tsipiplus, EC, EC	Chlorpyriphos+Cypermethrin(480+50g/L)	II
19	Priban 240	Chlorpyriphos(240g/L)	II

It is obvious from the above table that the pesticides used in Georgian agriculture contain a big concentration of chlorpyriphos (used as a fungicide, herbicide, and pesticide) - one of the most widely used organophosphorus pesticides which undergo 4 stages of metabolism when gets into the soil. The products depleted on the 3-rd and 4-thstages – diethyl triphosphate, 3,5,6 tricolor 2-pyridinol – represent one of the most toxic substances (Chlorpyriphos remains undissolved in the soil for 360 days). The mentioned problem is aggravated by the fact that due to low awareness of ecology in Georgia the use of pesticides is non-regulated and is implemented with the breach of the dates.

Chlorpyriphos **$C_9H_{11}Cl_3NO_3PS$**

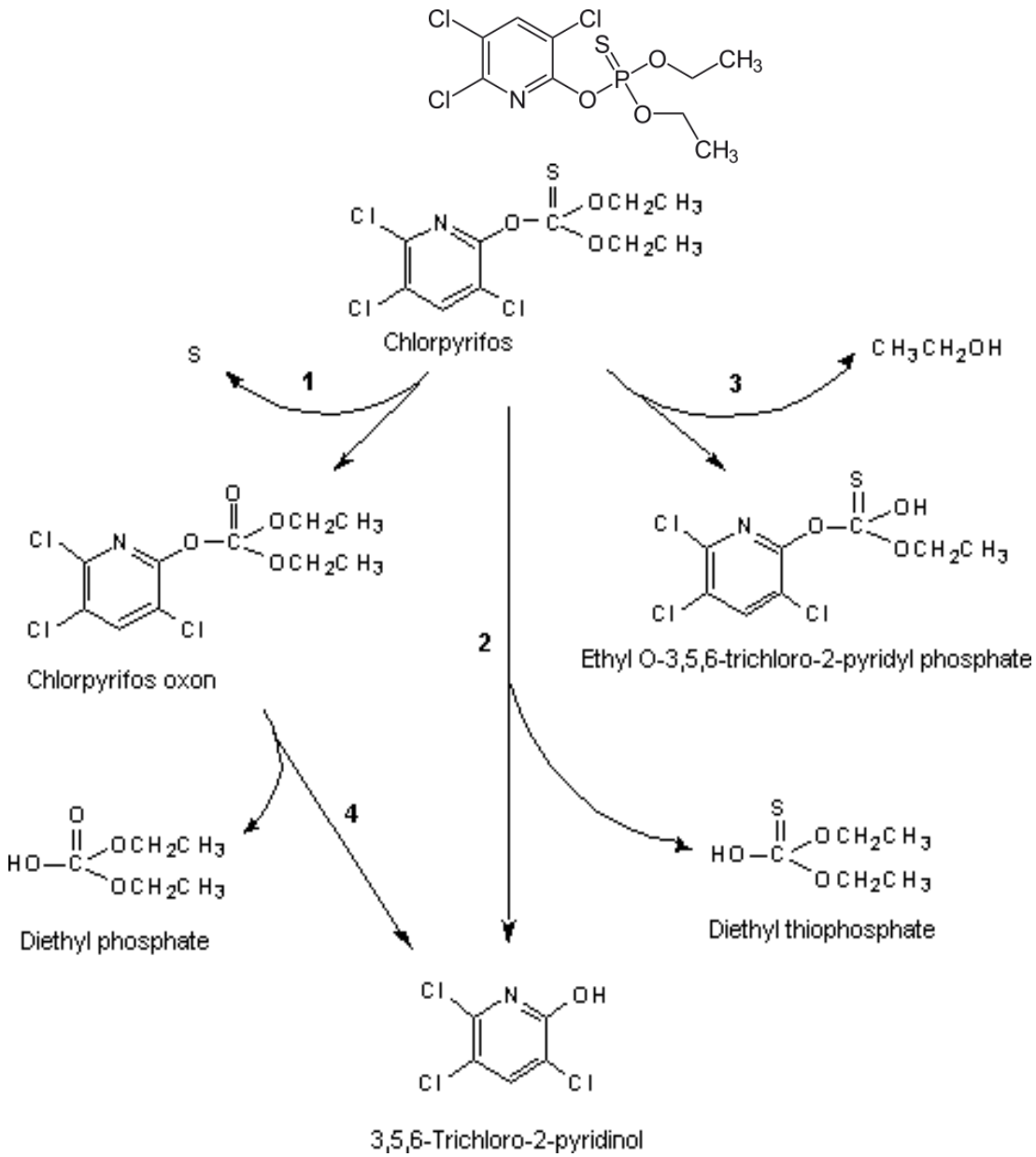


Fig. 1. General metabolic pathways of Chlorpyriphos

MAIN PART

Lately in Georgia on the background of intensive development of agriculture the problem of agricultural soil pollution became an urgent problem, since unregulated use of pesticides by the population became an indirect cause of many acute diseases spread (malignant tumors, cardio-vascular and respiratory system diseases, etc.) as a result of agricultural product consumption grown on pesticide-polluted soil.

Looking at the constraints faced in several remediation approaches, scientists shifted to microbial-based bioremediation of xenobiotics, which proves to be the most efficient, economical, and sustainable method of removal of pollutants from the environment. Bioremediation explores the natural capability of microorganisms to utilize the pesticide as its carbon source by sensitizing microbes using bioaugmentation and biostimulation methods (Kumar et al., 2021; Carolin et al., 2021b; Saravanan et al., 2021; Carolin et al., 2021a). Several microbes have been isolated to date with the potential to degrade chlorpyrifos, such as Pseudomonas, Bacillus, Klebsiella, Arthrobacter, Enterobacter, Xanthomonas, etc. these microbes utilize the CP and its degraded metabolites (Rayu et al., 2017; Duraisamy et al., 2018; Ibrahim et al., 2021; Mali et al., 2022).

The degradation process of pesticides can be divided into three phases, which can be summarized in:

Phase 1: Pesticides are transformed into more water-soluble and less toxic products through oxidation, reduction, or hydrolysis reactions.

Phase 2: The Phase-1 products are converted into sugars and amino acids, which have higher water solubility and lower toxicity.

Phase 3: Conversion of the Phase-2 metabolites into less toxic secondary conjugates.

Bacterial Degradation

In the years, several bacterial strains were identified as capable of degrading the pesticides present in the soils. Each bacterium has a specificity that makes it particularly suitable for a degradative process. The operative conditions, such as temperature, pH, water content, and types of pollutants, affect the adaptation, development, and role of a bacterial strain. Moreover, during the degradation process, metabolites can form and cause additional environmental problems, since they may be more difficult to remove than the original compound, and this must be considered a drawback. As an example, Chlorpyrifos, an organophosphate used as an insecticide, is hydrolyzed by microorganisms, and the primary and major degradation product is 3,5,6-trichloro-2-pyridinol (TCP). TCP has greater water solubility than Chlorpyrifos and causes widespread contamination in soils and aquatic environments. Few microorganisms can degrade the pesticide and its metabolite and among them the bacterium Ochabactrum sp. JAS2 and **Lactobacillus** are capable of hydrolyzing both compounds.

In many cases, the degradation is easier when a bacterial consortium is used compared to using an isolated pure culture. In nature, the bacteria coexist and depend on each other for their viability. In the metabolic pathways of pesticide degradation, each bacterium can generate metabolites that may be used as a substrate by others.

Enzymatic Degradation

Enzymatic biodegradation is due to the enzymes produced during the metabolic processes of microorganisms or plants. Enzymes are biological macromolecules that can catalyze biochemical reactions involved in pesticide degradation. These molecules act in the rate of reaction by lowering the activation energy of the reaction itself.

The main metabolic reactions, where they are involved, are oxidation, hydrolysis, reduction, and conjugation.

Oxidation, which is the first step of the degradation of pesticides, consists of the transfer of an electron from reductants to oxidants. Oxygenase and laccase enzymes may be involved in this reaction. Oxygenases catalyze the oxidation reaction by incorporating one or two molecules of oxygen; laccases cleave the ring present in aromatic compounds and reduce oxygen to water and produce free radicals. During the reaction, heat or energy is generated, and it is utilized by microorganisms for their metabolic activities.

Hydrolysis permits the cleavage of bonds of the substrate by adding hydrogen or hydroxyl groups from water molecules. The pesticide molecules are thus divided into smaller chain compounds than the original ones. Typical enzymes involved in the hydrolysis pathways are lipases, esterases, and cellulases. For example, Luo et al. have identified and cloned an esterase gene from Rhodo pseudomonaspalustris PSB-S capable of decomposing several synthetic pyrethroids, such as fenpropathrin, and tolerates temperature and pH changes. The enzyme is involved in the key step of hydrolysis, namely the cleavage of the ester bond in the fenpropathrin compound.

Reduction permits the transformation through reductive enzymes (nitroreductase).

The conjugation reaction is carried out using existing enzymes, and it is typical of fungal biodegradation. It involves the addition of exogenous or endogenous natural compounds to facilitate the mineralization of pesticides. This process includes reactions such as xyloxylation, alkylation, acylation, and nitrosylation.

Analytical method of chlorpyrifos

The samples obtained in CLP will be analyzed by high performance liquid chromatography (HPLC) using Varian Pro Star 410 HPLC Auto Sampler equipment, a KromasilC18 reverse phase column (15 × 0.40 cm2) and the mobile phase consisted of a mixture of acetic acid. Acid glacial/water/acetonitrile (0.1 V/10 V/90 V), at a flow rate of 1 ml. min1 and an injection volume of 20 µL, 290 nm L for detection of CLP, retention time. 2.07 min.

Chlorpyrifos extraction and analysis.

CP and its metabolites will be identified by protocol of Xu et al.23. Petroleum ether will be used to get cell-free supernatant. Supernatant will be dried, redissolved in methanol and filtered (0.45 mm pore size). Metabolites will be identified by GC–MS system (Agilent, USA).

Analytical Methods for the Detection of Chlorpyrifos

The techniques for detection of Chlorpyrifos are mainly based on three methods:

- Classical analytical techniques
- Immunoassays
- Biosensors

Temperature and pH observations in soil;

The Chlorpyrifos concentration in soil will be determined every 48 h for 14 days.

Analysis of Chlorpyrifos degradation and end product metabolites by Liquid chromatography–mass spectrometry (LC–MS).

Gas chromatographic determination: The extract will be analyzed on GC (Varion-3600) USA (equipped with flame ionization detector) with the parameters as column temperature 230°C, injector temperature 250°C, detector temperature 300°C, hydrogen gas flow 4.5 ml/min and air flow 175 ml/min. The parameter of the glass column will be1.5 % OV-17 + 1.75 % OV-210 Chrome W-HP 80/100 mesh 2 meters x ¼" x 2 mm ID (internal diameter). The retention time will be1.6 min., detection limit was 1µ gm and recovery percentage was 100 %.

Microbial growth activity: Aliquot samples (approximately 1 g) of soil from each treatment will be taken to monitor the microbial activity by the standard dilution plate technique (using nutrient agar medium) as described earlier (Shahida *et al*. 2004). Briefly, the plates will be incubated at room temperature (26°C) for 24 hours. Colonies will be observed and counted. Later on the colonies will be picked up and transferred to nutrient broth tubes for growth and further identification.

CONCLUSIONS

Lately in Georgia on the background of intensive development of agriculture the problem of agricultural soil pollution became an urgent problem, since unregulated use of pesticides by the population became an indirect cause of many acute diseases spread (malignant tumors, cardio-vascular and respiratory system diseases, etc.) as a result of agricultural product consumption grown on pesticide-polluted soil.

At present, there are no means for effective remediation of pesticide-contaminated land resources in Georgia, and it is this information vacuum that will be filled up by the proposed research on agricultural soils contaminated with pesticides and related metabolic products that involves the bioremediation of agricultural soils contaminated with chlorpyrifos-containing preparations (Dursban) using anaerobic bacteria.

REFERANCE

1. **L. Itriashvili**, Kh. Kiknadze, E. Khosroshvili, **M. Shavlakadze**, K. Dadiani. „Soil natures ruled by use polycomplex“, Institute of Water Managment of Georgian Technical University. Collected Papers #67.
2. **L. Itriashvili**, E. Khosroshvili, N. Nibladze, **M. Shavlakadze**, L. Maisaia, „Physic-chemical mechanism of the formation and regulation of soil structures'', Institute of Water Managment of Georgian Technical University, Collected papers #65.
3. **L. Itriashvili**, **M. Shavlakadze**, Kh.Kiknadze, T.Supatashvili, „The prospects of biotechnological rehabilitation of soils polluted with oil with the use of Georgian peats“, Institute of Water Managment of Georgian Technical University, Collected papers #65 p.108-111.
4. **I. Ćwieląg-Piasecka, A. Medyńska-Juraszek, M. Dębicka, M. Shavlakadze.** „Utilization of QUECHERS to pesticides residues assessment in soils“. 31 Aug.- 3 Sept., 2015- **Wroclaw, Poland**, 29th Congress of the Polish Society of Soil Science „Soil Resources and Sustainable Development”. Institute of Soil Science and Environmental Protection, Wroclaw University of Environmental and Life Sciences.
5. **F. J. Schenck and J. E. Hobbs** (July 2004). "Evaluation of the Quick, Easy, Cheap, Effective, Rugged, and Safe (QuEChERS) Approach to Pesticide Residue Analysis". Bulletin of Environmental Contamination and Toxicology. New York: Springer. **73** (1): 24–30. doi:10.1007/s00128-004-0388-y. PMID 15386067.
6. **Payá P, Anastassiades M, Mack D, et al.** (November 2007). "Analysis of pesticide residues using the Quick Easy Cheap Effective Rugged and Safe (QuEChERS) pesticide multiresidue method in combination with gas and liquid chromatography and tandem mass spectrometric detection". Anal Bioanal Chem. **389** (6): 1697–714. doi:10.1007/s00216-007-1610-7. PMID 17909760.
7. A Novel Sample Preparation Approach to Increase the Throughput of Pesticide Analysis by LC–MS-MS Archived August 7, 2009, at the Wayback Machine.
8. **E. Bakradze, T. Butkhuzi, S. Khmiadashvili, E. Bunin, K. Didebulidze, A.Gujabidze, N. Dumbadze, T. Glurjidze, A. Giorgadze.** „Arsenic contamination in Racha and Lower Svaneti district of Georgia, consequence sand remediation strategi“. Journal of Agrarian Sciences, 2021;
9. **G. Khatisashvili, T. Varazi, M. Kurashvili, M. Pruidze, E. Bunin, K. Didebulidze,T. Butkhuzi, E. Bakradze, N. Asatiani, T. Kartvelishvili and N. Sapojnikova**. „Remedial Approaches against Arsenic Pollution. DOI: 10.5772/intechopen.98779, 2021 https://www.intechopen.com/online-first/77387.

10. **N. Asatiani, E. Bakradze, T. Butkhuzi, K. Didebulidze, A. Gujabidze, T. Kartvelishvili, G. Khatisashvili, S. Khmiadashvili, M. Kurashvili, M. Pruidze, D. Razmadze, N. Sapojnikova, T. Varazi** " Microorganisms and Plants as Tools for Phytoremediation of Soil Polluted with Different Forms of Arsenic". Journal of Agrarian Sciences, Vol. 19 No.4, 360-363.2021.
11. **M. Shavlakadze, G. Natroshvili, L. Itriashvili, K. Didebulidze, A. Gujabidze.** "Modern research methods used for soil Bioremediation of Agricultural Lands Polluted by Chlorpyriphos-Containing Pesticides", Tbilisi Humanitarian Teaching University, collected papers #1.2022.
12. **Marine Shavlakadze, Giorgi Natroshvili, Levan Itriashvili, Kakha Didebulidze, Ana Gujabidze**, Khatuna Kiknadze "Agricultural Lands Polluted by Chlorpyriphos-Containing Pesticides in Georgia", Ts. Mirtskhulava water management institute of Georgian Technical University. Collected papers. 2023.
13. **Kruashvili I., Davitashvili A., Inashvili I, Natroshvili G.** „Regulation of soil moisture in irrigated agriculture", Institute of Water Management of Georgian Technical University, Collected Papers #69, p.282-284, Tbilisi.

MODELS OF THE FORMATION OF WATER-AIR REGIME OF SWELLING SOILS AND THE POSSIBILITIES OF THEIR USE IN THE CALCULATION OF DRAINAGE AND OTHER MELIORATION MEASURES

V. Shurghaia, Sh. Kupreishvili, G. Vakhtangishvili, L. Kekelishvili, S. Modebadze
Tsotne Mirtskhulava Water Management Institute of the Georgian Technical University
60[b] I. Chavchavadze ave., Tbilisi
E-mail: v.Shurghaia@gtu.ge

INTRODUCTION

From a theoretical point of view, due to the difficulty of exact mathematical description of the fluid movement nature in a deformable porous medium, this process is still poorly studied [1].In connection with this, more complex mathematical models used in catchment hydrology have recently been proposed for the calculation of drainage systems for the acceleration of surface runoff.

MAIN PART

One of these approaches is based on solving a system of differential equations (1) and (3), describing the movement and interaction of surface water (1) and soil moisture (2):

$$\frac{dh}{dt} + \frac{gQ}{dx} = o_c - W_a \tag{1}$$

$$i_t = -k_w\left(\frac{d\psi}{dz} - 1\right)_{z=0} \tag{2}$$

$$C_w\frac{dw}{dt} = \frac{d}{dz}\left(k_w\frac{d\psi}{dz}\right) - \frac{dk_w}{dz} \tag{3}$$

$$Q = \frac{\sqrt{i}}{n}h^m \tag{4}$$

Where h is the thickness of the water layer on the earth surface; t - time;Q – the surface flow consumption ; x- is the horizontal distance from the watershed; O_c - the well-known graph of the rain arrival and changes in its intensity (including changes in its intensity during rain); Wa – is the dynamics of the intensity of water absorption by the soil, taking into account the design features of the drying system (for example, the presence of trenches for the absorption of catchments, loosening, etc.). It is calculated by solving the differential equation (3); k_w and ψ are the water permeability coefficient and capillary potential depending on soil moisture (or the relation $k_w=f(\psi)$ is used); $C_w=dw/d\psi$ - differential moisture capacity; z -depth from the earth surface; i - soil surface slope; n - roughness; and $m \approx 5/3$ isthe exponent.

To calculate surface runoff dynamics, soil moisture regime, and ground water level, initial and boundary conditions are added to the system of equations (1) – (4), reflecting the initial state of the soil [2], location of ground water, structural features of the drainage system and list of completed hydro-agrotechnical and agromelioration measures, atmospheric precipitation data, total evaporation.

The differential equation of soil moisture (3) is used not only to predict the water regime in the aeration zone, but also to calculate the drainage action and the regime of groundwater levels.

To this end, the groundwater surface ($z \approx \Delta$) is considered as a moving boundary, for which the balance of water flowing from the aeration zone, caused by the full capacity (w = Wc) and water-carrying capacity of the drainage, is maintained:

$$z \approx \Delta;\ w = Wc;\quad \psi = 0;\ -k_w\left(\frac{d\psi}{dz} - 1\right) = q_{dr}(H_0 - \Delta) \tag{5}$$

where: H_0 – drainage depth;Δ – distance from the earth's surface to the edge of the depression; *Wc* — whole moisture capacity, q_{dr} — Modulus of drainage flow depending on the aggregate pressure of the drain.It is determined by formulas for calculating the distance between drains for established filtration conditions. For example, from Kostyakov's formula:

$$q_{dr} = \frac{\pi k}{B\left(ln\frac{B}{d} - 1\right)} \tag{6}$$

Where *k* is the filtration coefficient in the drainage work area; *B* — distance between drains; *d* — the effective diameter of the drains (taking into account the filter filling of the trench); $\pi = 3.14$.

Unfortunately, the method described above for modeling the operation of drying systems has not yet found wide practical application. This is due to some difficulties in modeling and using models. For swelling soils, the problem becomes even more complex due to changes in hydrophysical characteristics k_w and$\psi_w$during the swelling process.There are no sufficiently accurate models of moisture transport for swelling soils yet.Nevertheless, we consider it advisable to further develop this approach and implement it in practice.In any case, it is necessary to take into account the interrelated processes of the formation of surface, subsurface and ground (drainage) runoff.

In foreign practice (J. Philip, D. Smiles, etc.) in equations (3) and (5) during soil swelling, it is proposed to introduce a new variable Θ*, reflecting the ratio of the volume V_{wv} of water to the volume of solid soil particles V_{gr}: $\Theta^* = V_{wv}/V_{re}$.The value Θ^* is related to the volumetric soil moisture *w* as follows:

$$w = \frac{\Theta*}{1+\Theta*+\alpha} \tag{7}$$

Where α is the ratio of the volume of air in the soil V_{air} to the volume of solid soil particles V_{gr}. ($\alpha = V_{air} / V_{gr}$.).

The variable *m* is also introduced:

$$m = \int_0^z \frac{dz}{1+\Theta*}, \tag{8}$$

Which reflects the volume fraction of solid soil particles in the total volume of porous soil in the layer *(0 – z)*. Then equation (3) will take the form:

$$\frac{d\Theta}{dt} = \frac{d}{dm}\left(k_w\frac{d\psi}{dz}\right) - \frac{dk_w}{dm} \tag{9}$$

Where k_w and ψ are functions of the variable Θ^*.

Equation (9) is quite difficult to solve.This model has not yet been sufficiently studied.Therefore, we will try to adapt the model developed for non-swelling soils to swelling soils. According to it, conditions are added to equation (3) reflecting the hydrograph of precipitation inflow (actual data from the "Golden Fleece" area on the Kolkheti Lowland) and the values of total evaporation.At the lower limit — at the drain level, a condition of the type $z = H_{dr}$ (5).

The drain parameters were obtained: $H_0 = 1.2$ *m*, $B = 5.5$ *m*; $d = 0.56$ *m* (taking into account the filtration embankment of drainage trenches).The filtration coefficient was equal to $k=0.03$ m/day-night.The calculation was made for three types of soil water permeability, which are shown in *Fig. 1(curves 1, 2, 3)* [3].Curves 2 and 3 correspond to the properties of non-swelling soils, curve 3 is built for fictitious soil with lower water permeability than swelling soils.

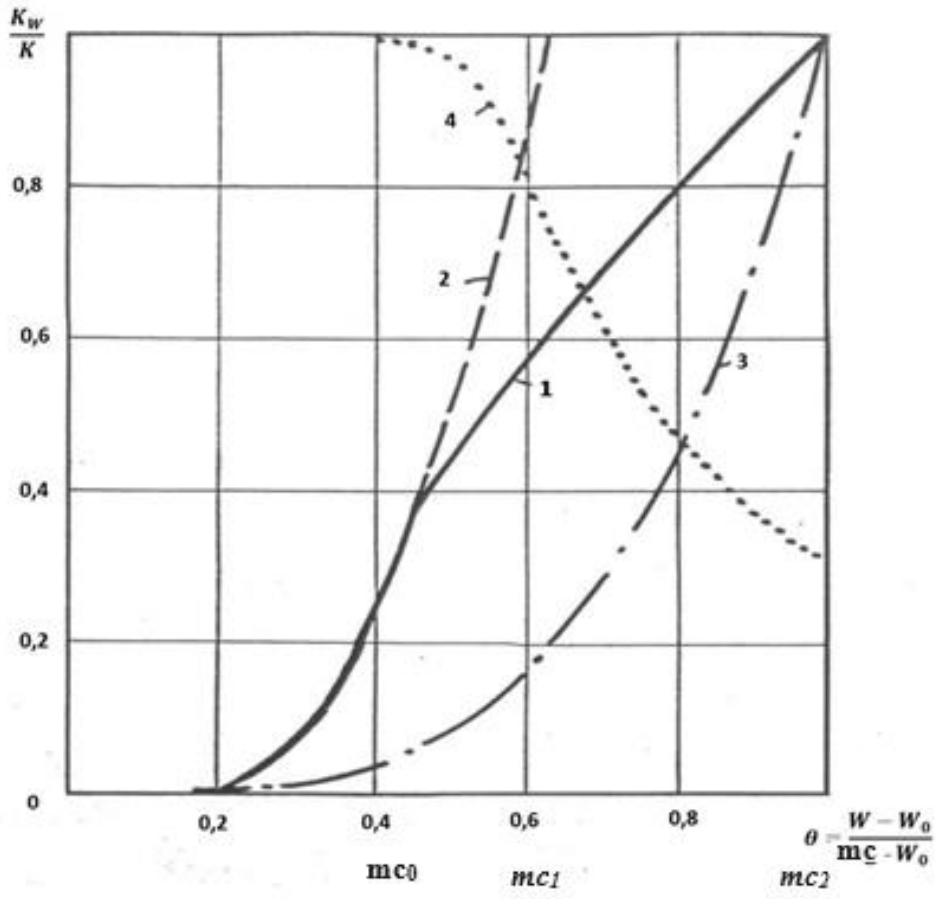


Figure 1. Characteristic curves of thermal conductivity K_W (in parts of the filtration coefficient K) from relative humidity (W_0— maximum molecular moisture capacity, fmc— full moisture capacity, mc_0— humidity capacity, at which the decomposition of soil aggregates and the swelling in clay soils begin, mc_1 —the full moisture capacity of non-swelling soil, equivalent to the indicator of swelling water permeability, mc_2—the full moisture capacity of saturated soil); 1 —the swelling clay soil;2 — approximate ratio $Kw(W)$ for the case when such soil is not swelling with water; 3 — the classical nature of the $K_w(W)$ dependence, when porosity reaches a value equal to mc_2 in the case of complete swelling of the soil; 4 — Percentage change in permeability coefficient when clay soil is swelled

All three curves cover the entire spectrum of the possible influence of soil saturation on the water regime.All three curves cover the entire range of possible effects of swelling on the water regime of soils. Based on the calculation, graphs of $w(t)$, $\Delta(t)$, $Q_{dr}(t)$ and $q(t)$ were constructed for the months June-July selected as an example. Atmospheric precipitation during this period was $O_C = 319$ *mm*, total evaporation was equal to $E_0 = 160$ *mm*. The following results were obtained (the number of the option corresponds to the number of the curve in *Fig. 1*):

Option №	Drainage module Q_{dr} *(mm)*	Surface flow $\tilde{S}_1$ *мм*
Option 1	25	129
Option 2	30	119
Option 3	18	137

From this we can conclude that the approach based on the formal replacement of the swelling soil model with a „rigid", non-deformable soil model is acceptable for predicting the hydrological regime.As expected, the water balance coefficients Q_{dr}, $\tilde{S}_1$,$w(t)$ and $\Delta(t)$, calculated from curve 1, turned out to be within the values of the properties of non-deformable soils, the water permeability coefficients of which are described by curves 2 and 3.In addition, models are needed that more accurately account for surface runoff and the two-dimensional nature of groundwater movement.

CONCLUSION

A preliminary calculation of the water-air regime of silty, marshy montmorillonite swelling soils showed the possibility of adapting mathematical models developed for rigid non-swelling porous media to swelling conditions.In the future, it is planned to improve the methodology for calculating the water-air regime of swelling soils and its practical use in the specific design of heavy soil reclamation of the Kolkheti Lowland.

REFERANCE

1. Itriashvili L.A., Iremashvili I.R., Ujma A., Khosroshvili E. Z., Natroshvili G.T. "An improved method for determining swelling." Collection papers of Ts. Mirtskhulava Water Management Institute of Georgian Technical University, № 73, Tbilisi, 2018, pp. 52-55;
2. Itriashvili L.A., Khosroshvili E.Z., Natroshvili G.T., Nibladze N.Sh. "Physico-chemical aspects of deformation processes in clayey soils." Collection papers of Ts. Mirtskhulava Water Management Institute of Georgian Technical University, № 72, Tbilisi, 2017, pp. 88-93;
3. Shurghaia V., Kechkhoshvili E., Vahktangishvili G., Kekelishvii L., Modebadze S. "Peculiarities of Water-Physical Properties of Kolhketi Permeable Soils". Collection papers of Ts. Mirtskhulava Water Management Institute of Georgian Technical University № 75, Tbilisi, 2022, pp. 241 -246.

THE NEED TO CONNECT BUILDINGS WITH THE NATURAL ENVIRONMENT AND RAINWATER RETENTION IN MODERN CONSTRUCTION

Adam Ujma[1)], Inga Iremashvili[2)], M. Tsutsqiridze[3)]

[1)] University of Applied Sciences in Nysa, Poland
E-mail: adam.ujma@pans.nysa.pl *; ORCID:0000-0001-5331-6808*
[2)] Tsotne Mirtskhulava Water Management Institute
of Georgian Technical University, Georgia, Tbilisi
E-mail: ingairema@yahoo.com*; ORCID: 0000-0002-0992-108X*
[3)] Georgian Technical University, Georgia, Tbilisi

INTRODUCTION

The Intergovernmental Panel on Climate Change believes that the human impact on the Earth's climate is obvious, and that recent anthropogenic greenhouse gas emissions are the highest in its history. Climate change will significantly increase the current threats to both the environment and humans. The scale of the damage caused by climate change will depend on the extent and quality of the international community's response to the process. Climate change mitigation action is urgent and necessary to contain climate change as much as possible and reduce existing environmental and social risks.

The latest report by the World Meteorological Organization indicates that we are halfway through the implementation of the 2030 Agenda for Sustainable Development. Only 15% of the Sustainable Development Goals (SDGs) have been achieved and the global climate goals are still far from being achieved. The 2022 SDG report highlights the increasing impacts of climate change and extreme weather events, as well as other interrelated global challenges that hamper development benefits and jeopardize the full achievement of the SDGs by 2030 [1].

MAIN PART

Significant climate change has been observed in Georgia, which has led to many negative effects. Between 1986 and 2015, compared to the years 1956-1985, average annual air temperatures increased almost throughout the country in the range of up to 1°C, with an average increase of 0.5°C.

Between 1986 and 2015, compared with 1956-1985, annual precipitation increased in most of western Georgia and decreased in some areas of eastern Georgia. An increase in precipitation of 5 to 15% was recorded in large parts of western Georgia. In eastern Georgia, precipitation has decreased by 5 to 15% in most areas over the past 30 years. In the south and east of the country (especially in Kakheti and Mtskheta-Mtianeti), precipitation reflects a decrease in precipitation due to prolonged periods of drought [2].

The average area air temperature in 2022 in Poland was 9.5°C and was 0.8 degrees higher than the annual long-term average (climatological normal period 1991-2020). The year 2022 is very warm in terms of average temperature for Polish. The analysis of historical series shows that since 1851 the air temperature in selected large cities of Polish has increased in the range from 1.49 ° C to 2.30 ° C. At the same time, in the last 40 years, the rate of temperature increase in large urban agglomerations has increased significantly. The area-averaged precipitation in Poland in 2022 was 534.4 mm, which was nearly 87.4% of the norm determined on the basis of measurements in the years 1991-2020. The year 2022 should be classified as dry years, and precipitation was characterized by strong spatial variation. The average area annual totals ranged from above 350 mm to nearly 950 mm. Compared to the long-term norm (1991-2020), they ranged from 70% to 110% of the norm [3].

The World Green Building Council estimates that by 2050, energy demand in buildings will increase by 50%. Construction and the built environment account for about 39% of global carbon dioxide (28% are energy-related emissions from heating, cooling and domestic energy, and the remaining 11% are emissions from the production of materials and construction).

Cities must first strive to reduce global carbon emissions. Over half of the world's population live in cities, accounting for over 70% of CO_2 emissions. Buildings are the largest contributor to emissions in cities, responsible for 50-70% of city emissions and 38% of global emissions. Roughly 75% of building emissions are operational emissions generated from building systems (e.g. heating, ventilation and air conditioning, lighting and other). The remaining 25% come in the form of embodied emissions – carbon generated from the manufacture of building materials, construction and internal furnishings [4].

The World Health Organization points out that, in general, the world's population breathes air that exceeds the pollution levels set by the WHO guidelines. Particularly high, often dangerous, levels of pollutants in the air are found in low- and middle-income countries.

The World Green Building Council report points to the need to:

- conservation of natural resources through investment infrastructure – e.g. prioritising green infrastructure in urban areas;
- enhancing the role of blue and green infrastructure in spatial planning;
- better management of water processes to reduce the depletion of freshwater resources, m.in. through the use of grey water in buildings;
- creating larger public and open green and blue spaces for both nature and people in cities, reducing the urban heat island effect;
- implementation of strategic conservation measures – such as flood measures [5].

Areas and surface overgrown with vegetation on buildings, as well as collection sites and systems using rainwater will play a special role for the proper, sustainable development of urban areas.

In urban areas, it is recommended that CO_2 flows in green infrastructure systems, including buildings with vegetation (green roofs, living facades and living interior walls), should be considered throughout the technical life cycle of buildings (Fig. 1) [6].

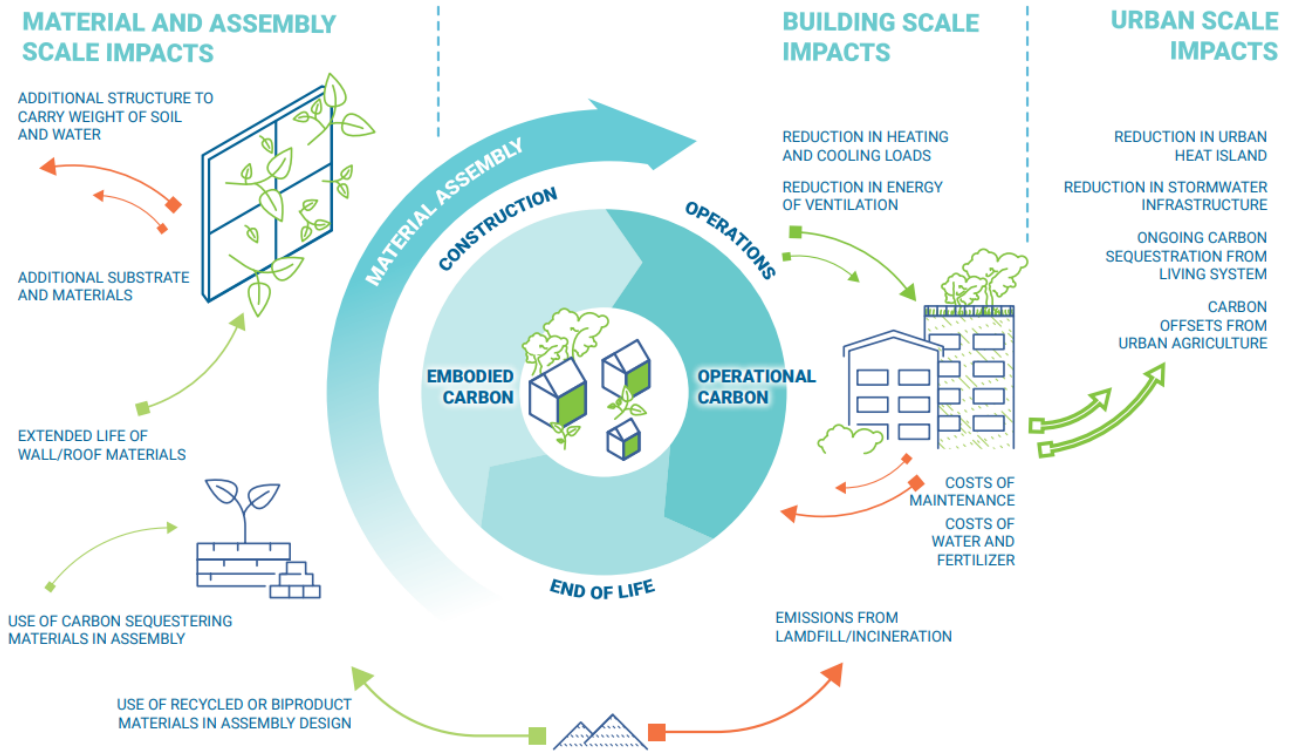


Fig. 1. Green infrastructure and biomaterial systems [6]

The amount of carbon emissions associated with assemblies and structures should be weighed against the potential to reduce carbon emissions by reducing the burden of cooling or heating buildings, reducing the urban heat island effect, improving air quality and biodiversity at both building and city scale. The assessment of carbon dioxide emissions and CO_2 reductions should be made as part of the analysis of the building throughout its life cycle. The final result of the assessment will largely depend on the climatic conditions, the thermal insulation of the building envelope and the tightness of the building, the type and technical parameters of the heating and cooling system, the type of fuel or energy used, the type of installation, the plant species and the area occupied by these plants. According to some authors, a full reduction in carbon dioxide emissions for some facilities is achieved even after a short period of about three years. Other benefits, such as positive effects on human health and well-being or an increase in biodiversity, are not taken into account in these assessments.

Unfortunately, the payback periods for this type of green building systems are not very encouraging, given the energy costs. Until these systems become the norm and are widely used, financial support is needed in the form of grants, concessions and relevant municipal building codes to overcome the additional upfront costs and concerns about ongoing maintenance costs. A report by the World Green Building Council points to the need to design systems in urban areas to protect, collect and efficiently use natural resources, such as rainwater harvesting facilities (e.g. wells and water reservoirs, carefully selected to provide sufficient storage space during periods of drought). Greywater reuse systems, flow reduction devices, and water-saving and heat recovery devices should also be put in place. Green and blue roofs or rain gardens should also be designed and built to effectively manage rainwater runoff with adaptive and native vegetation [6].

According to Habitat data from the United Nations, in 2050 about 68% of humanity will live in cities. It is important to know that currently:

- account only 2 % of the Earth’s surface;
- consume 78 % of energy;
- produce more 60 % of greenhouse gas emissions [7].

In 2016 the United Nations itself improved the New Urban Agenda [8] to advise countries on their urbanisation processes and make cities more habitable, inclusive, healthy, resilient and sustainable. This document draws attention to the challenges posed by increasing urbanization and suggests possible courses of action. In its latest version, it reinforces the 2030 Agenda's mission to support sustainable urbanization. In particular, universal access to safe, inclusive and accessible green and public spaces, in particular for women and children, older people and persons with disabilities, should be ensured by 2030 [8].

In May 2019, significant changes to the construction law were introduced in Georgia. The changes concern planning, architectural and construction activities. It defines land development zones (subzones) and/or the specificity of individual planning units, architectural and planning features as well as spatial and cubature features of buildings, location of buildings, and their parameters. For each type of zone, different requirements and dimensions of buildings, structures will be assigned. Therefore, the planned development should meet the requirements of the plot zone/subzone. In the case of Tbilisi, these are the following zones: landscape and recreation, forestry, agriculture, recreational, special, residential, transport, public and business, industrial and sanitation.

Specific greening factors are assigned to each of the zones and relevant subzones. K-3). The greening factor (K3) determines the minimum share of land with greenery in a given area. Example for residential zone 4, it is 0.30, 30%i.e. a minimum of 30% of the area must be covered with vegetation [9].

Green spaces play an important role in providing cities with basic natural processes. The research published in the article [10] made it possible to estimate the impact of Tbilisi's green cover on its ecosystem. The analysis showed that the annual removal of atmospheric pollutants and the total carbon stocks associated with the vegetation of trees and shrubs The results showed that the annual removal of air pollutants (CO, NO_2, O_3, SO_2, PM2.5 and PM10) is 1227 tons, or 2.444 t/km^2. The average annual carbon sequestration by

trees and other vegetation is 43.72 thousand tons (87.09 t/km^2). Trees store 1,097.9 kilotons of carbon (2,187.95 t/km^2) and the CO_2 equivalent is 4,025 kilotons. This is the first time that such an analysis of Tbilisi's ecosystem coverage has been carried out. The study revealed the significant scale and huge potential of the 'green benefits' that urban vegetation provides to the city. This provides additional arguments for better use of this knowledge for advanced urban green infrastructure planning in Tbilisi in order to strengthen its sustainable and resilient development. They point to the additional potential for environmental improvement that green roofs and green, living building facades can provide.

The study showed that the share of green spaces, especially those used for recreation and ecosystem services (i.e. parks, gardens, urban forests), is low in the centre of Tbilisi. A comparison of green cover and the total area of green areas (approx. 5 m2 of green areas per capita) with the European average proves that Tbilisi's green infrastructure should be expanded and developed. In addition, the results of the presented study also revealed several important aspects of management and environment in Tbilisi's urban space, such as the uneven distribution of urban greenery, insufficient number of environmental services for the city's residents. It is necessary to further develop "green zones" supported and taken into account in spatial planning, especially in districts with limited accessibility and poor access to large urban parks (over 10 hectares) or other natural areas. It is particularly important for the city authorities to treat urban "green" spaces not as "decorative elements", but as an important urban asset of Tbilisi, important for its residents and visitors to the capital [10].

An interesting and valuable initiative is the Spatial Development Plan developed by the Tbilisi City Hall and the City Hall, which includes the concept of a "green city". When implementing the Green City conceptual approach and including it in the spatial development plan, the following key provisions were considered important:

- "The River and the City" (prioritizing recreational development on the banks of the Mtkvari River and emphasizing the cultural connection between the city and the Mtkvari River);
- Opening and releasing small rivers and their beds;
- Development of unified green areas and garden parks;
- Separation of undeveloped areas from built-up areas with urban planning restrictions;
- Prioritising recreational and ecological functions to reuse brownfield land;
- Prioritise recreational and green functions in the planning of the development of Tbilisi's central multi-purpose area;
- Polycentric development.

The development of Tbilisi by its local government unit will be based on the above-mentioned concept and key provisions. [11].

Examples of modern green building in Tbilisi and Kutaisi are illustrated in photographs (Figs. 2, 3).

Such activities are in line with the concept of sustainable development, which among its strategies is the creation of green buildings GB The development of the United Kingdom is a topic of increasing interest due to the massive development of conventional infrastructure, which has a significant impact on the degradation of the natural environment. The article [12] discusses the scoring that is assigned to the different types of buildings described in the UK, based on the assessment of several specific parameters. The developed rules give designers and tenants, a coherent view of the GB concept.

The paper [13] examines the impact of green roofs and double green façade on efficiency and energy consumption in multi-storey buildings. Optimal configurations of the designed building envelope were sought, examining their interaction and impact on energy demand. Analyses indicate that certain combinations of green roof characteristics, such as vegetation types and coverage factors, can result in significant energy savings through the right combination of façade design and building envelopes. The combination of a roof structure with a green roof and a double façade significantly reduces carbon emissions in hot climates.

Fig. 2. Production coffee plant in Tbilisi (Project Khmeladze Architects) [https://www.surfacesreporter.com/myuploads/1coffee%20plant.jpg]

Green roofs and green facades bring many benefits (e.g. mitigate the potential occurrence of flooding, reduce the urban heat island, save energy, increase biodiversity, sequester CO_2) and support sustainable urban development. They are still being explored m.in order to implement them more widely in urban areas. While the benefits of green roofs and facades are widely recognized, community perception and willingness to pay for their installation in urban areas is still not clear or quantified. Public opinion and willingness to pay for green roofs are fundamental to urban planners and policymakers, as they represent community participation in sustainable urban development. Studies have shown that the majority of citizens are aware of what green roofs are and facades that they can make a significant contribution to mitigating adverse climatic and operational events in cities and buildings. The results also indicate a greater interest in installing green roofs on public buildings than on private buildings, due to the high cost of installation [14].

Fig. 3. Green roof of the Kutaisi airport building
[Photos: Kutaisi International Airport and taken by the authors]

Despite the green roofs on the outside of the buildings, there are green structures in the form of green gardens, covered with transparent structures. An adequate supply of solar radiation is very important for their proper functioning, ensuring the proper development of plants. In this paper [15], the curves of solar and phytotubal spectra, mean sensitivity and spectral luminous efficiency for photopic vision were analyzed. The integration of the curves makes it possible to recalculate the lux meter reading for the equivalent solar illumination or the last one for the power of the phytolamp. This allows you to choose the optimal way to illuminate your plants depending on the species.

The article proposes [16] a project of a new green roof structure to improve the efficiency of rainwater management "Hybrid Green Roofs". The possibility of using the "blue" roof as a rainwater management technology without vegetation, which allows for effective rainwater retention, was analyzed. The design scheme and the principle of operation of the "green-blue" roof are given, and a comparative analysis of its effectiveness in rainwater management with traditional and "green" roofs was carried out. The results of the research were presented, which showed that the measured rainwater runoff from the "blue" roof is about 0.45 dm^3/s compared to an ordinary roof with a runoff volume of 1.55 dm^3/s. On the other hand, the runoff from the "green-blue" roof is about 0.1 dm3/s, compared to the control roof (0.3 dm^3/s). A "green-blue" roof has been proven to be more effective at stopping rain runoff during prolonged rainfall than a "blue" roof. However, both options can be used in urban buildings as effective methods of stormwater runoff management in urban areas. A construction diagram and working principle of a "purple" roof is given - as a type of roof that contains a spongy layer of hydrophilic rock wool, a dense layer of polyester fabric, and can contain an additional cellular layer to increase the amount of rainwater that can be retained, thus reducing peak flow by up to 95%. The results of research are presented, which confirm the technical feasibility of the "purple" roof technology in terms of slowing down the flow and reducing the volume of rainwater during rainfall of varying intensity. A "purple" roof, based on the concept of "storage", is conceptually and technically different from a "green" roof, and can effectively delay peak rainfall, thereby reducing the pressure on the local rainwater management system. Unlike a "green-blue" roof, a "purple" roof is passive – the water runs off without any mechanical drainage points that could direct it elsewhere.

Provisions indicating the need to take into account spatial and environmental aspects in the current urban policy, the need for revitalization and sustainable spatial planning will be included in the study [17]. The document shows the Polish approach in the context of the guidelines of the New Urban Agenda, highlighting the important role of solutions based on natural and natural resources and the particular need to promote such an approach.

The roadmap for Buildings and Construction 2020-2050 [18] to fully decarbonize buildings throughout their life cycle and to support the development of national or regional strategies and policies sets

out short, medium and long-term scopes for action to create a built environment that is carbon-free, efficient and resistant. It includes eight "actions": urban planning, new buildings, existing buildings, construction operations, devices and systems, materials, resilience and clean energy. This document provides guidance on actions on m.in green and blue infrastructure in cities (Fig. 4). It contains guidelines with set goals, indicators that cities should achieve by 2030, 2040 and 2050.

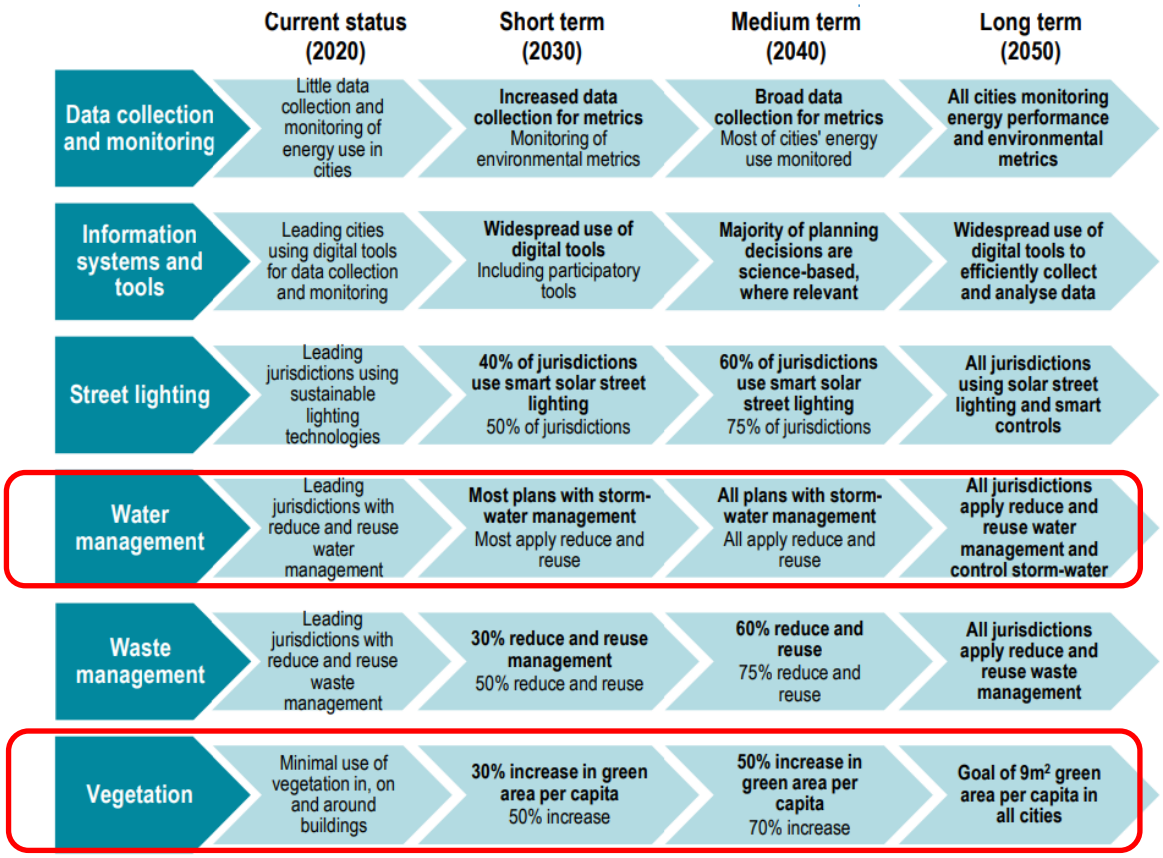


Fig. 4. Technology timelines for urban planning globally [18]

In the case of water management in urban areas, the need to support the increased use of water management technologies, reduce the volume and speed of rainwater runoff, increase landscape permeability and rainwater retention is indicated. This will increase flood resilience and improve the quality of soil and underground aquifers. Introducing the measurement of rainwater flow in downspouts, tanks, and drains using smart sensors, giving city agencies the ability to identify where green infrastructure is needed to improve drainage and mitigate the effects of the urban heat island.

For vegetation, proper landscape and vegetation planning can increase resistance to excess rainwater, reduce the need for heating and cooling, and improve air quality through measures such as green roofs, green facades, rain gardens in streets, parking lots, squares. Urban parks, in particular, are critical to improving the quality of life in cities, cooling cities, and acting as sinks for greenhouse gas emissions and other air pollutants. Vegetation measures should give priority to the use of native plant species.

Mitigation of the effects of urban heat islands (UHIs) should be sought (Fig.5). Impermeable, devoid of vegetation and dark surfaces in cities tend to generate UHI effects, i.e. an increase in ambient temperature, compared to other suburban areas. Buildings, streets, parking lots, and paved surfaces absorb more heat than the moist surfaces of plants and their ground substrate, which release water vapor and provide shade to cool the surrounding air. To minimize this effect and mitigate extreme heat, cities should set UHI reduction targets and implement various programs to do so. Local authorities may seek to reduce impervious areas, increase the protection of large volumes of tree canopy, create cool or green roofs and facades, or enlarge

wetlands. Quantitative targets should be included in the city's formal plans and specify a future target date or annual commitments.

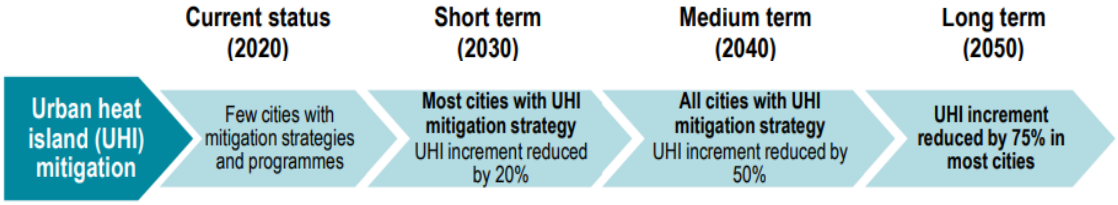


Fig. 5. Timeline of urban planning policies around the world, in relation to the urban heat island (UHI) effect [18]

The latest version of the EU EPED (Energy Performance of Buildings Directive (recast)) [19] points to the need to integrate green infrastructure, such as living roofs and walls, into urban planning and architectural design. This can be an effective tool for adapting to climate change and reducing the harmful effects of climate change in urban areas. Buildings should take into account climatic conditions, including adaptation to climate change through green infrastructure, etc. Member States should encourage the installation of vegetation surfaces that help retain and retain water, thereby reducing urban run-off and improving stormwater management. Improving the good use and adaptation of public space surrounding buildings with elements such as wood, green roofs and facades, and solutions inspired and supported by natures.

According to the 2023 amendments to the EPBD Directive, buildings in the European Union must meet zero-emission CO_2 standards:

- from 1 January 2026 – newly designed buildings occupied, operated or owned by public authorities;
- from 1 January 2028 – all newly designed buildings;
- from 2050, all buildings (both new and existing) [20].

The use of building envelopes with vegetation (green roof and green façade) should help achieve the objectives of the EPBD. According to the Polish building regulations, green areas in buildings are classified as biologically active areas in Poland Technical conditions to be met by buildings and their location – Announcement of the Minister of Investment and Development of 8 April 2019 (Journal of Laws of 2019, item 1065)

According to Polish building regulations, a biologically active area is an area:

- with an area arranged in a way that ensures natural vegetation of plants and rainwater retention;
- such an area also covers 50% of the surface of terraces and flat roofs with a vegetation layer with vegetation and other surfaces (e.g. green façade), providing natural vegetation of plants, with an area of not less than 10m^2;
- surface water in this area.

Polish building regulations contain requirements for a minimum biologically active area.

1. On building plots intended for multi-family housing, health care buildings (except clinics) and education and upbringing, at least 25% of the plot area should be developed as a biologically active area, if a different percentage does not result from the provisions of the local spatial development plan.
2. The group of multi-family buildings covered by a single building permit provides for playgrounds for children and recreational areas accessible to the disabled, according to utility needs, with at least 30% of this area located in a biologically active area, unless separate regulations provide otherwise.

Green roofs are designed to withstand heavy rainfall and provide protection against both very high and very low air temperatures or high temperatures on the surface of outdoor floors. Such properties are primarily possessed by a green retention roof, which ensures an appropriate rate of water evaporation and prevents the soil from drying out:

- extensive or standard green roofs are green roofs with a relatively thin layer of soil and vegetation; suitable types of vegetation are succulents or, in the case of shady roofs, a mixture of mosses and

herbaceous plants; succulents have a high water storage capacity; photovoltaic panels can also be placed on such a roof, which further reduce the temperature on the roof surface; due to the relatively light weight of succulent roofs, they can often be laid on top of existing roofs, even at an angle of about 35°;

- intense green roofs have a thicker substrate and vegetation layer, as well as a greater variety of plants, including shrubs, small trees, and nesting sites for birds and bats; such roofs can contribute to biodiversity.

A way to encourage the creation of green roofs and facades are property tax reliefs and exemptions introduced in several cities in Poland.

Below in the tables 1, 2, 3 are listed the amount of discounts in property tax, depending on the type of partition with vegetation and the area occupied by it. Tax relief applies primarily to residential buildings.
In Table 1, data from Wrocław adopted in 2015 for residential buildings and residential premises.

Table 1

Property tax reliefs in force in Wrocław

Type of partition with vegetation	Area occupied by plants	Percentage of property tax relief
Green roof in a building up to 5 storeys high	50 – 80%	50 – 80%
	80 – 100%	80 – 100%
Green roof in a building with a height of more than 5 storeys	50 – 80%	25 – 40%
	80 – 100%	40 – 50%
Vertical garden on the façade	< 30 m^2	20%
	30 m^2 – 45 m^2	25%
	> 45 m^2	50%

An example of a building with vegetation, from Wroclaw. Extensive green roof 1600 m^2, intensive roof 860 m^2, greenery on native land and in pots 360 m^2 (Fig. 6) [21]. Green façade with ivy on the external walls of the Wroclavia shopping mall, Business Garden in Wroclaw and National Museum in Wrocław (Fig. 5, 6, 7).

Fig. 6. Green square on the roof of the Wroclavia shopping mall in Wrocław [Photos: taken by the authors]

In Table 2, data from Katowice adopted in 2021 and from Kalisz adopted in 2021.Example of a green roof over the International Congress Centre in Katowice (Fig. 8) [22]. Green façade on the façade of the Mercure hotel building in Katowice (Fig 9) [23].

Fig. 7. Green roof at Business Garden in Wrocław [10]

Fig. 8. Green façades on the building of the National Museum in Wrocław [own photos]

Table 2

Property tax reliefs in force in Katowice and Kalisz

Type of partition with vegetation	Percentage of area occupied by plants	Percentage of property tax relief
Green roof	100%	100% (reduction to 50% in Katowice in buildings with a height of more than 6 storeys)
Green façade (minimum one) with vegetation rooted in the ground	-	
Vertical garden on the façade	50%	

Fig. 9. Green roof over the International Congress Centre in Katowice [22]

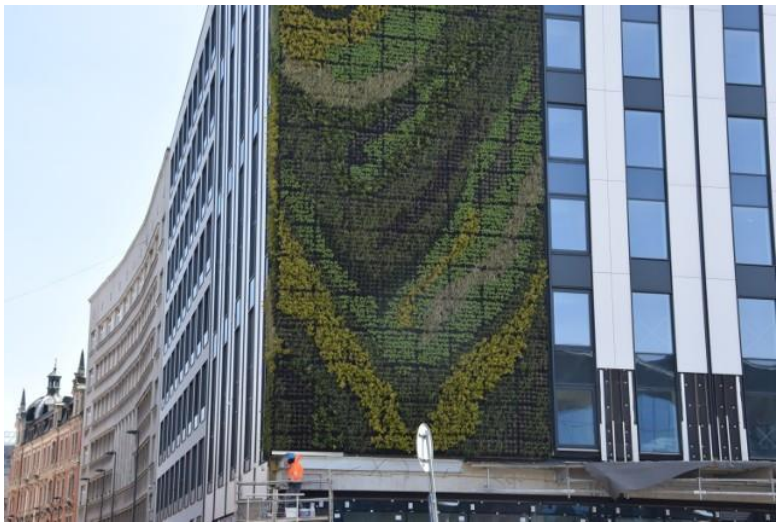


Fig. 10. Green façade on the Mercure hotel building in Katowice [23]

Fig. 11. Green façade on a building located in Kalisz [24]

In Table 3, data from Częstochowa adopted in 2022, established only for single-family buildings.

Example of a green roof over the EXG office building in Częstochowa (Fig. 11) [25]. Green façade created on the external wall of the City Hall building in Częstochowa (Fig 12) [26].

Fig. 12. Green roof over the EXG office building in Częstochowa [25]

Fig. 13. Green façade created on the external wall of the City Hall building in Częstochowa [26]

Table 3

Property tax reliefs in force in Częstochowa

Type of partition with vegetation	Percentage of area occupied by plants	Percentage of property tax relief
Green roof	100%	50%
Green façade (minimum one) with vegetation rooted in the ground	50%	
Vertical garden on the façade	75%	

Financial incentives for the creation of green roofs or facades have also been introduced by the city of Poznań. Individuals, housing communities, entrepreneurs who set up a vertical garden or a green roof can recover up to 100% of the costs incurred, but not more than PLN 25,000 (about EUR 5,600). The subsidy is

awarded for the creation of a vertical garden or a green roof on single-family, multi-family and utility buildings only in Poznań. Co-financed projects must meet certain conditions [27].

CONCLUSION

Outdoor vertical gardens must form an area of not less than 15 m^2; plants should be placed on or climbed on the outer vertical wall of the building; plantings should be watered.

Green roofs, on the other hand, should be adapted to the load-bearing capacity of the building; have a maximum angle of inclination of 30° and a minimum area of 10 m^2; They must also have a specific substrate layer [27].

The authors propose the use of a new PLA composite in green structures (roofs, facades and around buildings) in order to improve the vegetation processes of plants [28]. Thanks to the very slow water release process of PLA, the maintenance conditions and quality of green areas on soils containing this composite improve significantly. This is especially important in urban environments, which in many regions are characterized by a lack of humidity, especially in summer.

This is one of the proposals that is part of the global trend of maintaining a sustainable path of construction development, in particular in urban, industrial and communication areas, based on respect and enrichment of the natural environment in order to preserve it for future generations.

REFERENCES

1. United in Science 2023. A multi-organization high-level compilation of the latest weather-, climate and water-related sciences and services for sustainable development. Sustainable Development Edition. World Meteorological Organization, 2023
2. Georgia's 2030. Climate Change Strategy, Government of Georgia, Tbilisi 2021
3. Klimat Polski 2022, Meteo IMGW-PIB, 2023
4. Accelerating the Decarbonization of Buildings: The Net-Zero Carbon Cities Building Value Framework. World Economic Forum. Briefing Paper 2022
5. Climate change resilience in the built environment. Principles for adapting to a changing climate. World Green Building Council 2022
6. Global Status Report for Buildings and Construction: Towards a Zero-emission, Efficient and Resilient Buildings and Construction Sector. Nairobi 2022
7. Green Building Principles: The Action Plan for Net-Zero Carbon Buildings. Insight Report 2021 World Economic Forum
8. New Urban Agenda. United Nations, Quito 2017
9. How to obtain a construction permit in Georgia 2019, Price water house Coopers Georgia
10. Alpaidze, L.; Salukvadze, J. Green in the City: Estimating the Ecosystem Services Provided by Urban and Peri-Urban Forests of Tbilisi Municipality, Georgia. Forests 2023, 14, 121. https://doi.org/10.3390/f14010121
11. Green Economy in Georgia. Regulatory Overview. PwC Georgia
12. Bungau, C.C.; Bungau, T.; Prada, I.F.; Prada, M.F. Green Buildings as a Necessity for Sustainable Environment Development: Dilemmas and Challenges. Sustainability 2022, 14, x. https://doi.org/10.3390/xxxxx
13. Mahshad Azimal, Senem Seyis, Analysing the Impacts of Green Roofs and Building Envelopes on Energy Consumption in High-Rise Buildings. Proceedings of 3rd International Civil Engineering and Architecture Congress (ICEARC'23), DOI 10.31462/icearc.2023.000000
14. Elena Cristiano, Roberto Deidda, Francesco Viola, Awareness and willingness to pay for green roofs in

Mediterranean areas. Journal of Environmental Management 344 (2023) 118419, https://doi.org/10.1016/j.jenvman.2023.118419
15. Tetiana Tkachenko, Viktor Mileikovskyi, Anna Moskvitina, Iryna Peftieva, Viktoriia Konovaliuk, Adam Ujma. Problems of standardising illumination for plants in greenhouses and green structures, Engineering for Rural Development Jelgava, 24.-26.05.2023, DOI: 10.22616/ERDev.2023.22.TF204
16. Maryna Kravchenko, Tetiana Tkachenko, Viktor Mileikovskyi, Modification of the "green" roof using technical solutions to reduce the negative impact of stormwater in urban conditions. Problems of watersupply, drainage and hydraulics, issue 43, 2023
17. Sustainable urban development in Poland: National Urban Policy in the Context of the 2030 Agenda's Goal 11 and the New Urban Agenda. Ministry of Investment and Economic Development, Warszawa 2019
18. Global ABC Roadmap for Buildings and Construction 2020-2050. Towards a zero-emission, efficient, and resilient buildings and construction sector. Global Alliance for Buildings and Construction, United Nations Environment Programme 2020
19. Directive of the European Parliament and of the Council on the Energy Performance of Buildings (recast). European Parliament 2023
20. EU-level Technical Guidance on Adapting Buildings to Climate Change. Best Practice Guidance. European Union, 2023
21. https://www.soprema.pl/images/referencje/BIUROWIEC-BUSINESS-GARDEN-WROCLAW/BUSINESS-GARDEN-A.jpg
22. https://bi.im-g.pl/im/4e/63/13/z20329038AMP,Widok-na-dach-Miedzynarodowego-Centrum-Kongresoweg.jpg
23. https://d-art.ppstatic.pl/kadry/k/r/2f/fb/60703951d3058_o_medium.jpg
24. https://www.whitemad.pl/wp-content/uploads/2021/10/zielone_fasady_kalisz_1.jpg
25. https://www.architekturaibiznes.pl/matematyczna-precyzja,4810.html
26. https://d-art.ppstatic.pl/kadry/k/r/ff/fa/6114f7f06a9cc_o_full.jpg
27. https://bip.poznan.pl/bip/aktualnosci/dotacje-na-zielone-dachy-oraz-wymiane-drzwi-i-okien,207801.html
28. Itriashvili L., Iremashvili I., Khosroshvili E., Ujma A. New multi-purpose polymineral composite and areas of its application, Budownictwo o Zoptymalizowanym Potencjale Energetycznym Vol. 7, Nr 1/2018, s. 77-82, DOI: 10.17512/bozpe.2018.1.11

SOME PROBLEMS OF THE BLACK SEA POLLUTION

M. Vartanov, I. Iordanishvili, G. Natroshvili, M. Shavlakadze

Ts. Mirtskhulava Water Management Institute of Georgian Technical University
I. Chavchavadze Ave. 60[b], 0179, Tbilisi, Georgia
E-mail: m.vartanov@gtu.ge

INTRODUCTION

The aging of natural and man-made objects raises the problem of assessing their critical, i.e. the limit state at which the object no longer satisfies operational requirements. The evaluation of the critical pollution of the Black Sea based on the forecast of maximum permissible loads allows recommending a system of conservation and protective measures that ensure the ecological balance of its use. The Black Sea is polluted tens of times more than the central parts of the World Ocean. The main task is to assess the molismological[1] condition of the Black Sea, i.e., to quantitatively determine the magnitude of pollutants in the water and sediments introduced into the sea by both human activity and nature itself; calculate the economic efficiency of investments in environmental protection measures.

MAIN PART

The geographical location of the Black Sea unites six countries - Bulgaria, Romania, Ukraine, Russia, Georgia and Turkey. The maximum length of the sea from west to east is 1150 km, from north to south - 580 km, the area is 422,000 km^2, the maximum depth is 2210.0 m, the volume is 555,000 km^3, the total length of the coastline is 4100 km, of which borders of Georgia - 310 km. The main factors determining the formation and variability of ecological indicators of the Black Sea are: salt balance, dynamics of the sediment transport by rivers. Significant contributions to the pollution of the Black Sea were made by the catastrophic accidents at the Chernobyl Nuclear Power Plant and the breach of the dam of the Kakhovskaya hydroelectric Power Station in the valley of the river Dnieper. Another important factor affecting the ecological condition of the Black Sea is the change in climate conditions. The increase in temperature on the Earth and the rise in the level of the World Ocean noticeably affect the sea level regime of the Black Sea.

Based on the analysis of data from several meteorological stations, a trend graph of changes in the sea level regime, surface water temperature and air temperature over the Black Sea waters has been constructed (Fig. 1, 2).

[1]Greek “molismos” – dirt, pollution

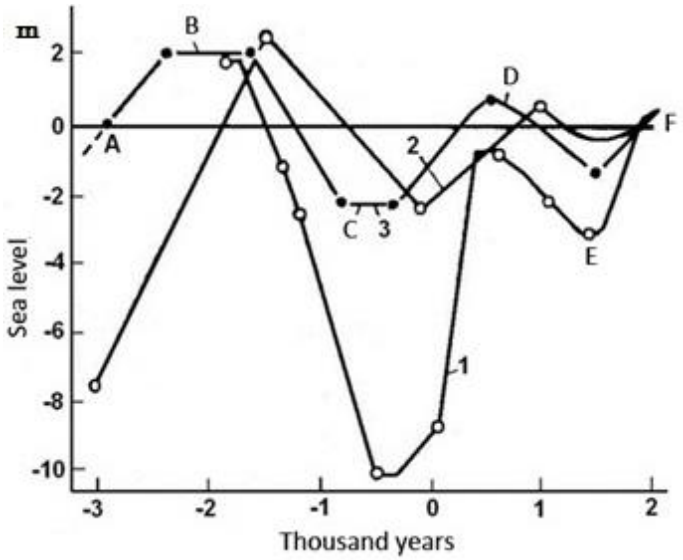


Fig 1. Water level fluctuations in the Black Sea over the past 5000 years
1-according to K.K. Shilik; 2- according to S.V. Varushchenko; 3 - according to P.V. Fedorov: A - Ancient Black Sea basin; B - New Black Sea transgression; C - Phanagorian regression; D – Nymphean transgression; E-Corsunis regression; F-Modern transgression

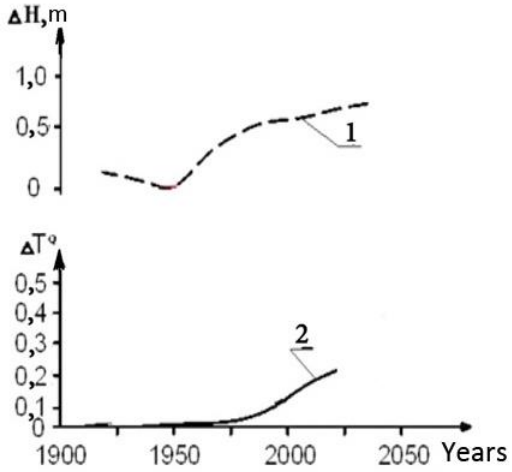


Fig.2. Average trend of the Black Sea level in the coastal zone of Colchis (ΔH) (1) and air temperature (ΔT) (2)

One significant factor in the pollution of the Black Sea is the solid sediments carried by the flow of rivers flowing into the sea. According to research conducted by scientists from various countries, the average sediment load of the major rivers flowing into the Black Sea is approximately 0.1 km^3/per year. If we assume that the age of the formulated water mass in the Black Sea is 7000 years, then during this period 700 km^3 of sediments have entered the sea, which amounted to 0.13% of the total volume of the Black Sea water.

The Black Sea is replenished by freshwater runoff from rivers and saline waters coming from the Marmara Sea through the Bosporus Strait. Due to the flow of dense saline water from the Marmara Sea into the Black Sea and the formation of a denser lower layer of water and an oncoming lighter layer of water from the Black Sea to the Marmara Sea, a layer with a rapid density change, known as the “pycnocline”, has formed, with a depth ranging from 40 to 200 meters. The pycnocline serves as the boundary of the deep anoxic (dead) zone.

One of the most significant factors contributing to the pollution of the Black Sea is the waters of the rivers flowing into the sea and carrying, along with solid runoff, organic and radioactive waste in increasing volumes. This has led to a catastrophic progression of Black Sea pollution. Irreversible ecological changes

are already occurring in the northwestern regions of the continental shelf, while other areas are in a pre-crisis state (Iordanishvili, I.,2014; Iordanishvili, I., 2009).

The transformation of the Black Sea ecosystem and mass mortality events are the result of the presence of toxic heavy metals ions, chloroorganic compounds in the water, high concentrations of substances hazardous to health on the surface, seabed eutrophication leading to hydrogen sulfide poisoning, the input of organic waste, and radioactive substances into the sea. Based on ecological research data from the international company „Ecosi", it has been determined that anthropogenic **phosphates** input from river runoff amounts to 50 thousand tons per year, with a cumulative volume of approximately 0.002 km^3 over the last 50 years. **Petroleum hydrocarbons** (PH) accumulate in the upper layers of the sea, up to a depth of 1.0 meter, with an average concentration of (PH) over the last 50 years reaching 3 mg/l, totaling 0.000004 km^3; the average hydrogen sulfide concentration increases with depth, measuring 0.4 ml/l at a depth of 150 meters, 1.5 ml/l at a depth of 500 meters, and 8.0 ml/l at a depth of 2000 meters; **chlorinated hydrocarbons** – specifically gamma-hexachlorocyclohexane accumulate in the upper water layer (up to 10 m deep), with an average concentration of up to 20 mg/l. Detergents (synthetic surfactants) and **aromatic hydrocarbons** (AH) are in deeper layers, with concentrations of up to 100 µg/l; **mercury** concentration reaches 1 µg/l, salinity is estimated by salt composition - more than $200 \cdot 10^{-4}$ % m (Gavardashvili A., 2017). Among the pollutants of the sea, **radioactive contamination** occupies a special place. An unprecedented source of radioactive isotopes has been the accident at the Chernobyl Nuclear Power Plant. It should also be noted here that as a result of the destruction of the dam of the Kakhovka HPP in Ukraine, which occurred on June 6 2023 18.2 million m^3 of water was released into the Black Sea, pollutants from livestock, agricultural and other facilities were discharged into the Black sea. Since the perimeter of the Black Sea is 4150 km, and the speed of the surface water flow is 30 cm/s, then the polluted discharged water is deflected to the right by the Cariolis force and has a counterclockwise direction (Fig. 3). Subsequently, the direction of currents is influenced by wind and coastal configuration. As for the polluted waters of the Kakhovka Reservoir, they are expected to reach the Kolkhida zone of the Black Sea, probably by the end of october 2023.

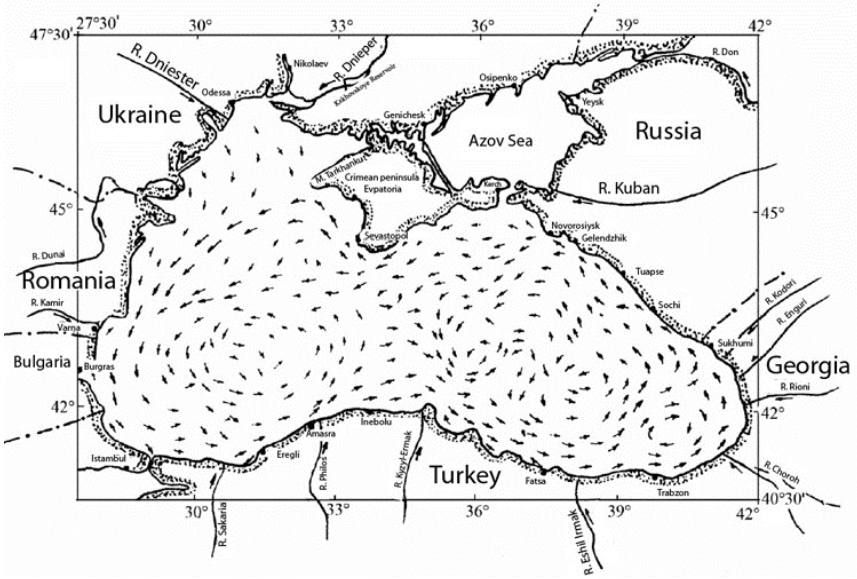


Fig.3. The main directions of surface currents in the Black Sea

The theoretical definition of the maximum permissible (critical) pollution of the Black Sea, in accordance to the definition by academician Ts. Mirtskhulava, looks as follows: the critical state of the Black Sea will occur when the maximum value of polluting factors equals the value of the parameter determining resistance to external factors (Mirtskhulava T.E., 2003). Then, for a monotonic dynamic process that depends on the degradation of the Black Sea over time, it is possible to use a statistical differential equation:

$$dy(t) = m_0(t)dt + \sigma(t)dx(t), \quad (1)$$

Where: y(t) is the determining (polluting) parameter; $m_0(t)$ is the average rate of change of the polluting parameter; σ(t) is the standard deviation of the polluting parameter; x(t) is a random component of the Gaussian process.

The task is reduced to determining the time to reach a specified indicator of the degradation process. In the case of a known conditional density of transition for a Markov process of the diffusion type from one state to another, the problem can be solved using the Facker-Planck-Kolmogorov equation. The main task is to identify the main cause of degradation, which is done with a known rate (m) of change of the polluting parameter (I) with a constant standard deviation (σ). After several mathematical transformations of equation (1), a dependence for calculating the time of onset of vulnerable of the Black Sea to one or more of pollutants is obtained:

$$t = \frac{I_{kp}(2+Z^2 C_v) \pm \sqrt{(4+Z^2 C_v^2) Z^2 C_v^2}}{2m} \quad , \qquad (2)$$

Where: I_{kp} is the limit value of the parameter that determines the degradation of the object, after reaching which the object (the Black Sea) becomes vulnerable; Z is statistical resistance margin, which determines the functioning of the object before it reaches its vulnerable state with a range of 0.00 ≤Z≤4.99; m is the average rate of change of the polluting parameter; $C_v = \frac{\sigma_x}{\bar{x}}$ is the coefficient of variation, the value of which is equal to the ratio of the standard deviation of the change in the polluting parameter (σ) to its average value ($\overline{x}$).

For especially important objects, the introduction of the system (6σ) - will drastically reduce the intensity of hazardous situations and increase the duration of the object (Black Sea) operation. To simplify calculations using the "three sigma" rule with the help of the tolerance field, which is usually taken equal to 20% of the average value of the parameter (m), we have:

$$\sigma_{\bar{m}} = \frac{0{,}2\bar{m}}{6} = 0{,}033\bar{m} \qquad (3)$$

The results of the calculation for the main pollutant element - **river sediment** load to the Black Sea - are given in Table 1.

Table 1

Results of calculations of the Black Sea vulnerability onset from river sediment load

№	Determining factor of pollution	σ=0,033•m	$C_x = \sigma_x/m$	Index reliability,P	Average rate of sediment load to the Black Sea, m*	Statistical resistance margin,Z**	Limit value of degradation parameter Inr	Black Sea normal operating time, t years
1	2	3	4	5	6	7	8	9
1	River sediment load to the Black Sea	0,00396	0,033	0,95	0,13 (км^3/y)	1,65	300,000 km^3 - Black Sea volume limit minus the pycnocline dead zone	207735.0 years, taking into account the probable amount of sediment load from the Kakhovka reservoir

*)The average rate of sediment load in the Black Sea calculated since its existence - 7000 years;

**) Z - statistical resistance margin, determined by reliability level P>0.95

The pollution of the Black Sea is primarily caused by rivers carrying domestic and stormwater runoff from populated areas, runoff from watersheds, discharge of wastewater from industrial facilities, and pollution related to tourism in the summer and autumn seasons. One of the largest sources of pollution in the sea is the Dnieper River, which is one of the longest European rivers and flows through the territories of three countries. Numerous industrial and agricultural facilities, cities, and smaller settlements are polluting the Dnieper with various waste products, which has taken on catastrophic proportions in recent years. To this day, traces of radioactive contamination from the Chernobyl nuclear disaster continue to be found in its waters.

According to research by scientists from the Lancet Commission on Pollution and Health, over 9 million premature deaths per year are caused by pollution in the World Ocean. This is one of the most important but still poorly studied and not universally recognized problems, the scale of which is yet to be fully assessed. The ocean is filled with toxic metals, plastics, industrial and pharmaceutical chemicals, oil, urban and industrial waste, pesticides, fertilizers, and sewage. More than 80% of these substances enter the ocean through atmospheric deposition and direct discharges, while the remaining 20% come from ships and offshore platforms. The effects of human activity are visible along the coastlines of low- and middle-income countries, but this problem knows no bounds—pollution can be found far beyond national jurisdictions, in the open ocean and near uninhabited islands. Trash, mercury, and toxin-contaminated fish have even been discovered in the deepest point on Earth—the Mariana Trench, at a depth of 11,000 meters.

According to the Portnews agency, 23% of all Russian oil, 74% of Kazakh oil, and 65% of Azerbaijani oil is exported via the Black Sea. Therefore, the Black Sea basin is polluted with heavy metals, oil, and oil products, as well as garbage and chemical waste. According to the "Marine Red Book," the Black Sea ranks high in terms of the amount of oil product discharge into it (research on water pollution by petroleum products).

Studies by ecologists have shown that the water in the Black Sea is polluted with iron and oil to levels exceeding permissible norms by four times. Specifically, there is a fourfold excess in iron concentration and a 1.2 to 1.8-fold excess in oil and oil product concentration. Currently, about 160 species of fauna in the Black Sea are at risk of extinction. Intensive shipping and the popularity of Black Sea resorts also contribute to worsening the overall unfavorable environmental situation. The water in the Black Sea is unique: 87% of its volume consists of hydrogen sulfide-saturated water, which is deadly to all living organisms. It could become unsuitable for marine life within 20 years. Anthropogenic pollution of the marine environment is currently significant, and the marine ecosystem is under substantial stress and unable to self-purify. Improving the ecological state of the Black Sea can be achieved through various measures, including reducing discharges, upgrading wastewater treatment facilities, raising environmental awareness among the population, and implementing legislative and policy measures. The current situation of Black Sea pollution highlights that individual countries are the contributors to this pollution, and the resulting damage affects all countries in the region. Therefore, systematic international control and planning for the rational use of natural resources and environmental protection are required. The effectiveness of these measures is related to the determination of the amount of economic and social damage to society and nature. At the same time, economic and social damage should be understood as losses in the economy and society, directly or indirectly related to anthropogenic impact on nature and expressed in environmental pollution by all kinds of pollutants, including aggressive toxic substances, noise, electromagnetic and other impacts.

Calculation of economic efficiency of capital investments in protection of water area from pollution can be calculated in the first approximation by the formulas:

$$NPV = \sum_{k=1}^{n} \frac{P_k}{(1+r)^k} - \sum_{j=1}^{m} \frac{IC_j}{(1+i)^j}; \quad (4)$$

$$\sum_{k=0}^{n} \frac{CF_k}{(1+IRR)^k} = 0\,, \qquad (5)$$

where: NPV - Net present effect (mln. monetary units); IRR - Internal rate of return, %; P_k - Annual amount of prevented damage, (mln. monetary units); IC_j - Capital investments in environmental protection measures (mln. monetary units); r - Discount factor.

The calculation of economic efficiency of investments in environmental protection measures in the Black Sea area has shown their high efficiency. Thus, the net present value (NPV) calculated per one million monetary units of national income of the countries of the coastal basin for ten years of its accumulation amounted to 63.0 million monetary units, and the internal rate of return (IRR) of 22%.

CONCLUSIONS

Preservation of the Black Sea ecosystem is possible with careful attitude to it, implementation of a set of measures including technical, organizational, educational, etc. activities. This problem requires constant monitoring and search for new solutions.

The current pollution situation in the Black Sea shows that the polluters of the water area are usually individual States; the damage caused by this pollution extends to all countries in the region. Therefore, systematic international control and planning for the rational use of natural resources and environmental protection is required.

The economic efficiency of investments in environmental protection measures in the Black Sea area is characterized by a high net present value (NPV) and internal rate of return (IRR).

REFERANCE

1. Iordanishvili, I.K., Vartanov, M.V., Iordanishvili, K.T., Potskhveria, D.Sh. Global warming and the sea level regime of the Black Sea. 4th International Scientific and Technical Conference, 27-30 September, Tbilisi-2014, pp. 102-114.
2. Iordanishvili, I.K., Iordanishvili, K.T., Khosroshvili, E.Z., Khubulava, I.V. Problems of anthropogenic climate change. Ecological systems and devices, 05, Moscow 2009, pp. 55-57.
3. Mirtskhulava, T.E. Hazards and risks in some water and other systems. Types, analysis, assessment. Tbilisi, Metsniereba-2003 (in two books), 537 p.
4. Gavardashvili A. Research of ecological parameters of the Black Sea based on multimedia databases. Tbilisi, 2017, 147 p. UDC(UAC) 551.46(262.5) + 574(262.5) G-15.

CERTAIN PRINCIPLES FOR CALCULATION OF ECONOMIC DAMAGE CAUSED BY MUDFLOWS AND LANDSLIDES

M. Vartanov[1)], E. Kechkhoshvili[1)], N. Beraia[1)], M. Macharashvili [1)], L. Toklikishvili[1)], M. Shogiradze[2)]

[1)] Ts. Mirtskhulava Water Management Institute of Georgian Technical University
60[b] Chavchavadze Ave., 0179, Tbilisi
[2)] Georgian Technical University
77 Kostava str., 0168, Tbilisi
E-mail: v.martin.hm@gmail.com

INTRODUCTION

The disasters, caused by mudflows and landslides, as a rule, are characterized by extremely serious results and entail not only violation of population's normal business, but also casualties, ruining and destruction of material values, infrastructure, established natural eco-systems.

As a result of the landslide and mudflow event in Shovi mountain resort, Georgia, 31 people are dead, two are gone missing (the data as of August 25); bridges are ruined and the Shovi access road is damaged. Rescuers and police removed from the disaster zone more than 200 people by helicopters.

The Shovi tragedy, unfortunately, is not a local or episodic event. Mudflows and landslides are serious problem faced by the entire world.

MAIN PART

As a result of climate changing during the last ten years, disasters caused by mudflows and landslides have become more frequent in the world. As examples can serve the natural calamities of the year 2017: December 23 – in Philippines, September 1 – in Kabardino-Balkaria, August 8 – in China, April 19 – in Columbia, causing many cases of death. In 2016 Kirgizia was simultaneously attacked by several mudflows.

On June 13, 2015, in Tbilisi (Georgia), drastically increased level of precipitation caused landslide, the landslide mass blocked the Vere River bed and created the mudflow, which resulted in serious harm for the city. In 2014 mudflows, landslides and floods inflicted great damage to various regions of China, Tajikistan and USA.

This tragic list of disasters caused by mudflows and landslides can be endlessly extended. The given examples show the necessity to create the methodology for determination of the damage caused by mudflows and landslides. As a consequence, it should be mentioned, that the technological equipment becomes useless (if not washed away by the flow). In the case of mudflows and, especially, of landslides, if such equipment is only damaged by mud, while the disaster results liquidation works, it is damaged to such extent, that it can never be restored.

Generally, the damage caused by the mudflow and landslide can be defined by the formula:

$$D_i(t) = \int_{y_1}^{t_2} d_i dt \qquad (1)$$

where d_i is i-object damage, equal

$$d_i = K_1 + K_2 + K_3,$$

K_1 - balance cost of the i-object's destroyed part;

K_2 - capital cost of restoration of the i-object's destroyed part;

K_3 - structure restoration cost.

Damage of industrial objects can be defined by the formula:

$$D_{in}(t) = \int_{y_1}^{t_2} d_i dt \quad (2)$$

where d_i is i-object's damage, equal

$$d_i = d_1 + d_2 + d_3 + d_4 + d_5 + d_6$$

d_1 - the damage caused by destruction and destroying of industrial equipment;

d_2 - the damage caused by destruction and destroying of industrial and non-industrial buildings-structures;

d_3 - the costs of restoration-repairing of industrial buildings-structures, replacement of destroyed equipment and repairing of damaged ones;

d_4 - the costs of restoration-repairing of non-industrial buildings-structures, replacement of destroyed equipment and repairing of damaged ones;

d_5 - the damaged caused by destruction of raw materials, supplies and non-realized final products;

d_6 - he damages caused by the industry downtime due to the disaster.

Ecologic-economical damage in resort-recreation, village and forestry is expressed by destruction of resort-recreation infrastructure, agricultural and forest areas, perennial plants and death of animals, destruction and destroying of agricultural machines and equipment. The caused damage can be calculated using the formula:

$$D_{ec}(t) = \int_{y_1}^{t_2} f(d_r + d_p + d_a + d_f)dt \quad (3)$$

where d_r is the damage of the resort and recreation zones;

dp - the damage of the plant-growing branches;

da - the damage of the animal husbandry and fisheries;

d_f - the damage of forestry.

The damage of the resort and recreation zones means the damage caused by damaging and destroying of the spa buildings-structures and destruction of recreation facilities and the cost of their restoration-repairing. The damage caused to the environment is calculated as the forestry damage.

The damage of the plant-growing branches means loss of agricultural annual and perennial crops, the cost of restoration of agricultural land productivity, replacement of destructed perennial plats with new ones, restoration-repairing of damaged agricultural machines and equipment.

The damage of animal husbandry and fisheries means the damage caused by killing of animals and destruction of fish, the expenses incurred for restoration of the animal and fish population, the cost of restoration and repairing of the animal husbandry structures, restoration and repairing of the fish pool structures, initiating of sanitary-epidemiological measures.

The forestry damage arises as a result of washing away of the forest areas, decreasing their productivity, the cost of forest restoration.

The damage of the communal service is defined by the formula:

$$D_{com}(t) = \int_{y_1}^{t_2} f(d_1 + d_2 + d_3 + d_4 + d_5 + d_6)dt \quad (4)$$

where d_i is the damage caused by destroying of damaging of the residential fund;

d_2 - the cost of construction and repairing of the residential fund;

d_3 - the cost of the damaged public transport repairing;

d_4 - the cost of the road infrastructure restoration;
d_5 - the cost of green plants planting and improvement;
d_6 repairing of the potable water infrastructure.

Besides, the general damage shall involve the cost of search and rescue operations (C_1), evacuation of the population (C_2) and disaster results liquidation (C_3) works:

$$D_{liiki}(t) = \int_{y_1}^{t_2} f(C + C_2 + C_3)dt \quad (5)$$

The economic efficiency of anti- mudflow and landslide measures is defined by the formula:

$$NPV = \sum_{k=1}^{n} \frac{P_k}{(1+r)^k} - \sum_{j=1}^{m} \frac{IC_j}{(1+i)^j} \quad (6)$$

The IRR implies the value of the discount coefficient (*r)*, for which *NPV = f(r)* = 0. If we get $IC_J = CF_I$, the IRR can be calculated from the functional connection:

$$\sum_{k=0}^{n} \frac{CF_k}{(1+IRR)^k} = 0 \quad (7)$$

where *NPV* is the net present value (mln GEL);
IRR - internal rate of return (%);
P_K - annual value of the avoided damage (mln GEL);
IC_J - capital investments in environment protection measures (mln GEL);
r - discount coefficient;
i - expected average level of inflation.

As an example, there is given the calculation of economic efficiency of the anti- mudflow structure innovative design of Ts. Mirtskhulava Water Management Institute of Georgian Technical University.

The calculation has shown that the 20-year operation of the structure using IRR 42% allows accumulation of the NVP in the amount of GEL 87,6, which indicates high economic efficiency of capital investments in protection of the country territories against natural calamities.

CONCLUSIONS

To minimize the number of casualties as a result of mudflows and landslides it is necessary to establish the population early warning system against possible mudflow and disastrous landslide; construction of new residential buildings and recreation-resort facilities to be categorically prohibited in the hazardous mudflow and landslide zones, construction of the structures causing additional load for the ground to be restricted.

In the hazardous mudflow directions, there should be constructed a system of anti- mudflow structures which will minimize the destructive outcomes of the dangerous natural event.

REFERANCES

1. **Vartanov M., Kukhalashvili E., Beraia N., Maisaia L. Economic Efficiency of Debris-Flow Control** American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) ISSN (Print) 2313-4410, ISSN (Online) 2313-4402 **(**2019) Volume 57, No 1, pp. 22-28;
2. **Gavardashvili G., Vartanov M.** Methods to calculate the social-economic damage caused by floods Development of Management and Entrepreneurship Methods on Transport, UDK 333.1:574(571.56) JEL L 90, M 21 DOI 10.31375/2226-1915-2020-3-5-11 № 3 (72), 2020, pp. 6-11;
3. **Gavardashvili G., Vartanov M.** Engineering and technical structures of the Zhinvali hydroengineering complex and assessment of the state of their management PRODUCTION ENGINEERING ARCHIVES 2023, 29(1) ISSN 2353-5156 (print) ISSN 2353-7779 (online), pp. 37-43.

PROSPECTS Of THE ECONOMIC SIGNIFICANCE Of ECOLOGICAL TOURISM IN THE AREAS Of RARE PLANTS DISTRBUTION

G. Yeghiazaryan, A. Hambardzumyan, N. Aloyan
Department of Water and Land Resources Management,
Armenian National Agrarian University, Yerevan, Armenia
E-mail: sfwmzc@yahoo.com

INTRODUCTION

The mountain-meadow zone includes Ararat, Aragatsotn, Gegharkunik, Lori, Kotayk, Syunik, Vayots Dzor, Tavush, Shirak regions of the administrative territory of RA. There are many resources for the socio-economic and environmental development of this area, but it is necessary to explore alternative innovations to promote and support the development of these territories. Visiting the distribution areas of rare plant species can be attributed to one of the important areas for the development of ecotourism. For a visual and geographical display of the distribution areas of rare plant species, the following plant species (GIS) of the environment are mapped in geographic information systems, the same map is compared with the PA layer in order to it was clear what arrangement the studied plant species have in relation to various historical and cultural plants, places and objects at the preparatory stage of research on the example of the Armavir Marz (highlighted in pink) it was shown that there are no plants in the mountain meadow zone (above 1800m), but there are specially protected territories in Armavir marz where insects live (Ararat cochineal). In ancient times, the Armenians received a paint with the same name, and the country was named scarlet in honor of this paint. The results of digital mapping of the protected areas of the Republic of Armenia in combinationwith the distribution of rare plant species of the mountain-meadow zone in the ArcMAP system are presented in Fig.1.

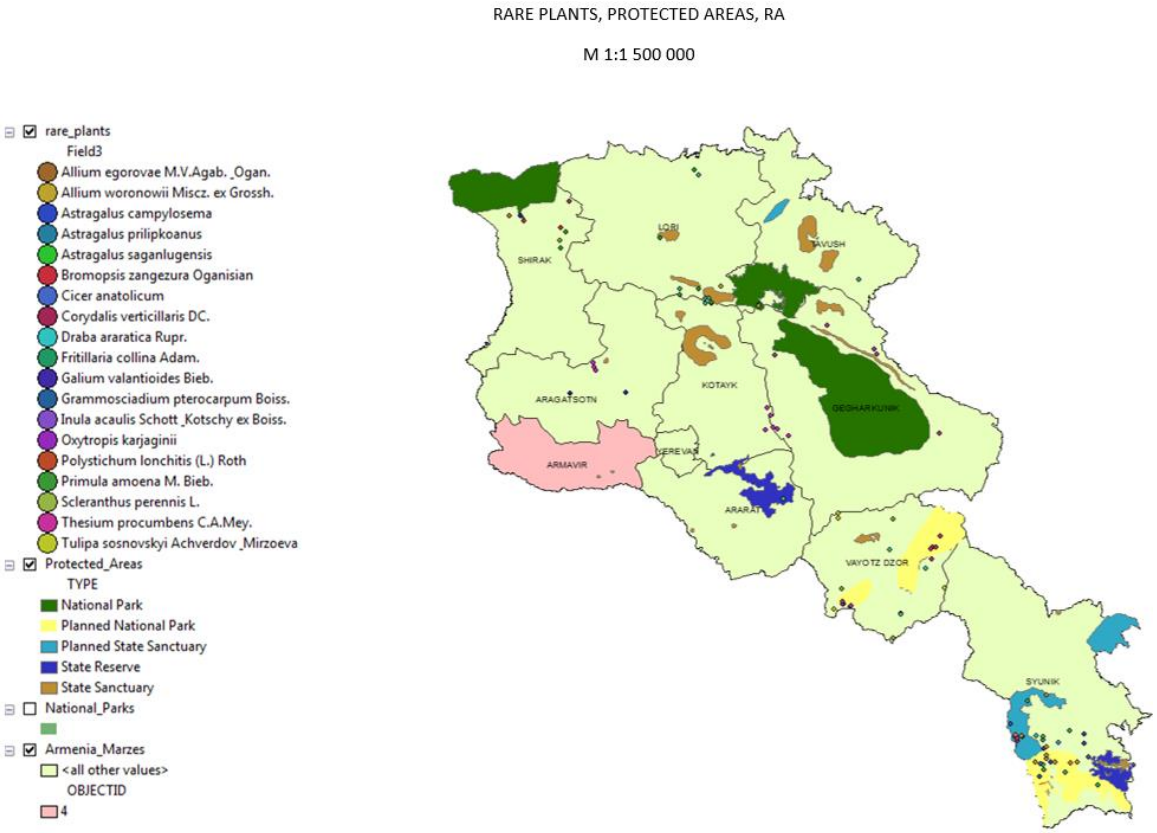


Figure 1. Results of digital mapping of Specially Protected Natural Territories of the Republic of Armenia of rare plant species in the mountain meadow zone in the ArcMAP system

MAIN PART

It is clear that ecotourism, based only on the observation of rare plant species, is unlikely to give a sufficient economic result, but if it is combined with cultural, educational, environmental, historical, everyday fundamental approaches of communities, then the number of visitors to these objects can reach sufficient volumes, to contribute to the individual sustainable economic development of communities [8], [9], [10].

The material of the study is the mountain-meadow zone of the Republic of Armenia, at an altitude of 1800-3000 m, according to biodiversity data, 452 plant species were selected from the Red Book of the Republic of Armenia, 47 plant species with the smallest number of locations were selected, and more than 20 species of rare plants were mapped and located in an ArcGIS environment. The results of their placement and digital mapping are presented in (Fig. 1) [1], [2].

The research method consisted in comparing the results of digital cartography with the settlements of the mountain-meadow zone, land owners, land designation and land ownership entities.

The paper highlights the territories occupied by rare plant species of Vayots Dzor (Table1) and Syunik (Table 2) of the 2 regions of the Republic of Armenia and the historical and cultural places surrounding them.

Table 1

Rare plants of Vayots Dzor region [3], [4]

№	***Rare plant***	*Locality*	*Height above sea level*
1	Astragalus prilipkoanus Grossh.	3	1000–2500
2	Cicer anatolicum	5	1800–2550
3	Allium woronowii Miscz. ex Grossh.	4	1800– 2300
4	Astragalus saganlugensis	2	1800-2700
5	Oxytropis karjaginii	3	1200-1400
6	Inula acaulis Schott & Kotschy ex Boiss.	4	2300-2800

Table 2

Rare plants of Syunik region [3], [4]

№	***Rare plant***	*Locality*	*Height above sea level*
1	Astragalus prilipkoanus Grossh.	3	1000–2500
2	Cicer anatolicum (Chickpea)	5	1800–2550
3	Polystichum lonchitis (L.) Roth	2	2200-3000
4	Astragalus saganlugensis	2	1800-2700
5	Corydalis verticillaris DC.	4	1900-3100
6	Tulipa sosnovskyi Achverdov & Mirzoeva	5	700-2300
7	Bromopsis zangezura Oganisian	5	1500-3200
8	Allium egorovae M.V.Agab. & Ogan.	1	2300

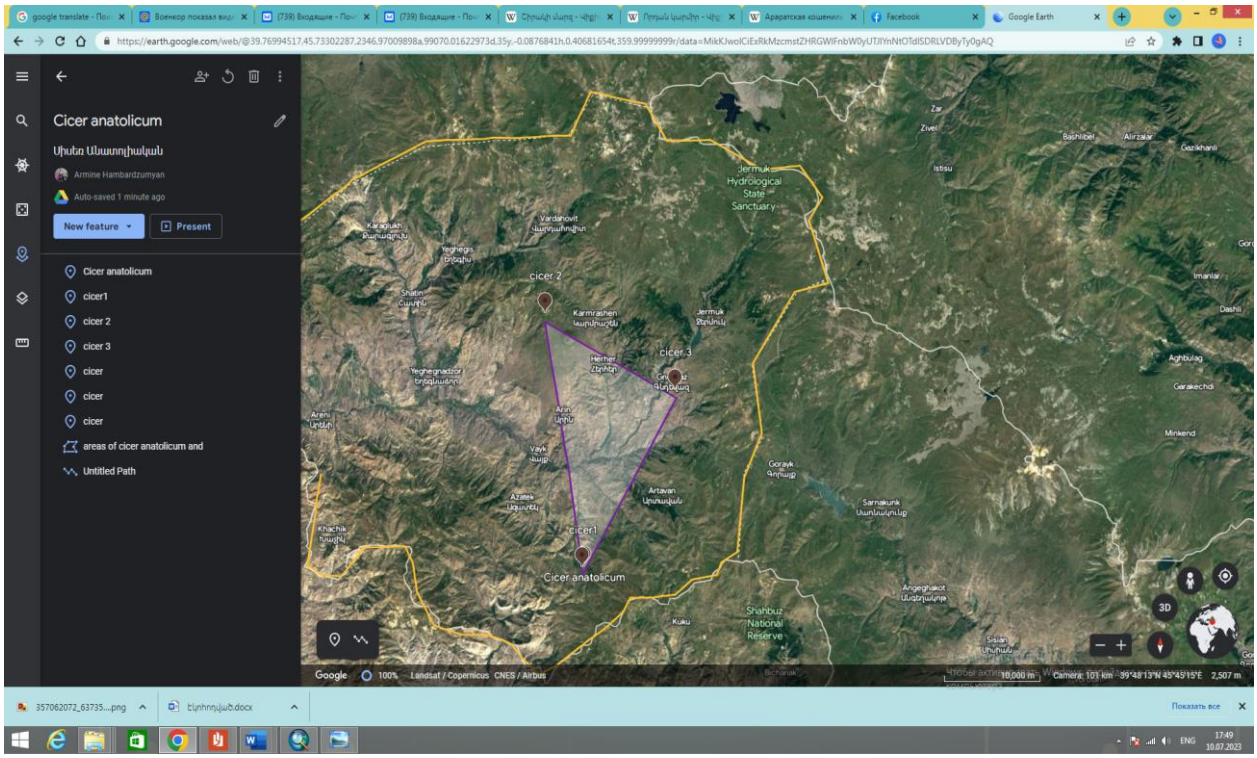


Figure 2. Results of digital mapping of a rare plant species of the mountain-meadow zone of Cicer anatolicum in the Google Earth system [12]

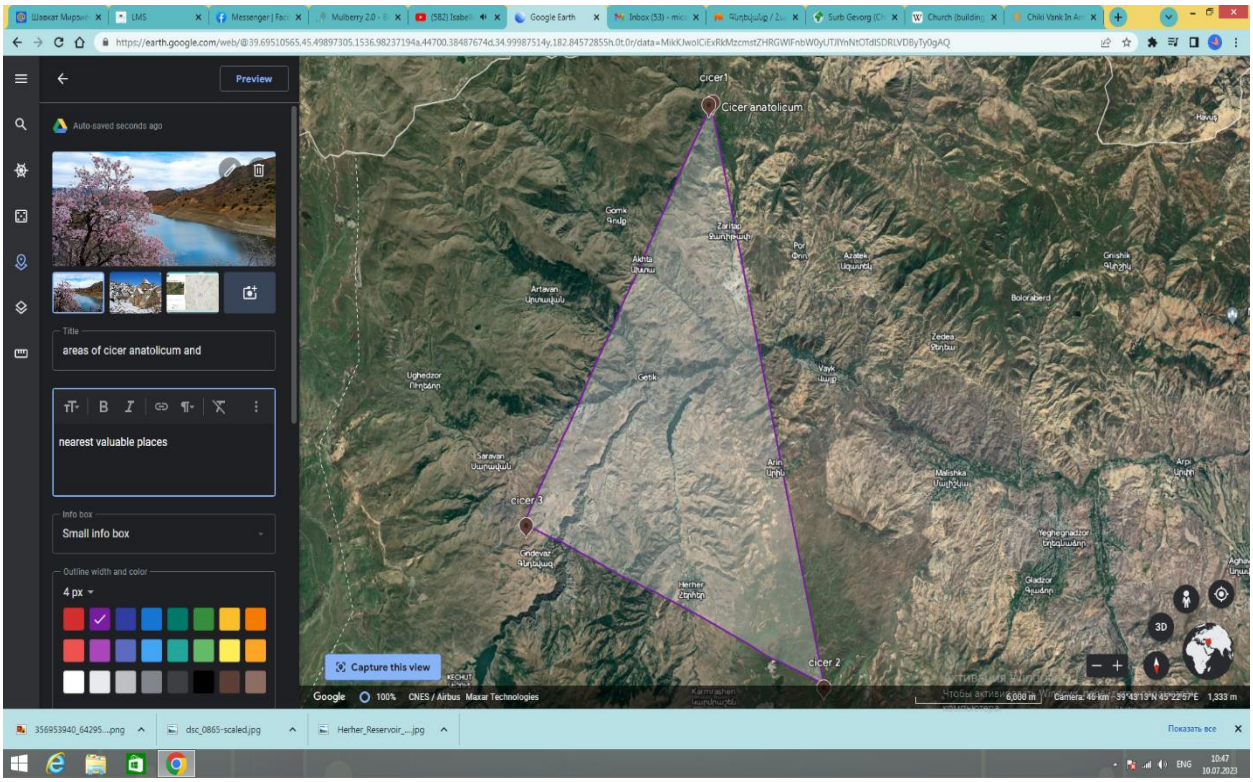


Figure 3. Valuable and picturesque places of Vayots Dzor region in the Google Earth system around the Cicer anatolicum, a rare plant species of the mountain meadow zone [12]

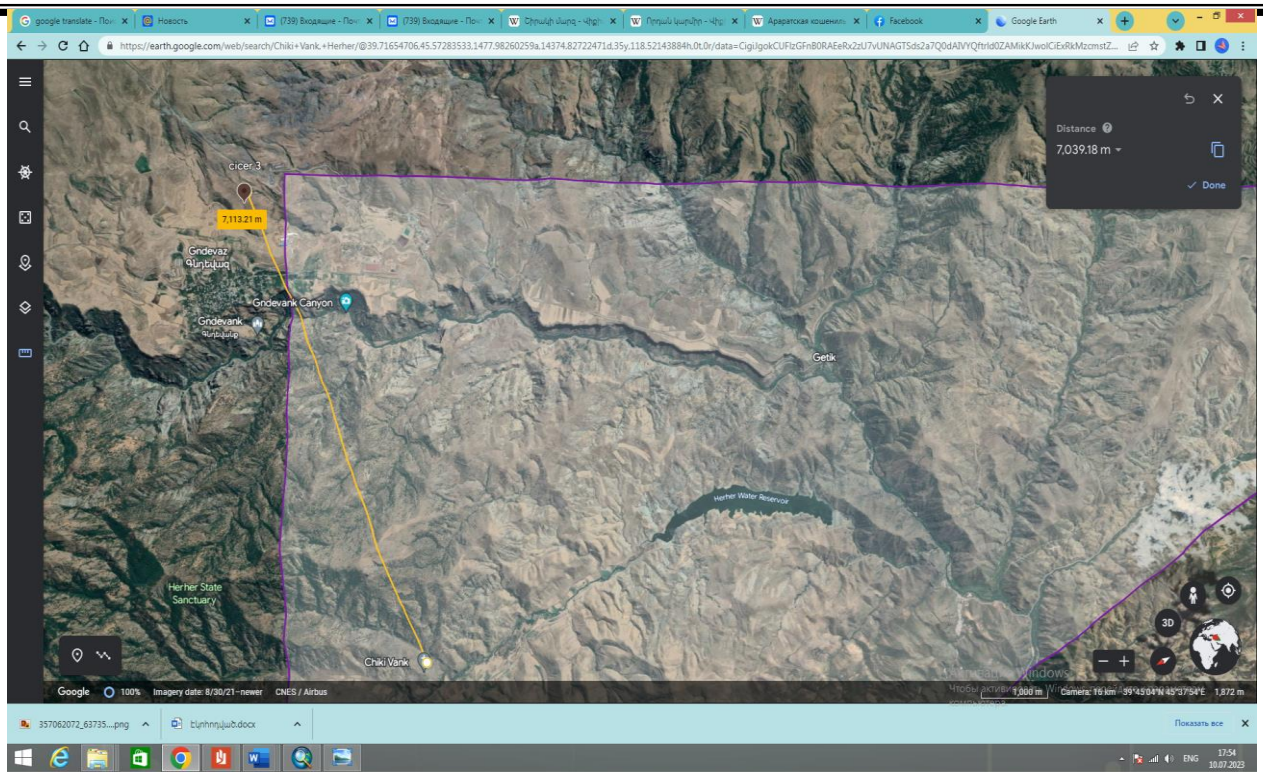


Figure 4. Cicer anatolicum, a rare plant, is located at a distance of 7113 m northeast of the Vayots Dzor Church of St. Gevorg or Chiki Monastery in the Google Earth system [12]

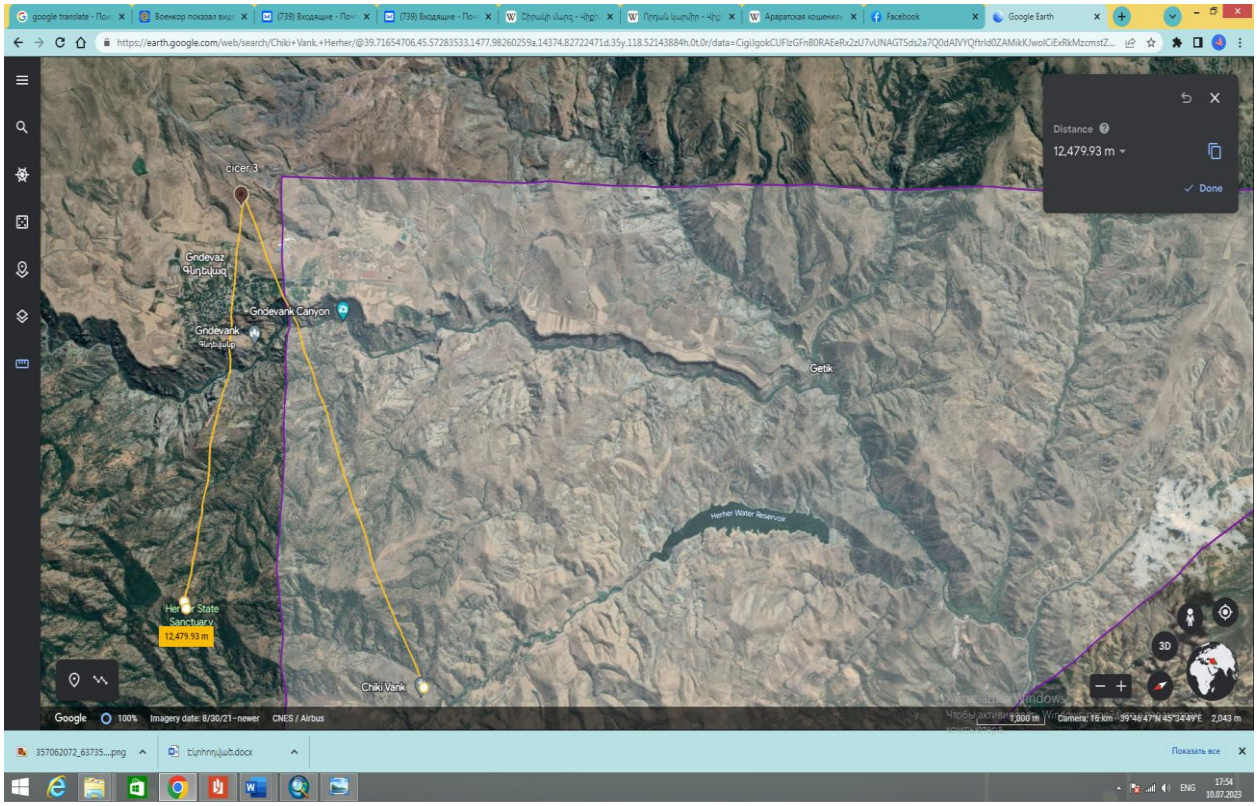


Figure 5. Cicer anatolicum, a rare plant, is located 7113 m northeast of the Vayots Dzor church of St. Gevorg, or Chiki monastery, and the Gndevank and reservoir Ger-Ger are located another 5366 m southeast of the rare plant in the Google Earth system [12]

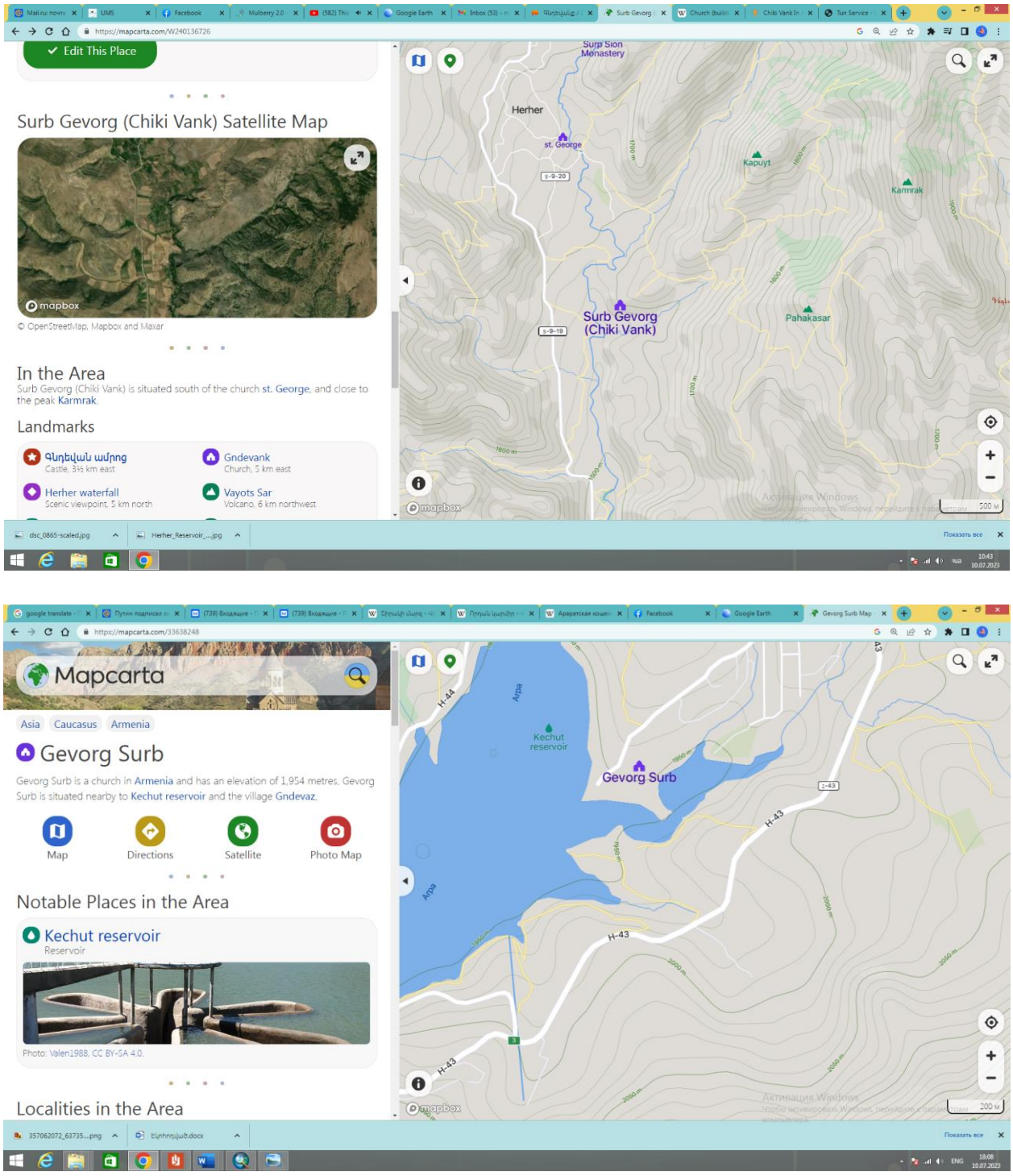


Figure 6. St. Gevorg Church in Vayots Dzor region, Mapcarta.com shows at what level it is located and what recreation areas there are around the St. Gevorg Church

The object of digital mapping, as already seen from the mapping results, is Cicer anatolicum (Table. 1), (Fig. 1), the agrobiological features and practical significance of which are as follows: chickpea is an ancient crop in Armenia, there are forms of cultivated chickpea (C.arietinum L.) belonging to different geographical groups [6], [7]. Only the number of varieties is 51, in addition, several dozen more forms by ecotypes are indicated, which are characterized by the shape of seeds, color, etc. The shape of the seeds is very variable. In arid conditions, the main part of chickpea seeds is angular, with a thick skin, in wet conditions it is pea-shaped, with a thin skin. Local chickpeas in Armenia are very diverse, many of them are endemic and are of great value as breeding raw materials. Unfortunately, local forms of chickpeas are

currently less common in cultivation. Wild chickpea species (C. minutum Boiss. et Hohen and C. anatolicum Alef.) also grow in Armenia, which also confirms that this region should be considered as one of the centers of chickpea genealogy and development. C. anatolicum is a rare species found in isolated places in the Khosrov State Reserve, Daralagyaz and Meghri floristic regions. C. minutum Boiss is also a rare species of great scientific importance, growing on the outskirts of the alpine zone of Daralagiaz. The challenge is to conserve and use the rich gene pool (Fig. 2), (Fig. 3), (Fig. 4), (Fig. 5).

The next object of research was very valuable and beautiful plants of the Syunik region, the national park, the Shikahogh reserve (Table. 2), (Fig. 7).

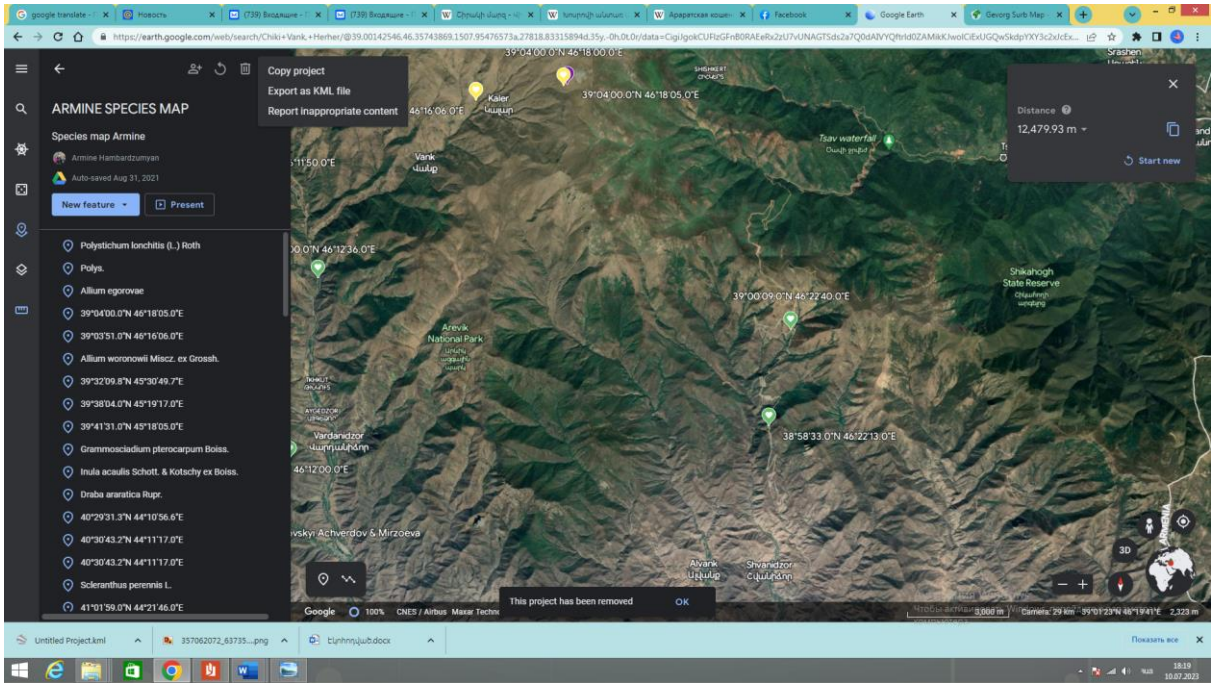


Figure 7. In the national park of the Syunik region, in the Shikahogh reserve, in the vicinity of which the waterfall Tsavi, Alvank, Shvanidzor are located, there are many valuable and beautiful plants that are the best examples of wildlife and tourism [12]

Using the site data-download-gfw.hub.arcgis.com, the river network of the study area was mapped and supplemented with tabular data, in particular, for the development of water tourism [13].

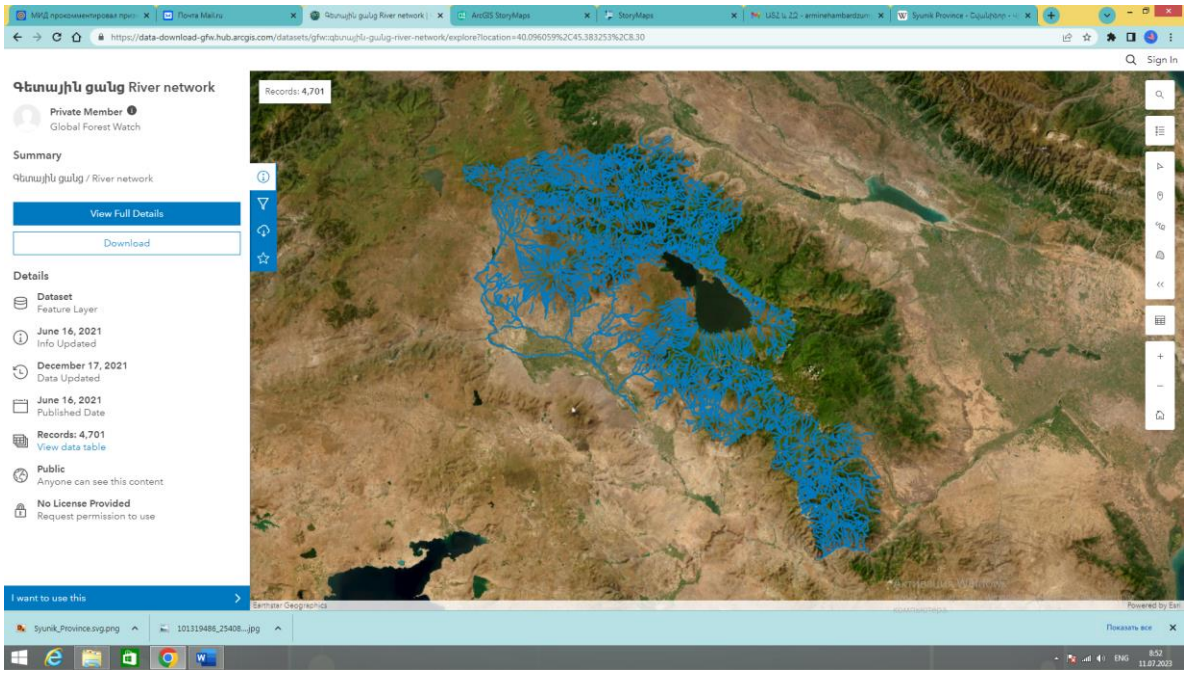


Figure 8. River network of RA in Santa data-download-gfw.hub.arcgis.com

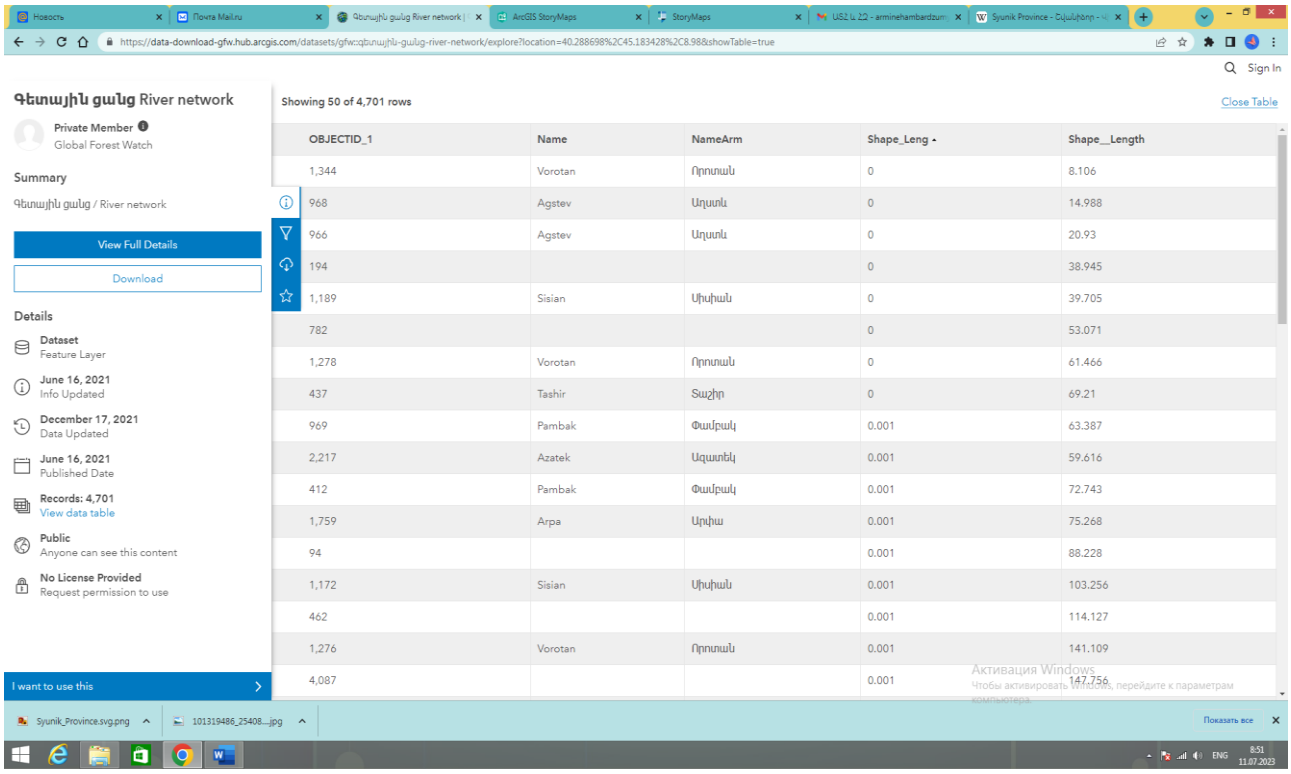


Figure 9. River network of RA in Santa data-download-gfw.hub.arcgis.com in the form of a table [13]

With the help of storymaps, it was possible to map the historical information of individual objects using pictures and develop it in order to promote tourism in the region [11].

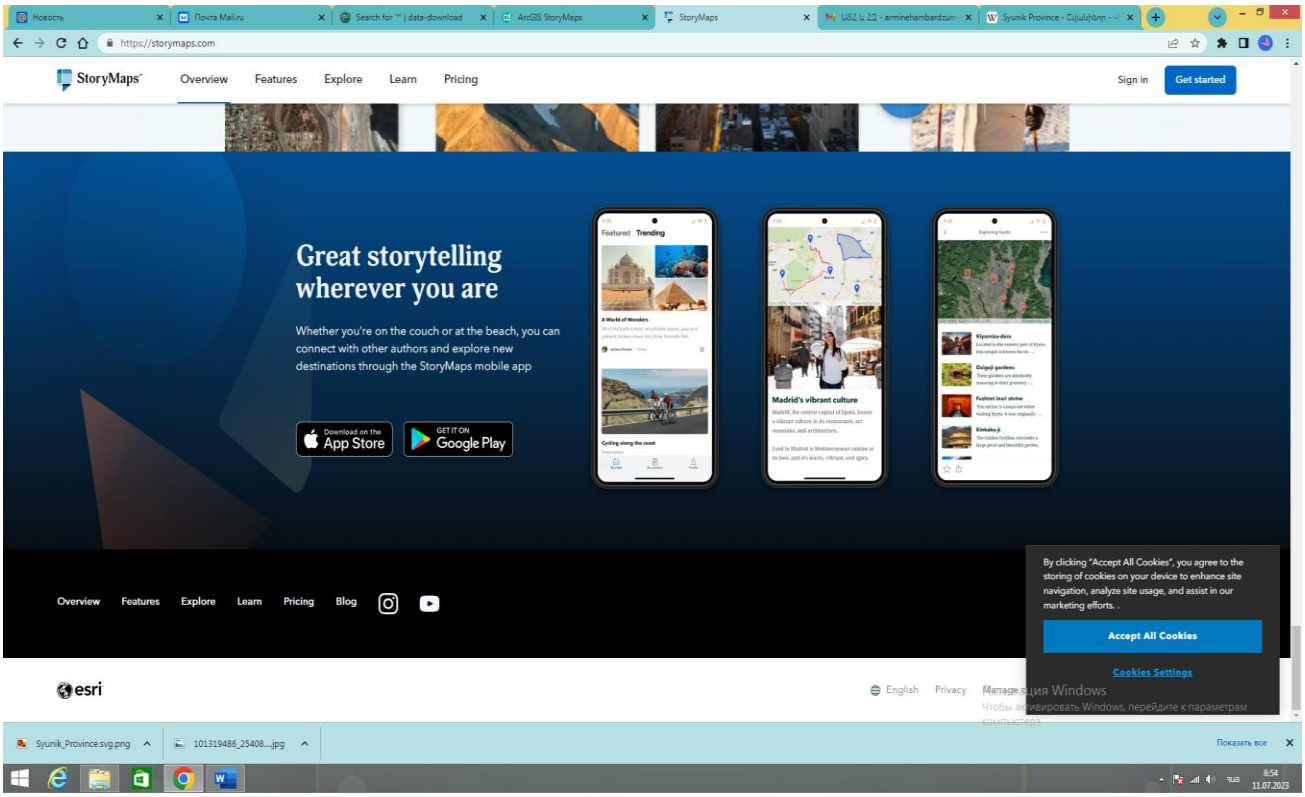


Figure 10. https://storymaps.arcgis.com/

CONCLUSIONS

The study allows us to conclude that in order to preserve wildlife, develop activities that promote a healthy lifestyle for people, spread ecotourism, motivate the local population and generate economic profit, the created maps can help organize these activities more efficiently and for socio-economic sustainable management. Ecotourism is often considered an economic alternative for rural areas facing declining profits [5]. Ecotourism contributes to the conservation of ecologically sensitive areas, benefits the economy of local communities, provides the population with an educational experience based on nature, and introduces visitors to the local culture. Unlike mass tourism, nature tourism is characterized by individuality, a small number of tourist groups and a territorially dispersed provision of services, which makes it difficult to assess economic and regional development [10]. Nature tourism is already playing a role in supporting the lives of people in peripheral, rural areas and providing valuable additional jobs in regions suffering from severe structural unemployment.

REFERANCE

1. Yeghiazaryan, G. M., Hambardzumyan, A. M. (2021). The problems of effective management of rare plant species on the example of the mountain meadow zone: Scientific bulletin of Shirak State University after M.Nalbandyan, 2021, 66-73. https://doi/ 10.54151/27382559-2021.2a-66 (in Armenian).
2. Hambardzumyan A. M. (2023). Mapping of rare plant species in the mountainous zone of Kotaik and Gegharkunik regions in GIS environment: Agricultural science and technology, National Agrarian University of Armenia, 2023, Vol.1(81), 42-48, anau.am/scientific-journal: https://doi./ 10.52276/25792822-2023.1-42, hambardzumyan.pdf (anau.am) (in Armenian).
3. Red book of RA plants, (2023), [Online]. Available: http://env.am/karmir-girq [Accessed July 11, 2023].
4. Free and open access to biodiversity data, (2021) [Online]. Available: https://www.gbif.org/ [Accessed September 17, 2021].
5. Fundamentals of tourism, (2014). Under the scientific editorship of Doctor of Law Pisarevsky, E.L., [Online] Available: http://library.shsu.am/wp-content/uploads/2018/05/osnovy-turizma.pdf. [Accessed July 11, 2023] (in Russian).
6. The structure and life activity of plants, (2020), [Online]. Available: https://znanio.ru/ [Accessed July 11, 2023] (in Armenian).
7. The flora of Armenia [Online]. Available: https://www.armgeo.am/flora-of-armenia/ [Accessed July 11, 2023].
8. Marwa, M. Abdel-Fadeel; Samar, K. Saad and Souad Omran (2013). Conference of Egypt-Thailand Relations: Lessons in Business and Social & Cultural Development, February 3, 2013, Volume: 6th., [Online]. Avalible: (PDF) Opportunities and challenges of using GIS in sustainable tourism development: the case of Egypt (researchgate.net) [Accessed July 11, 2023].
9. Verka Jovanović, Angelina Njeguš, (2008). Yugoslav Journal of Operations Research,Vol 18 (2008), Number 2, 261-272. January 2008 [Online]. Avalible: (PDF) The Application of GIS and its component in Tourism (researchgate.net)., DOI: 10.2298/YUJOR0802261J [Accessed July 11, 2023].
10. Afanasyeva, A.V. (2020). Foreign experience in ecological tourism management: trends and development models [Online]. Available: https://cyberleninka.ru/article/n/zarubezhnyy-opyt-upravleniya-v-sfere-ekologicheskogo-turizma-trendy-i-modeli-razvitiya/viewer [Accessed July 11, 2023].
11. For organizations and specialists in the field of GIS [Online]. Available: https://storymaps.arcgis.com/ [Accessed July 11, 2023].
12. Google's project, within the framework of which satellite images of the entire earth's surface were placed on the Internet (2001) [Online]. Available: https://earth.google.com/ [Accessed July 11, 2023].
13. Open data portal of Armenia [Online]. Avalible: https://data-download-gfw.hub.arcgis.com/ [Accessed July 11, 2023].

ABSTRACTS

Management of water resources

GIS TECHNOLOGIES IN THE ASSESSMENT OF THE MORPHOMETRIC PARAMETERS OF THE MOUNTAIN RIVER

A. Arifjanov, D. Atakulov, U. Vokhidova, M. Osmonova
National research university "Tashkent institute of irrigation and agricultural mechanization engineers"
Tashkent, Uzbekistan

The article presents the results of the research on erosion and accumulation processes in the foothills of the river. Sox stream was selected as the research object. Relationships of morphometric parameters in the Sox stream were studied on the basis of GAT technologies. Used Sentinel 2 satellite images. Downloaded images were analyzed using Arc Map software. Natural field studies were conducted in the selected part of the Sokh River in the Fergana Valley of Uzbekistan. In natural field studies, hydraulic parameters of the stream, water turbidity and morphometric parameters of the bed were measured over the years. Based on the statistical analysis of the data collected in the characteristic plots during the researches, the graph of the dependence of the width of the flow level B on the water discharge Q was constructed Q=f(B). Using GIS technologies, the surface of the stream level was determined by the normalized difference index of water NDWI. The obtained results were compared with existing methods. As a result, it is possible to use GIS technologies to evaluate the morphometric parameters of the riverbed in the mountain river. The changes taking place in the river bed are analyzed and conclusions are presented.

Key words: GIS, Sentinel, satellite, river, map, channels, flow, water consumption, image analysis, morphometry.

Hydraulic Engineering

DETERMINING THE AVERAGE DIAMETER OF SEDIMENTS TRANSPORTED BY THE DEBRIS FLOW

Q. Dadiani, I. Qufarashvili, M. Mghebrishvili, L. Maisaia, N. Nibladze
Ts. Mirtskhulava Water Management Institute of Georgian Technical University
Tbilisi, Georgia

The article presents the results of field scientific expedition research and determines the average diameter of sediments transported by the debris flow. The scientific research of the riverbed was carried out in the territory of Mtskheta Municipality, particularly, in the Monastic ravine, nearby the Shiomghvime Monastery Complex.

Key words: Sediments, debris flow, granulometry, gradation, integral curve.

Hydrology – meteorology

CLIMATE CHANGE-INDUCED DISASTERS AND THEIR PREVENTION

R. Diakonidze, J. Phanchulidze, L. Tsulukidze, I. Kvirkvelia, K. Dadiani, N. Nibladze, M. Glunchadze
Ts. Mirtskhulava Water Management Institute of Georgian Technical University
Tbilisi, Georgia

The scientific article showcases the findings from natural field studies, discusses the predictive value of maximum water costs based on field studies conducted in Sighnaghi municipality. The study was carried

out at the monastery of St. Nino of Bodbi and on the damaged section of the road connecting Sighnaghi-Dedoflistskaro.

The study determined the predictive values of different provisions for maximum water costs on two waterways, near St. Nino Mother Monastery of Bodbi and the Sighnaghi-Dedoflistskaro highway section.

The report presents the causes of flooding, along with relevant conclusions and recommendations.

Key words: freshet, flooding, drainage, water consumption, drainage collector, catchment basin.

Hydraulic Engineering, Environmental protection

DEBRIS FLOW REGULATE ELASTIC BARRAGE (Innovation, modeling, design, construction)

Givi Gavardashvili[1,2], Eduard Kukhalashvili[1,2], Inga Iremashvili[1,2]

[1] Tsotne Mirtskhulava Water Management Institute of Georgian Technical University

[2] Ecocenter for Environmental Protection the Organization in Category of Consultative Status with the Economic and Social Council (ECOSOC) of UN

Tbilisi, Georgia

The article presents the whole cycle of the implementation of the debris flow regulation elastic dam in practice, such as: innovation, laboratory modeling, development of scientific methodology for designing, preparation of the designing project and construction.

The scientific work was carried out under the financial support of the Shota Rustaveli National Science Foundation of Georgia Grant Project AR_18-1244 (2018-2023), and the following work was carried out - an innovative debris flow regulation structure was developed, the priority of which is certified by the Georgian patent certificate # P 2020 7068 B.

In the Hydraulic Engineering Laboratory of the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, which has 98 years of experience, a large-scale laboratory modeling of the debris flow regulation elastic dam was carried out and the hydraulic parameters of the innovative structure were determined that are used for developing the structure designing methodology.

Using the topographical, hydrological, and other main characteristics of the Mletis Khevi river and the computer program "Lira Sapr 2019" (License Number 1/7165), the optimal sizes of the debris flow control elastic dam and foundation were calculated.

With the help of the developed detailed design project, in September-October 2022 the structure was built in the bed of the Mletis Khevi river, and in the summer of 2023 the structure operated effectively under the first dynamic debris flow load.

***Key words*:** Mleta River gorge, Debris flow, Debris Flow Regulating Elastic Barrage.

Environmental protection

FORMATION OF WATER QUALITY SELF-CLEANING PROCESSES IN THE ISANI-SAMGORI FILTER STATION OF THE TBILISI RESERVOIR

K. Iordanishvili[1)], I. Iordanishvili[1)], K. Bziava[1)], N. Kandelaki, T. Supatashvili[2)], G. Omsarashvili[1)], E. Khosroshvili[1)], D. Potskhveria[1)], L. Bilanishvili[1)]

[1)] Ts. Mirtskhulava Water Management Institute of Georgian Technical University

[2)] University of Georgia

Tbilisi, Georgia

The article discusses the dynamics of the chemical composition of water in the Isani-Samgori filter station of the Tbilisi reservoir, taking into account the water change and morphological indicators of the deep water period. The main chemical indicators of water are compared to allowable normative indicators.

Key words: Tbilisi reservoir, water chemical indicators.

Earth Sciences

REASONS, PREDICTIONS AND PROBLEMS OF EXTREME EVENTS AND PREVENTION

L. Itriashvili[1)], E. Khosroshvili[1)], G. Kighuradze[2)]

[1)] Ts. Mirtskhulava Water Management Institute of Georgian Technical University

[2)] Ilia State University

Tbilisi, Georgia

Rivers are complex systems whose condition depends on the mutual influence of many inter-dependent climatic, hydrological and geological factors. These are connected with hydrological systems, which are presently departing from the state of thermodynamic equilibrium, and are subject to instabilities. with non-linear effects. As a consequence, the mean values of moisture reserves, river runoff, amplitude of temperature fluctuations, evaporation and other parameters are exhibiting characteristic behavior of self-excited oscillations. This paper shows that use of standard processing of hydrological time series of distributions from the exponential family presupposes uniform stability of the hydrological system over the entire range of its parameters, without taking into account the specificity of hydro-physical processes in the catchment area, which in definite conditions may lead to extreme phenomena. It is concluded that descriptions of multiyear fluctuations of river runoff by linear equations cannot be satisfactory from the physical point of view, as even small non-linearities in a dynamic system substantially alter the tails of distributions, and hence the assessment of the probability of catastrophes.

Key words: catastrophic floods, river basin, river runoff, self-excited oscillations, tails of distribution.

Hydro-amelioration

DETERMINING THE WATERREQUIREMENTS OF AGRICULTURAL CROPS FORTAMARSI VILLAGE OF MARNEULI MUNICIPALITY IN KVEMO (LOWER) KARTLI REGION

O. Kharaishvili[1)2)], P. Sichinava[1)], N. Mebonia[2)], M. Kikabidze[1)2)], L. Baidauri[2)], N. Sukhishvili[2)], L.Toklikishvili[1)]

[1)] Tsotne MirtskhulavaWater Management Institute of Georgian Technical University,

[2)] Georgian Technical University

Tbilisi, Georgia

The water requirements of agricultural crops under natural conditions can be satisfied by the available moisture in the soil and atmospheric precipitation, but in drought periods, this amount is often not enough, and therefore irrigation is necessary.

For agricultural crops, it is important to determine the irrigation mode correctly. For estimation of water supply, Prof. G. Selianinov's method was used. The need for irrigation was determined for Tamarisi village of Marneuli municipality, soil irrigation indicators were defined and stated that values of which are significantly differ from the existing ones.

The share of the occupied area of each crop on each agricultural plot of the village Tamaris and the values of the water duty were calculated and determined, were constructed, an uncompleted water duty graph was created, which showed us the uneven distribution of water demand, as a result, after adjusting the uncompleted graph of the water duty, a complete water duty graph was created according to which the amount of water required by the village of Tamarisi, taking into consideration the irrigation periods, was defined and the water demand curve was built.

Key words: irrigation, water duty, irrigation rate, water requirement, water supply.

Hydro-amelioration

AMELIORATIVE INDICATORS OF SOILS IN THE IRRIGATION ZONE OF THE CASPIAN AND MTSKHETA MUNICIPALITIES OF THE SHIDA KARTLI PLAIN OF GEORGIA

O. Kharaishvili, E. Kechkhoshvili, F. Lortkipanidze
Tsotne Mirtskhulava Water Management Institute of Georgian Technical University
Tbilisi, Georgia

The article considers the issue of determining the reclamation indicators of soils in the irrigation zone of the Caspian and Mtskheta municipalities of the Shida Kartl Plain in order to clarify the irrigation regime. The soils of the considered zone, from the reclamation point of view, are grouped into seven categories based on the relevant experimental data. For each category, the values of ameliorative indicators are given. Based on the data obtained, the irrigation rate was determined. The minimum value of soil moisture, which determines the start date of the next irrigation, has been established.

Key words: The soil, Bulk mass, Limiting moisture capacity, Maximum molecular moisture capacity, Irrigation rate.

Earth Sciences

EFFECT OF SHEAR FORCE ON THE STABILITY OF VULNERABLE SLOPES

N. Kvashilava, I. Khubulava, I. Kvirkvelia
Tsotne Mirtskhulava Water Management Institute of Georgian Technical University
Tbilisi, Georgia

In the article, it is discussed in what cases the soil can move from the landslide-prone slope during water saturation.

It is also discussed how important the soil's grip strength is for its dry state and in the case of water saturation.

Key words: shear force, debris flow dangerous slope, slopestability.

Construction

ARTIFICIAL INTELLIGENCE AS AUTOMATION AND ROBOTISATION TOOL IN CONSTRUCTION PROCESSES

J. Niemiro-Maźniak, M. Major, I. Major
Czestochowa University of Technology
Czestochowa, Poland

Artificial intelligence is becoming a widely used tool in various areas of human activity. Its dynamic development makes the integration of AI technology in the construction industry a primary focus of research and development. Alongside the technologically advanced production of building materials and prefabricated components, robotics becomes a key element in the construction process itself. Automation and robotization in construction, involving the replacement of human labor with machines, lead to increased efficiency and reduced costs in construction investments.

The paper discusses the impact of artificial intelligence on construction, based on the technology of implementing construction processes using digital tools. Examples of effective pursuit of autonomous implementation of construction processes were indicated, reducing human work and increasing the efficiency of implementation. The characteristics of new technologies are presented and the role of machine learning in construction is discussed. Based on a literature review, examples of utilizing machine learning, including deep learning, in the construction industry are highlighted. The observed increase in the integration of advanced artificial intelligence technologies with traditional construction processes creates numerous possibilities influencing the efficiency and development of the construction industry.

***Key words**:* artificial intelligence, robotics construction industry.

Hydrology – meteorology

ANTROPOGENIC IMPACTS TO RIVERBED DEFORMATIONS – CASE STUDY AGHSUCHAY RIVER

A. Nuriyev
Baku State University
Baku, Azerbaijan

Shirvan region rivers, similar to most mountain rivers in Azerbaijan, have experienced significant changes in their depositional environment due to anthropogenic disturbances and climatic influences in recent decades. Urbanization and agricultural developments caused an increase in hydrotechnical constructions and gravel mining facilities in the river basins. However, knowledge of how the river channel and bed deformation respond to these changes is limited. This study takes the Aghsuchay river as a case study. Bathymetric and cross-sectional data were collected from 2013 to 2021 and were analyzed to address the changes in the depositional environment. The results indicate that the whole riverbed in the Aghsuchay River has been scouring after the construction of the intake facility of the irrigation canal and this trend is expected to continue in the future due to decreasing sediment supply from the upper watershed. Based on observations, approximately 3 m of vertical deformation occurred in the riverbed.

Key words: Aghsuchay river, riverbed deformation, gravel abstraction, anthropogenic impact, sedimentation transport

Environmental protection

AGRICULTURAL LANDS POLLUTEBLY CHLORPYRIPHOS – CONTAINING PESTICIDES IN GEORGIA

M. Shavlakadze[1)], G. Natroshvili[2)], L. Itriashvili[3)], K. Didebulidze[4)], A. Gujabidze[5)], Kh. Kiknadze[6)]

[1),2),3),6)] Tsotne Mirtckhulava Water Management Institute of the Georgian Technical University,
[4),5)] Agricultural University of Georgia
Tbilisi, Georgia

The pesticides used in Georgian agriculture contain a big concentration of chlorpyriphos $C_9H_{11}C_{l3}NO_3PS$- one of the most widely used organophosphorus pesticides which undergo 4 stages of metabolism when getsinto the soil. The products depleted on the 3-rd and 4-th stages – diethyl triphosphate, 3, 5, 6 tricolor 2-pyridinol – represent one of the most toxic substances. The mentioned problem is aggravated by the fact thatdue to low awareness of ecology the use of pesticides is non-regulated and is implemented with the breach ofthe dates.

Lately in Georgia on the background of intensive development of agriculture the problem of agricultural soil pollution became an urgent problem, since unregulated use of pesticides by the population became an indirect cause of many acute diseases.

At present, there are no means for effective remediation of pesticide-contaminated land resources in Georgia, and it is this information vacuum that will be filled up by the proposed research on agricultural soils contaminated with pesticides and related metabolic products that involves the bioremediation of agricultural soils contaminated with chlorpyrifos-containing preparations (Dursban) using anaerobic bacteria.

In case of implementation of studies planned in the grant project, the activity characteristics of microorganisms will be determined to achieve the biodegradation of the final toxic products of chlorpyrifos-containing pesticide metabolism, which in its turn is an innovative approach to the issue.

***Key Words*:** Chlorpyrifos, Biodegradation, Metabolites.

Hydro-amelioration, hydrotechnics

MODELS OF THE FORMATION OF WATER-AIR REGIME OF SWELLING SOILS AND THE POSSIBILITIES OF THEIR USE IN THE CALCULATION OF DRAINAGE AND OTHER MELIORATION MEASURES

V. Shurghaia, Sh. Kupreishvili, G. Vakhtangishvili, L. Kekelishvili, S. Modebadze

Tsotne Mirtskhulava Water Management Institute of Georgian Technical University,
Tbilisi, Georgia

Due to its complexity, the exact mathematical description of the process of fluid movement in the swelling soil has not been properly studied, so in such cases, more complex mathematical models used in related fields are often used.The authors propose the adaptation of the model obtained for non-swelling soils to the swelling soils of the Kolkheti Lowland, taking into account their properties. The fairness of such an approach was tested under natural conditions.The obtained result confirmed the validity of its use.

Key words: swelling soils, non-swelling soils, mathematical model, total moisture capacity, precipitation, total evaporation.

Construction, Environmental Protection

THE NEED TO CONNECT BUILDINGSWITH THE NATURAL ENVIRONMENT AND RAINWATER RETENTION IN MODERN CONSTRUCTION

A. Ujma [1)], I. Iremashvili [2)], M. Tsutsqiridze [3)]

[1)] University of Applied Sciences
Nysa, Poland

[2)] Tsotne Mirtskhulava Water Management Institute
of Georgian Technical University
Tbilisi, Georgia

[3)] Georgian Technical University
Tbilisi, Georgia

Anthropogenic human activity contributes to very adverse changes in the natural environment. This is especially true for urban areas. Hence, for some time now, scientists, institutions and institutions have been aware of the risks, sustainability has become a key factor in various industries. In particular, the construction industry has adopted the concept of green infrastructure, which focuses on the design and construction of buildings and infrastructure with minimal environmental impact, and the World Green Building Council estimates that energy demand in buildings will double by 2050. Globally, buildings and the built environment are responsible for approximately 39% of global CO_2 emissions (28% from operational emissions, the energy needed to heat, cool and power them, and the remaining 11% from materials and structures). Construction consumes 50% of the world's natural resources.

The process of increasing demand for energy in the construction industry must be accompanied by a gradual reduction in the production rate of CO_2 and other air pollutants, improving the comfort of use of buildings and ensuring environmental safety, and others. Actions aimed at such effects must be carried out in many areas, including building partitions.

The main task of contemporary, modern construction is to participate in the process of improving the condition of the natural environment, m.in. by increasing the energy efficiency of the construction sector. These tasks can be solved by using, m.in, green structures in combination with building structures (green roofs, living facades and living interior walls). Guidelines for such an approach to construction can be found in the documents of the United Nations, the World Green Building Council, the European Parliament and the Council, as well as the Global Alliance for Buildings and Construction. They point to the need for the development of green and blue infrastructure and sustainable urbanisation, including the decarbonisation of buildings and mitigating the effects of urban heat islands. Greening buildings is a way to meet these requirements. In addition, it improves the health and well-being of people in such environments. Increases the biodiversity of the urban area.

In Poland, regulations are being created to stimulate the processes of greening buildings and their surroundings. Selected regulations and guidelines are presented in this paper, along with examples of building implementations.

In Georgia, efforts are also underway to increase the number of facilities with green, biologically active surfaces in the building's structure.

***Key words**:* green structures; green construction; biologically active area; rain water retention; sustainable development.

Hydraulic Engineering, Environmental protection

SOME PROBLEMS OF THE BLACK SEA POLLUTION

M. Vartanov, I. Iordanishvili, G. Natroshvili, M. Shavlakadze
Tsotne Mirtskhulava Water Management Institute
of Georgian Technical University
Tbilisi, Georgia

This paper presents some considerations regarding the assessment of the vulnerability of the Black Sea. The proposed positions are based on an analysis of the existing loads around the entire perimeter of the sea. The time required to reach an indicator of the Black Sea degradation process is determined. A methodical approach to the calculation of the economic efficiency of investments in environmental protection measures is provided.

Key words: vulnerability of the Black Sea, time to reach the indicator of sea degradation, sea pollution factors, economic efficiency of investments in environmental protection measures.

Economics

CERTAIN PRINCIPLES FOR CALCULATION OF ECONOMIC DAMAGE CAUSED BY MUDFLOWS AND LANDSLIDES

M. Vartanov[1)], E. Kechkhoshvili[1)], N. Beraia[1)], M. Macharashvili [1)], L. Toklikishvili[1)], M. Shogiradze[2)]
[1)] Tsotne Mirtskhulava Water Management Institute
of Georgian Technical University
[2)] Georgian Technical University
Tbilisi, Georgia

As of today, there is no universally acknowledged radical engineering structure to fight mudflows and landslides; nor is there a unified approach to calculation of the damage caused by them. The article proposes the methodology for calculation of the economic damage associated with these spontaneous natural calamities. There is given the assessment of the economic efficiency of the measures directed to reduction of the damage caused by mudflows and landslides.

Key words: economic efficiency, disasters, mudflows, landslides.

Environmental protection, Ecotourism

PROSPECTS Of THE ECONOMIC SIGNIFICANCE Of ECOLOGICAL TOURISM IN THE AREAS Of RARE PLANTS DISTRBUTION

G. Yeghiazaryan, A. Hambardzumyan, N. Aloyan
Armenian National Agrarian University
Yerevan, Armenia

In order to discover the ecosystems of the Republic of Armenia, improve the well-being of the local population, preserve wildlife and develop tourism, the areas of rare plants of the mountain meadow zone of the Republic of Armenia were mapped, which are combined with valuable natural places of historical, cultural and scenic value in their vicinity.

The combination of rare plant areas with historical monuments and sites has provided an opportunity to develop new measures to support the sustainable development of ecotourism. Within the framework of the organization of ecotourism, the possible impact of visits to rare plants on the development of the intra-community economy was evaluated.

The great potential of ecotourism to influence the development of economic growth of rural communities has been found, and as a result of accurate organization, communities can have certain profits and new opportunities to use the development potential.

The results of the research create prerequisites for the protection of wildlife and cultural values of local communities, increasing people's incomes, sustainable management of natural landscapes and solving the problems of employment of local residents.

Considering the above, the research presents the rare plants distribution areas mapping in a geographic information systems (GIS) environment as an innovative approach to sustainable tourism management.

Key words: GIS, environmental protection, rare plant species, ecotourism, economic growth.

ანოტაციები

ჰიდროლოგია

GIS ტექნოლოგიები მთის მდინარის მორფომეტრული პარამეტრების შეფასებისას

ა. არიფჯანოვი, დ. ატაკულოვი, უ. ვოხიდოვა, მ. ოსმონოვა
ეროვნული კვლევითი უნივერსიტეტი
„ტაშკენტის ირიგაციისა და სოფლის მეურნეობის მექანიზაციის ინსტიტუტი”
ტაშკენტი, უზბეკეთი

სტატიაში წარმოდგენილია მდინარის მთისწინეთში ეროზიული და აკუმულაციური პროცესების კვლევის შედეგები. კვლევის ობიექტად შეირჩა სოხის ნაკადი. მორფომეტრიული პარამეტრების კავშირები სოხის ნაკადში შესწავლილი იქნა GAT ტექნოლოგიების საფუძველზე. გამოყენებული სენტინელ 2 სატელიტური სურათები. გადმოწერილი სურათები გაანალიზდა Arc Map პროგრამული უზრუნველყოფის გამოყენებით. ბუნებრივი საველე კვლევები ჩატარდა უზბეკეთის ფერგანას ველზე მდინარე სოხის შერჩეულ ნაწილში. ბუნებრივ საველე კვლევებში წლების განმავლობაში იზომებოდა ნაკადის ჰიდრავლიკური პარამეტრები, წყლის სიმღვრივე და კალაპოტის მორფომეტრიული პარამეტრები. კვლევების დროს დამახასიათებელ ნაკვეთებზე შეგროვებული მონაცემების სტატისტიკური ანალიზის საფუძველზე აშენდა დინების B დონის სიგანის დამოკიდებულების გრაფიკი წყლის ჩაშვებაზე Q=f(B). GIS ტექნოლოგიების გამოყენებით, დინების დონის ზედაპირი განისაზღვრა წყლის NDWI-ის ნორმალიზებული სხვაობის ინდექსით. მიღებული შედეგები შეადარეს არსებულ მეთოდებს. შედეგად შესაძლებელია GIS ტექნოლოგიების გამოყენება მთის მდინარეში მდინარის კალაპოტის მორფომეტრიული პარამეტრების შესაფასებლად. გაანალიზებულია მდინარის კალაპოტში მიმდინარე ცვლილებები და წარმოდგენილია დასკვნები.

საკვანძო სიტყვები: GIS, სენტინელი, სატელიტი, მდინარე, რუკა, არხები, ნაკადი, წყლის მოხმარება, გამოსახულების ანალიზი, მორფომეტრია.

ჰიდროტექნიკა და გარემოს დაცვა

ღვარცოფსარეგულაციო ელასტიკური ბარაჟი (ინოვაცია, მოდელირება, დაპროექტება, მშენებლობა)

გ. გავარდაშვილი[1)2)], ე. კუხალაშვილი[1)2)], ი. ირემაშვილი [1)2)]
[1)] საქართველოს ტექნიკური უნივერსიტეტის
ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
[2)] გარემოს დაცვის ეკოცენტრი - გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC)
საკონსულტაციო სტატუსის ორგანიზაცია
თბილისი, საქართველო

ნაშრომში წარმოდგენილია ღვარცოფსარეგულაციო ელასტიკური ბარაჟის პრაქტიკაში განხორციელების სრული ციკლი, როგორიცაა: ინოვაცია, ლაბორატო-

რიული მოდელირება, დაპროექტების სამეცნიერო მეთოდოლოგიის შემუშავება, პროექტის მომზადება და მშენებლობა.

სამეცნიერო საქმიანობა შესრულდა შოთა რუსთაველის ეროვნული სამეცნიერო ფონდის საგრანტო პროექტის AR-18-1244 (2018-2023) ფინანსური მხარდაჭერით, რომლის ფარგლებში განხორციელდა შემდეგი სამუშაოები - შემუშავდა ღვარცოფსარეგულაციო ინოვაციური ნაგებობა (დამოწმებულია საქართველოს საპატენტო სერტიფიკატით #P 2020 7068 B საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალმომარაგების ინსტიტუტის ჰიდროტექნიკურ ლაბორატორიაში, რომელიც ითვლის 98–წლიან გამოცდილებას), ჩატარდა ღვარცოფსა-რეგულაციო ელასტიკური ბარაჟის ფართომასშტაბიანი ლაბორატორიული მოდელირება და განისაზღვრა ინოვაციური კონსტრუქციის ჰიდრავლიკური პარამეტრები, რომლებიც გამოიყენება ნაგებობის საპროექტო მეთოდოლოგიის შესამუშავებლად; მდინარე მლეთისხევის ტოპოგრაფიული, ჰიდროლოგიური და სხვა ძირითადი მახასიათებლებისა და კომპიუტერული პროგრამის „ლირა საფრ 2019“ (ლიცენზიის ნომერი 1/7165) გამოყენებით გაანგარიშდა ღვარცოფსარეგულაციო ელასტიკური ბარაჟისა და საძირკვლის ოპტიმალური ზომები. შემუშავებული დეტალური პროექტის დახმარებით, 2022 წლის სექტემბერ-ოქტომბერში მდინარე მლეთის ხევის კალაპოტში აშენდა ნაგებობა, ხოლო 2023 წლის ზაფხულში ნაგებობა ეფექტურად მუშაობდა პირველი ღვარცოფის დინამიკური დატვირთვით.

საკვანძო სიტყვები: მდინარე მლეთისხევი, ღვარცოფული ნაკადი, ღვარცოფსარეგულაციო ელასტიკური ბარაჟი.

<u>ჰიდროტექნიკა და მელიორაცია</u>

ღვარცოფის მიერ ტრანსპორტირებული ნატანების საშუალო დიამეტრის დადგენა

ქ. დადიანი, ი. ქუფარაშვილი, მ. მღებრიშვილი, ლ. მაისაია, ნ. ნიბლაძე

საქართველოს ტექნიკური უნივერსიტეტის

ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი

თბილისი, საქართველო

სტატიაში წარმოდგენილია საველე სამეცნიერო ექსპედიციური კვლევის შედეგი და დადგენილია ღვარცოფის მიერ ტრანსპორტირებული ნატანის საშუალო დიამეტრი. მდინარის კალაპოტის სამეცნიერო კვლევა განხორციელდა მცხეთის მუნიციპალიტეტის ტერიტორიაზე, კერძოდ, შიომღვიმის სამონასტრო კომპლექსის მიმდებარედ, სამონასტრო ხევში.

საკვანძო სიტყვები: ნატანები, ღვარცოფი, გრანულომეტრია, გრადაცია, ინტეგრალური მრუდი.

ჰიდროლოგია და მეტეოროლოგია

კლიმატის ცვლილებით გამოწვეული სტიქიები და მათი პრევენცია

რ. დიაკონიძე, ჯ. ფანჩულიძე, ლ. წულუკიძე, ი. კვირკველია,
ქ. დადიანი, ნ. ნიბლაძე, მ. გლუნჩაძე
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

სამეცნიერო სტატიაში წარმოდგენილია საველე ნატურული კვლევის მასალები.

სტატია ეძღვნება წყლის მქსიმალური ხარჯების პროგნოზური სიდიდეების დადგენას. საველე კვლევები ჩატარდა სიღნაღის მუნიციპალიტეტში, კერძოდ, წყალმოვარდნის შედეგად ბოდბის წმინდა ნინოს სახელობის დედათა მონასტერსა და სიღნაღი-დედოფლისწყაროს დამაკავშირებელი საავტომობილო გზის დაზიანებულ მონაკვეთზე.

დადგენილია მოსალოდნელი წყლის მაქსიმალური ხარჯების სხვადასხვა უზრუნველყოფის პროგნოზული სიდიდეები მონასტრისა და საავტომობილო გზის მონაკვეთთან არსებულ ორ წყალსადინარზე.

წარმოდგენილია წყალმოვარდნის მიზეზები, შესაბამისი დასკვნები და რეკომენდაციები.

საკვანძო სიტყვები: წყალმოვარდნა, დატბორვა, წყალარინება, წყლის ხარჯი, სადრენაჟო კოლექტორი, წყალშემკრები აუზი.

გარემოს დაცვა, ეკოტურიზმი

ეკოლოგიური ტურიზმის ეკონომიკური მნიშვნელობის პერსპექტივები იშვიათი მცენარეების გავრცელების რაიონებში

გ. ეგიაზარიანი, ა. ჰამბარცუმიანი, ნ. ალოიანი
წყლისა და მიწის რესურსების მართვის დეპარტამენტი,
სომხეთის ეროვნული აგრარული უნივერსიტეტი,
ერევანი, სომხეთი

სომხეთის რესპუბლიკის ეკოსისტემების შესწავლის, ადგილობრივი მოსახლეობის კეთილდღეობის გაუმჯობესების, ველური ბუნების შენარჩუნებისა და ტურიზმის განვითარების მიზნით, შედგენილი იქნა სომხეთის რესპუბლიკის მთა-მდელოს ზონის იშვიათი მცენარეების რუკა, რომელშიც გაერთიანებულია ღირებული ისტორიული, კულტურული და ბუნებრივი ადგილები.

იშვიათ მცენარეთა ტერიტორიების კომბინირებამ ისტორიული ძეგლების არეალთან შექმნა ახალი ღონისძიებების შემუშავების შესაძლებლობა ეკოტურიზმის მდგრადი განვითარების მხარდასაჭერად. ეკოტურიზმის ორგანიზების ფარგლებში შეფასდა იშვიათი მცენარეების მოსანახულებელი ვიზიტების შესაძლო გავლენა შიდასაზოგადოებრივი ეკონომიკის განვითარებაზე.

მიგნებულია ეკოტურიზმის დიდი პოტენციალი სასოფლო საზოგადოებების ეკონომიკურ ზრდაზე გავლენის თვალსაზრისით, ხოლო ფაქიზი ორგანიზების შედეგად საზოგადოებებს შეუძლიათ ორიენტირება გარკვეულ მოგებასა და განვითარების პოტენციალის გამოყენების ახალ შესაძლებლობებზე.

კვლევის შედეგები ქმნის წინაპირობებს ადგილობრივი თემების ველური ბუნებისა და კულტურული ფასეულობების დაცვის, მოსახლეობის შემოსავლების გაზრდის, ბუნებრივი ლანდშაფტების მდგრადი მართვისა და ადგილობრივი მოსახლეობის დასაქმების პრობლემების გადასაჭრელად.

ზემოაღნიშნულის გათვალისწინებით, კვლევა წარმოგიდგენთ იშვიათი მცენარეების გავრცელების ზონებს გეოგრაფიული საინფორმაციო სისტემების (GIS) გარემოში, როგორც მდგრადი ტურიზმის მართვის ინოვაციურ მიდგომას.

საკვანძო სიტყვები: გეოინფორმაციული სისტემები, გარემოს დაცვა, იშვიათი მცენარეული სახეობები, ეკოტურიზმი, ეკონომიკური ზრდა.

შავი ზღვის დაბინძურების ზოგიერთი პრობლემა

მ. ვართანოვი, ი. იორდანიშვილი, გ. ნატროშვილი, მ. შავლაყაძე
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

წინამდებარე ნაშრომში წარმოდგენილია რამდენიმე მოსაზრება შავი ზღვის მოწყვლადობის შეფასებასთან დაკავშირებით. შემოთავაზებული პოზიციები ეფუძნება არსებული დატვირთვების ანალიზს ზღვის მთელ პერიმეტრზე. განსაზღვრულია შავი ზღვის დეგრადაციის პროცესის ინდიკატორის მისაღწევად საჭირო დრო. გათვალისწინებულია მეთოდური მიდგომა გარემოს დაცვის ღონისძიებებში ინვესტიციების ეკონომიკური ეფექტიანობის გაანგარიშებისადმი.

საკვანძო სიტყვები: შავი ზღვის მოწყვლადობა, ზღვის დეგრადაციის ინდიკატორის მიღწევის დრო, ზღვის დაბინძურების ფაქტორები, ინვესტიციების ეკონომიკური ეფექტურობა გარემოს დაცვის ღონისძიებებში.

ეკონომიკა

ღვარცოფითა და მეწყერებით გამოწვეული ეკონომიკური ზიანის გამოთვლის გარკვეული პრინციპები

მ. ვართანოვი[1)], ე. კეჩხოშვილი[1)], ნ. ბერაია[1)], მ. მაჭარაშვილი [1)],
ლ. ტოკლიკიშვილი[1)], მ. შოგირაძე[2)]
[1)] საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
[2)] საქართველოს ტექნიკური უნივერსიტეტის
თბილისი, საქართველო

დღეის მდგომარეობით, არ არსებობს საყოველთაოდ აღიარებული რადიკალური საინჟინრო სტრუქტურა ღვარცოფებთან და მეწყერებთან საბრძოლველად; არც მათ მიერ მიყენებული ზარალის გაანგარიშების ერთიანი მიდგომა არსებობს. სტატიაში წარმოდგენილია ამ სპონტანურ სტიქიურ უბედურებებთან დაკავშირებული ეკონომიკური ზარალის გაანგარიშების მეთოდოლოგია. მოცემულია ღვარცოფითა და მეწყერით გამოწვეული ზარალის შემცირებისკენ მიმართული ღონისძიებების ეკონომიკური ეფექტურობის შეფასება.

საკვანძო სიტყვები: ეკონომიკური ეფექტურობა, კატასტროფები, ღვარცოფები, მეწყრები.

გარემოს დაცვა

წყლის ხარისხის შეფასება თბილისის წყალსაცავის ისანი-სამგორის საფილტრ სადგურში

კ. იორდანიშვილი, ი. იორდანიშვილი, კ. ბზიავა, ნ. კანდელაკი, თ. სუპატაშვილი,
გ. ომსარაშვილი, ე. ხოსროშვილი, დ. ფოცხვერია, ლ. ბილანიშვილი
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

სტატიაში განხილულია თბილისის წყალსაცავის ისანი-სამგორის საფილტრ სადგურში წყლის ქიმიური შემადგენლობის დინამიკა სიღრმის, წლის პერიოდისა და წყალცვლის მაჩვენებლების გათვალისწინებით. წყლის ძირითადი ქიმიური მაჩვენებლები შედარებულია დასაშვებ ნორმატიულთან.

საკვანძო სიტყვები: თბილისის წყალსაცავი, წყლის ქიმიური მაჩვენებლები.

დედამიწის შემსწავლელი მეცნიერებები

ექსტრემალური მოვლენების მიზეზები, პროგნოზირებისა და პრევენციის პრობლემები

ლ. იტრიაშვილი[1)], ე. ხოსროშვილი[1)], გ. კიღურაძე[2)]

[1)] საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი

[2)] ილიას სახელმწიფო უნივერსიტეტი
თბილისი, საქართველო

განხილულია ექსტრემალური მოვლენების კერები, როგორც მრავალფაქტორიანი არამდგრადი ეკოფიზიკური სისტემები, რომლებსაც ახასიათებს ძნელად პროგნოზირებადი ეფექტები.

ნაჩვენებია, რომ ექსტრემალური მოვლენების წარმომქმნელი მრავალრიცხოვანი ფაქტორები იმყოფებიან აქტიურ ურთიერთკავშირში და ურთიერთგავლენის პროცესებში. გეოფიზიკური სისტემები გარკვეულ პირობებში გამოდიან დინამიკური წონასწორობიდან, გადადიან ავტორხევით მდგომარეობაში არაწრფივი ეფექტებით, რის შედეგადაც ვღებულობთ ძნელად პროგნოზირებად დამანგრეველ მოვლენებს.

ამიტომ გეოფიზიკურ სისტემებში მრავალრიცხოვანი ფაქტორების აღწერა მარკოვის მარტივი ჯაჭვების, ანუ წრფივი, ან მათი გართულებული მოდიფიკაციებით, ექსტრემალური მოვლენების მეტნაკლებად ზუსტი პროგნოზირება პრაქტიკულად შეუძლებელია.

საკვანძო სიტყვები: ექსტრემალური მოვლენები, გეოფიზიკური მიზეზები, ავტორხევები, მოულოდნელობა, პროგნოზირების არასაიმედოობა, პრევენციის გზები.

დედამიწის შემსწავლელი მეცნიერებები

შეჭიდულობის ძალის ზეგავლენა მოწყვლადი ფერდობების მდგრადობაზე

ნ. კვაშილავა, ი. ხუბულავა, ი. კვირკველია

საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

სტატიაში განხილულია, თუ რა შემთხვევაში შეიძლება მოძრაობდეს ნიადაგი მეწყერსაშიში ფერდობიდან წყლით გაჯერებისას.

ასევე განიხილება, თუ რამდენად მნიშვნელოვანია ნიადაგის შეჭიდულობის ძალა მისი მშრალი მდგომარეობისათვის და წყლით გაჯერების შემთხვევაში.

მცირე შეჭიდულობის შემთხვევაში ფერდი შეიძლება დაიძრას „მშრალ“ მდგომარეობაშიც კი, მაშინ, როცა დიდი შეჭიდულობის ძალის შემთხვევაში, მისი წყლით გაჯერებაც კი არ წარმოადგენს საშიშროებას.

საკვანძო სიტყვები: შეჭიდულობის ძალა, მეწყერსაშიში ფერდობი, ფერდობის მდგრადობა.

მშენებლობა

ხელოვნური ინტელექტი, როგორც ავტომატიზაციისა და რობოტიზაციის ინსტრუმენტი სამშენებლო პროცესებში

ჯ. ნიემირო-მაზნიაკი, მ. მაიორი, ი. მაიორი
ჩესტოხოვას ტექნოლოგიური უნივერსიტეტი
ჩესტოხოვა, პოლონეთი

ხელოვნური ინტელექტი წარმოადგენს ფართოდ გამოყენებად ინსტრუმენტს ადამიანის საქმიანობის სხვადასხვა სფეროში. მისი დინამიკური განვითარება უზრუნველყოფს ხელოვნური ინტელექტის ტექნოლოგიის ინტეგრაციას სამშენებლო მრეწველობაში. სამშენებლო მასალების და ასაწყობი კომპონენტების ტექნოლოგიურად მოწინავე წარმოების პარალელურად, რობოტიკა ხდება თავად სამშენებლო პროცესის მთავარი ელემენტი. მშენებლობაში ავტომატიზაცია და რობოტიზაცია, რაც გულისხმობს ადამიანის შრომის ჩანაცვლებას მანქანებით, იწვევს ეფექტურობის გაზრდას და მშენებლობის საინვესტიციო ხარჯების შემცირებას.

ნაშრომში განხილულია ხელოვნური ინტელექტის გავლენა მშენებლობაზე, ციფრული ხელსაწყოების გამოყენებით სამშენებლო პროცესების განხორციელების ტექნოლოგიაზე დაყრდნობით. ნაშრომში მოყვანილია სამშენებლო პროცესების ავტონომიური განხორციელების ეფექტური განხორციელების მაგალითები, რაც ამცირებს ადამიანის შრომას და ზრდის განხორციელების ეფექტურობას. წარმოდგენილია ახალი ტექნოლოგიების მახასიათებლები და განხილულია მანქანათმცოდნეობის როლი მშენებლობაში. არსებული სალიტერატურო მასალის მიმოხილვის საფუძველზე, ხაზგასმულია მანქანური სწავლების, მათ შორის ღრმა სწავლის, სამშენებლო ინდუსტრიაში გამოყენების მაგალითები.

მოწინავე ხელოვნური ინტელექტის ტექნოლოგიების ტრადიციულ სამშენებლო პროცესებთან ინტეგრაციის დაფიქსირებული ზრდა ქმნის უამრავ შესაძლებლობას, რომელიც გავლენას ახდენს სამშენებლო მრეწველობის ეფექტურობასა და განვითარებაზე.

საკვანძო სიტყვები: ხელოვნური ინტელექტი, რობოტიკა, სამშენებლო მრეწველობა.

ჰიდროლოგია-მეტეოროლოგია

ანთროპოგენური ზემოქმედება მდინარის კალაპოტის დეფორმაციებზე – მდინარე აღსუჩაის მაგალითზე

ა. ნურიევი
ბაქოს სახელმწიფო უნივერსიტეტი
ბაქო, აზერბაიჯანი

ბოლო ათწლეულების განმავლობაში ანთროპოგენური დარღვევებისა და კლიმატური ზემოქმედების გამო შირვანის რეგიონის მდინარეები, ისევე როგორც აზერბაიჯანის მთის უმეტესი მდინარეები, განიცდიდნენ მნიშვნელოვან ცვლილებებს

დეპონირების გარემოში. ურბანიზაციამ და სოფლის მეურნეობის განვითარებამ გამოიწვია მდინარის აუზებში ჰიდროტექნიკური ნაგებობების და ხრეშის მოპოვების ობიექტების ზრდა. თუმცა, ცოდნა იმის შესახებ, თუ როგორ რეაგირებს მდინარის არხი და კალაპოტის დეფორმაცია ამ ცვლილებებზე, შეზღუდულია. ამ კვლევაში მაგალითების სახით აღებულია მდინარე აღსუჩაი. ბათიმეტრიული და ჯვარედინი მონაცემები შეგროვდა 2013 წლიდან 2021 წლამდე და გაანალიზდა დეპონირების გარემოში ცვლილებების გამოსასწორებლად. შედეგები მიუთითებს, რომ მდინარე აღსუჩაის მთლიანი კალაპოტი წყდება სარწყავი არხის წყალმიმღები ნაგებობის მშენებლობის შემდეგ და ეს ტენდენცია, სავარაუდოდ, მომავალშიც გაგრძელდება ზედა წყალგამყოფიდან ნატანის მიწოდების შემცირების გამო. დაკვირვების საფუძველზე, მდინარის კალაპოტში მოხდა დაახლოებით 3 მ ვერტიკალური დეფორმაცია.

საკვანძო სიტყვები: მდინარე აღსუჩაი, კალაპოტის დეფორმაცია, ხრეშის ამოღება, ანთროპოგენური ზემოქმედება, დალექვის ტრანსპორტი

მშენებლობა, გარემოს დაცვა

შენობების დაკავშირების აუცილებლობა ბუნებრივ გარემოსთან და წვიმის წყლის შეკავება თანამედროვე მშენებლობაში

ა. უიმა[1)], ი. ირემაშვილი[2)], მ. ცუცქირიძე[3)]

[1)] გამოყენებითი მეცნიერებების უნივერსიტეტი
ნუსა, პოლონეთი
[2)] საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო
[3)] საქართველოს ტექნიკური უნივერსიტეტი
თბილისი, საქართველო

სამშენებლო ინდუსტრიამ აღიარა მწვანე ინფრასტრუქტურის კონცეფცია, რომელიც ფოკუსირებულია შენობებისა და ინფრასტრუქტურის დიზაინსა და მშენებლობაზე, გარემოზე მინიმალური ზემოქმედებით, ხოლო მწვანე შენობების მსოფლიო საბჭოს შეფასებით, 2050 წლისთვის ნაგებობებში ენერგომოთხოვნა გაორმაგდება. ზოგადად, შენობები და სამშენებლო გარემო CO_2-ის მთლიანი გამონაბოლქვის დაახლოებით 39%-ის წყაროს წარმოადგენს (28% – ოპერატიული ემისიიდან - ენერგია გათბობის, გაგრილებისა და კვებისთვის; დანარჩენი 11% კი მასალებიდან და სტრუქტურებიდან). მშენებლობის პროცესი მოიხმარს მსოფლიო ბუნებრივი რესურსების 50 %-ს.

სამშენებლო ინდუსტრიაში ენერგიაზე მოთხოვნის გაზრდის პროცესს თან უნდა ახლდეს CO_2-ის და ჰაერის სხვა დამაბინძურებლების წარმოების ეტაპობრივი შემცირება, შენობებში კომფორტის გაუმჯობესება და გარემოსდაცვითი უსაფრთხოების უზრუნველყოფა და სხვ.

თანამედროვე მშენებლობის მთავარი ამოცანაა მონაწილეობა მიიღოს ბუნებრივი

გარემოს მდგომარეობის გაუმჯობესების პროცესში, სამშენებლო სექტორის ენერგოეფექტურობის გაზრდით. ამ ამოცანების გადაჭრა შესაძლებელია მწვანე სტრუქტურების გამოყენებით შენობის კონსტრუქციებთან ერთად (მწვანე სახურავები, საცხოვრებელი ფასადები და საცხოვრებელი შიდა კედლები). მშენებლობისადმი ასეთი მიდგომის მითითებები შეგიძლიათ იხილოთ გაერთიანებული ერების ორგანიზაციის, მსოფლიო მწვანე შენობების საბჭოს, ევროპარლამენტისა და საბჭოს დოკუმენტებში, ასევე გლობალური შენობებისა და მშენებლობის ალიანსში. ისინი მიუთითებენ მწვანე და ლურჯი ინფრასტრუქტურის განვითარებისა და მდგრადი ურბანიზაციის აუცილებლობაზე, მათ შორის შენობების დეკარბონიზაციასა და ურბანული სითბოს კუნძულების ზემოქმედების შერბილებაზე. შენობების გამწვანება არის ამ მოთხოვნების დაკმაყოფილების საშუალება. გარდა ამისა, ასეთ გარემოში ის აუმჯობესებს ადამიანების ჯანმრთელობას და კეთილდღეობას. ზრდის ურბანული ტერიტორიის ბიომრავალფეროვნებას.

პოლონეთში იქმნება რეგულაციები შენობებისა და მათი შემოგარენის გამწვანების პროცესების სტიმულირებისთვის. ამ ნაშრომში, შენობების განხორციელების მაგალითებთან ერთად წარმოდგენილია შერჩეული რეგულაციები და მითითებები.

საქართველოში ასევე მიმდინარეობს ძალისხმევა შენობის სტრუქტურაში მწვანე, ბიოლოგიურად აქტიური ზედაპირის მქონე ობიექტების რაოდენობის გაზრდაზე.

საკვანძო სიტყვები: მწვანე სტრუქტურები; მწვანე მშენებლობა; ბიოლოგიურად აქტიური ტერიტორია; წვიმის წყლის შეკავება; მდგრადი განვითარება.

გარემოს დაცვა

საქართველოში ფართოდ გამოყენებული ქლორპირიფოს შემცველი პესტიციდებით დაბინძურებული სასოფლო-სამეურნეო დანიშნულების ნიადაგები

მ. შავლაყაძე[1)], გ. ნატროშვილი[2)], ლ. იტრიაშვილი[3)], კ. დიდებულიძე[4)], ა. გუჯაბიძე[5)], ხ. კიკნაძე[6)]

[1),2),3),6)] საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი

[4),5)] საქართველოს აგრარული უნივერსიტეტი

თბილისი, საქართველო

საქართველოში სოფლის-მეურნეობაში გამოყენებული პესტიციდების შემადგენლობაში დიდი კონცენტრაციით შედის ქლორპირიფოსი C9H11Cl3NO3PS. იგი წარმოადგენს ერთ-ერთ ფართოდ გამოყენებულ ფოსფორორგანულ პესტიციდს, რომელიც ნიადაგში მოხვედრისას გადის მეტაბოლიზმის 4 საფეხურს. მეტაბოლიზმის მე-3 და მე-4 საფეხურზე წარმოქმნილი პროდუქტები დიეთილ ფოსფატი, დიეთილ ტრიფოსფატი, 3,5,6 ტრიქლორო 2-პირიდინოლი წარმოადგენენ ძლიერ ტოქსიკურ ნივთიერებებს. ზემოაღნიშნულ პრობლემას კიდევ უფრო ამძაფრებს ერთ-ერთი

გარემოება, რომ საქართველოში არსებულ სასოფლო-სამეურნეო სავარგულებში, ხშირ შემთხვევაში, პესტიციდების გამოყენება ხდება ვადების დარღვევით და არანორმირებულად, მოსახლეობის ეკოლოგიური ცნობიერების დაბალი დონის გამო.

ბოლო პერიოდში საქართველოში სოფლის მეურნეობის ინტენსიური ქიმიზაციის ფონზე, აქტუალური გახდა სასოფლო-სამეურნეო დანიშნულების ნიადაგების დაბინძურების პრობლემა, ვინაიდან მოსახლეობის მიერ უმართავად ხდება პესტიციდების გამოყენება, რაც ირიბად ადამიანებისთვის მრავალი მწვავე დაავადებების წარმოქმნის და გავრცელების მიზეზად გვევლინება.

დღეისათვის საქართველოში არ არსებობს პესტიციდებით დაბინძურებული მიწის რესურსების ეფექტური რემედიაციის შესაძლებლობები და სწორედ ამ ინფორმაციული ვაკუუმის შევსებას ხელს შეუწყობს ჩვენ მიერ პესტიციდების და მათი მეტაბოლური პროდუქტებით დაბინძურებული სასოფლო-სამეურნეო დანიშნულების ნიადაგებზე განსახორციელებელი კვლევები, რაც გულისხმობს ქლორპირიფოს შემცველი პრეპარატით (დურსბანი) დაბინძურებული სასოფლო-სამეურნეო დანიშნულების ნიადაგების ბიორემედიაციას ანაერობული ბაქტერიების გამოყენებით.

საკვანძო სიტყვები: ქლორპირიფოსი, ბიოდეგრადაცია, მეტაბოლიტები.

მელიორაცია, ჰიდროტექნიკა

გაჯირჯვებადი გრუნტების წყალ-ჰაეროვანი რეჟიმის ფორმირების მოდელები და დრენაჟის და სხვა მელიორაციული ღონისძიებების გაანგარიშებაში მათი გამოყენების შესაძლებლობები

ვ. შურღაია, შ. კუპრეიშვილი, გ. ვახტანგიშვილი, ლ. კეკელიშვილი, ს. მოდებაძე
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

გაჯირჯვებად გრუნტებში სითხის მოძრაობის პროცესის ზუსტი მათემატიკური აღწერა, მისი სირთულის გამო, თეორიული თვალსაზრისით, დღემდე არ არის სათანადოდ შესწავლილი, ამიტომ ასეთ შემთხვევებში ხშირად მიმართავენ მომიჯნავე დარგებში გამოყენებულ, უფრო რთულ მათემატიკურ მოდელებს. ავტორების მიერ შემოთავაზებულია არაგაჯირჯვებადი გრუნტებისათვის მიღებული მოდელის ადაპტაცია კოლხეთის დაბლობის გაჯირჯვებადი გრუნტებისათვის, მათი თვისებების გათვალისწინებით. ასეთი მიდგომის სამართლიანობა შემოწმებული იყო ნატურულ პირობებში; მიღებულმა შედეგმა დაადასტურა მისი გამოყენების მართებულობა.

საკვანძო სიტყვები: გაჯირჯვებადი და არაგაჯირჯვებადი გრუნტები, მათემატიკური მოდელი, სრული ტენტევადობა, ნალექები, ჯამური აორთქლება.

მელიორაცია

სასოფლო-სამეურნეო კულტურების წყალმოთხოვნილების განსაზღვრა ქვემო ქართლის რეგიონის მარნეულის მუნიციპალიტეტის სოფელ თამარისისთვის

ო. ხარაიშვილი[1)2)], პ. სიჭინავა[1)], ნ. მებონია[2)], მ. კიკაბიძე[1)2)], ლ. ბაიდაური[2)], ნ. სუხიშვილი[2)], ლ. ტოკლიკიშვილი[1)]

[1)] საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
[2)] საქართველოს ტექნიკური უნივერსიტეტი
თბილისი, საქართველო

სასოფლო-სამეურნეო კულტურების წყლის მოთხოვნილება ბუნებრივ პირობებში შეიძლება დაკმაყოფილდეს ნიადაგში არსებული ტენიანობით და ატმოსფერული ნალექებით, მაგრამ გვალვის პერიოდში ეს რაოდენობა ხშირად არ არის საკმარისი და ამიტომ საჭიროა მორწყვა.

სასოფლო-სამეურნეო კულტურებისთვის მნიშვნელოვანია მორწყვის რეჟიმის სწორად განსაზღვრა. წყალმომარაგების შესაფასებლად გამოყენებული იქნა პროფ. გ. სელიანინოვის მეთოდი. მარნეულის მუნიციპალიტეტის სოფელ თამარისისთვის დადგინდა მორწყვის საჭიროება, განისაზღვრა ნიადაგის ირიგაციის მაჩვენებლები და დადგინდა, რომ მოცემული ღირებულებები მნიშვნელოვნად განსხვავდება არსებულისგან.

გამოითვალა და განისაზღვრა სოფელ თამარისის თითოეულ სასოფლო-სამეურნეო ნაკვეთზე თითოეული კულტურის ოკუპირებული ფართობის წილი და წყლის გადასახადის ღირებულებები, აშენდა, შეიქმნა დაუსრულებელი წყლის ბაჟის გრაფიკი, რომელიც გვიჩვენებს წყალმოთხოვნის არათანაბრად გადანაწილებას. შედეგად, წყლის გადასახადის დაუსრულებელი გრაფიკის კორექტირების შემდეგ შეიქმნა წყალმომარაგების სრული გრაფიკი, რომლის მიხედვითაც განისაზღვრა სოფელ თამარისისთვის საჭირო წყლის რაოდენობა სარწყავი პერიოდების გათვალისწინებით და აიგო წყალმოთხოვნილების მრუდი.

საკვანძო სიტყვები: ირიგაცია, წყლის გადასახადი, სარწყავი მაჩვენებელი, წყალმოთხოვნილება, წყალმომარაგება

მელიორაცია

საქართველოს შიდა ქართლის ვაკის კასპის და მცხეთის მუნიციპალიტეტების სარწყავი ზონის ნიადაგების მელიორაციული მაჩვენებლები

ო. ხარაიშვილი, ე. კეჩხოშვილი, ფ. ლორთქიფანიძე
საქართველოს ტექნიკური უნივერსიტეტის
ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტი
თბილისი, საქართველო

სტატია ეხება შიდა ქართლის ვაკის კასპის და მცხეთის მუნიციპალიტეტების სარწყავი ზონის ნიადაგების მელიორაციული მაჩვენებლების დადგენას მორწყვის რეჟიმის დაზუსტების მიზნით. განსახილველი ზონის ნიადაგები, სათანადო ექსპერიმენტული მონაცემების საფუძველზე, მელიორაციული თვალსაზრისით, დაჯგუფებულია შვიდ კატეგორიად. თითეული კატეგორიისათვის მოყვანილია მელიორაციული მაჩვენებლების მნიშვნელობები. მიღებული მონაცემების საფუძველზე დადგენილია მორწყვის ნორმა, განსაზღვრულია ნიადაგის ტენის ის მინიმალური რაოდენობა, რომელიც განსაზღვრავს მორიგი რწყვის დაწყების დროს.

საკვანძო სიტყვები: ნიადაგი, მოცულობითი მასა, ზღვრული წყალტევადობა, მაქსიმალური მოლეკულური წყალტევადობა, მორწყვის ნორმა

ქ რ ო ნ ი კ ა

ინფორმაცია საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის მოღვაწეობის შესახებ 2023 წ.

ინსტიტუტში, რომელიც დაფუძნებულია 1925 წლიდან, ამჟამად მუშაობს 78 თანამშრომელი, აქედან 56% მეცნიერი თანამშრომელია, მათ შორის: 1 - საქართველოს მეცნიერებათა ეროვნული აკადემიის აკადემიკოსი, 4 - საინჟინრო აკადემიის წევრი, 5 - მეცნიერებათა დოქტორი, 28 - აკადემიური დოქტორი, 2 - დოქტორანტი და 19 - მაგისტრი.

ინსტიტუტის სამეცნიერო კვლევითი საქმიანობა

- ინსტიტუტის მეცნიერი თანამშრომლების მიერ 2023 წლის პერიოდულ გამოცემებში გამოქვეყნდა 40-მდე სტატია, 11 მონოგრაფია და 5 სახელმძღვანელო;
- ინსტიტუტში მუშავდება სამეცნიერო პროგრამული დაფინანსების თემის „**წყლის რესურსების უსაფრთხოება და ინტეგრირებული მართვა კლიმატის ცვლილების გათვალისწინებით**“ (თემის სამეცნიერო ხელმძღვანელი - საქართველოს მეცნიერებათა ეროვნული აკადემიის აკადემიკოსი გივი გავარდაშვილი) 6 ქვემიმართულება, დარგებში: წყალთა მეურნეობა, მელიორაცია, გარემოს დაცვა და ჰიდროტექნიკური ნაგებობები.

ინსტიტუტის სამეცნიერო ურთიერთობები

საქართველო

- **2023 წლის 20 იანვარს** საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტში სამუშაო ვიზიტით იმყოფებოდნენ კაუნასიდან (ლიეტუვა) დოვილ რუდოკაიტე და ვილდა გრიბაუსკიენე (კაუნასის ტექნოლოგიების საგანმანათლებლო ცენტრი). შეხვედრისას საუბარი შეეხო რამდენიმე მნიშვნელოვან საკითხს, სტუმრებმა დაათვალიერეს ინსტიტუტის ჰიდროტექნიკური ლაბორატორია, შემდგომ, პრეზენტაციით წარსდგნენ ინსტიტუტის მეცნიერ თანამშრომლების წინაშე.


ფოტო 1-2. პრეზენტაციისას - დოვილ რუდოკაიტე და ვილდა გრიბაუსკიენე (კაუნასის ტექნოლოგიების საგანმანათლებლო ცენტრი)
Photo 1-2. During the presentation - Dovil Rudokaite and Vilda Grybauskiene (Kaunas Technology Education Center)


ფოტო 3-4. ინსტიტუტის ჰიდროტექნიკური ლაბორატორიის დათვალიერებებისას
Photo 3-4. While visiting the institute's hydrotechnical laboratory

- **2023 წლის 14 მარტს,** თბილისში შედგა სამუშაო შეხვედრა შოთა რუსთაველის საქართველოს ეროვნულ სამეცნიერო ფონდთან არსებული ევროკავშირის საჯარო სამსახურების დაძმობილების პროგრამის ფარგლებში „ინტერსექტორული თანამშრომლობის შესაძლებლობების მხარდაჭერა კვლევასა და ინდუსტრიას შორის“.

ფოტო 5. შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდის გენერალურ დირექტორთან, პროფესორ ერეკლე ასტახიშვილთან ერთად
Photo 5. together with the Director General of the Shota Rustaveli National Science Foundation of Georgia, Professor Erekle Astakhishvili

ფოტო 6. იაპონიის საერთაშორისო თანამშრომლობის სააგენტოს საქართველოს ოფისის მუდმივი წარმომადგენელი ბ-ნ მორი ჰიროიუკისთან და იაპონიის საერთაშორისო თანამშრომლობის სააგენტოს საქართველოს ოფისის წარმომადგენელ ბ-ნ კონსტანტინე წერეთელთან
Photo 6. Mr. Mori Hiroyuki – Resident Representative at the Japan International Cooperation Agency, Georgia Office and Mr. Konstantine Tsereteli – Responsible representative at the Japan International Cooperation Agency, Georgia Office

ფოტო 7. აკადემიკოსი გივი გავარდაშვილი, პროფესორი ნიკა ლოლაძე და ასოც. პროფესორი კონსტანტინე ბზიავა
Photo 7. Academician Givi Gavardashvili, Professor Nika Loladze, Ass. Professor Konstantine Bziava

- **2023 წლის 23-24 მარტს** საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტში სამუშაო ვიზიტით იმყოფებოდა ოულუს უნივერსიტეტის (ფინეთი) გარემოსდაცვითი და ქიმიური ინჟინერიის ფაკულტეტის წყლისა და გარემოსდაცვის განვითარების დეპარტამენტის დოქტორანტი ჯუჰო ჰააპალასი.

ფოტო 8. შეხვედრისას
Photo 8. During the meeting

- **2023 წლის 11 აპრილს** ქ. თბილისში იაპონიის საერთაშორისო თანამშრომლობის სააგენტოში გაიმართა სამუშაო შეხვედრა. საუბარი შეეხო იაპონიის სააგენტოსა და საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა

მეურნეობის ინსტიტუტს შორის საერთაშორისო თანამშრომლობის მიმართულებებს და საერთაშორისო საგრანტო პროექტების ერთობლივ მომზადებას, ასევე სტუდენტებისა და ახალგაზრდა მეცნიერების იაპონიაში სწავლისა და სტაჟირების საკითხებს. შეხვედრას ესწრებოდნენ: ფოტოზე მარცხნიდან: ქალბატონი იშიი ჰოძუმი (საერთაშორისო პროექტების ფორმულირების მრჩეველი), ბატონი მორი ჰიროიუკი (სააგენტოს მუდმივი წარმომადგენელი), კონსტანტინე წერეთელი (პროგრამების ოფიცერი), აკადემიკოსი გივი გავარდაშვილი (ინსტიტუტის დირექტორი), ასოცირებული პროფესორი კონსტანტინე ბზიავა (ინსტიტუტის უფროსი მეცნიერ თანამშრომელი).

ფოტო 9. სამუშაო შეხვედრისას
Photo 9. At the work meeting

- **2023 წლის 3 მაისს,** თბილისში, გაიმართა ნატო-ს პროგრამის „მეცნიერება უსაფრთხოებისა და მშვიდობისთვის“ (NATO SPS) საინფორმაციო დღე, რომელშიც მონაწილეობდნენ: საქართველოს განათლებისა და მეცნიერების სამინისტროს, საგარეო საქმეთა სამინისტროს წარმომადგენლები, ნატო-ს გენერალური მდივნის თანაშემწის მოადგილე, ბ-მა ჯეიმს აპატურაი, საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტისა და სხვადასხვა ინსტიტუტის მეცნიერები.

ფოტო 10 - 11. სამუშაო შეხვედრისას
Photo 10 - 11. At the work meeting

- **2023 წლის 9 მაისს,** საქართველოს მეცნიერებათა ეროვნული აკადემიის ვებ-გვერდზე განთავსდა ინფორმაცია: http://science.org.ge/?p=13399&fbclid=IwAR0pQCK2AuullTDafmxXEOdynr1qGhCZlkK6YXiDFG_BY5emq6um8ADAoWc – „პირველად საქართველოში, შავი ზღვის მეცნიერული კვლევის ობსერვატორია (NPBSO) დაფუძნდება“, რომელიც მოკლედ აღწერს, რომ აკადემიკოს გივი გავარდაშვილის თანახელმძღვანელობით საქართველოს ტექნიკური უნივერსიტეტის (სტუ) ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის კოლხეთის საცდელ–ეკოლოგიურ პუნქტში, პირველად საქართველოში, ნატოს სტანდარტების გათვალისწინებით შავი ზღვის ობსერვატორია (NPBSO) დაფუძნდება, სადაც ინსტიტუტის მეცნიერები შავი ზღვის ეკოლოგიურ პრობლემებს შეისწავლიან.

- **2023 წლის 15 მაისს** საქართველოს მეცნიერებათა ეროვნულ აკადემიაში ჩატარდა ინოვაციებისა და მაღალი ტექნოლოგიების ცენტრის მორიგი სხდომა, რომელიც მიეძღვნა მტკნარი და მინერალური წყლების მოპოვებისა და ბუტილირებული წყლის ექსპორტის გაზრდის საკითხებს. სხდომაზე მოხსენებებით გამოვიდნენ: ზურაბ კაკულია, ზურაბ ვარაზაშვილი, მარინე მარდაშოვა (სტუ-ს ჰიდროგეოლოგიის და საინჟინრო გეოლოგიის ინსტიტუტი), ვახტანგ გელაძე (სტუ-ს საქართველოს საწარმოთა ძალებისა და ბუნებრივი რესურსების შემსწავლელი ცენტრი), აკადემიკოსი გივი გავარდაშვილი (სტუ-ს ცოტნე მირცხულავას სახ. წყალთა მეურნეობის ინსტიტუტი), არჩილ მაღალაშვილი (ილიას უნივერსიტეტი და “IDS Borjomi Georgia”), ეთერ ხარაიშვილი და ნინო ლობჟანიძე (თსუ), გიგა ნადირაძე (ენერგეტიკისა და წყალმომარაგების მარეგულირებელი კომისია, ირაკლი მიქაძე და რომან რურუა (სახალხო მოძრაობა საქართველოს ეკონომიკური აღმავლობისთვის).


ფოტო 12-13. სხდომის მიმდინარეობისას
Photo 12-13. During the session

- **2023 წლის 14 ივნისს,** საქართველოს სოფლის მეურნეობის მეცნიერებათა აკადემიის სხდომათა დარბაზში ჩატარდა სოფლის მეურნეობის მეცნიერებათა აკადემიის აგრარული ინოვაციების კომისიის სხდომა #6 (38) შემდეგი დღის წესრიგით: „წყლის რესურსების მართვა“ - ინფორმაცია საქართველოს კანონ-პროექტის თაობაზე ინფორმაცია. აღნიშნულ საკითხზე მოხსენებით გამოვიდა: მარიამ მაკაროვა - საქართველოს გარემოს დაცვისა და სოფლის მეურნეობის სამინისტროს გარემოსა და კლიმატის ცვლილების დეპარტამენტის წყლის სამმართველოს ხელმძღვანელი. მან დამსწრე საზოგადოებას გააცნო, რომ მომზადდა „წყლის რესურსების მართვის შესახებ“ ახალი კანონპროექტი, რომელიც მოწონებულ იქნა საქართველოს მთავრობის მიერ და წარდგენილია საქართველოს პარლამენტში. მიმდინარე წლის აპრილში კანონპროექტმა პლენარულ სხდომაზე პირველი მოსმენა წარმატებით გაიარა. ასევე დეტალურად შეეხო კანონპროექტის სიახლეებს: უფლებამოსილი ორგანოების კომპეტენციების გამიჯვნა; სააუზო მართვის სისტემის ჩამოყალიბება; აუზების ფარგლებში წყლის გამოყენების პრიორიტეტიზაცია; ზედაპირული წყლის ობიექტებიდან წყალაღებაზე და ზედაპირული წყლის ობიექტებში ჩამდინარე წყლების ჩაშვებაზე სანებართვო სისტემის აღდგენა (გაუქმდა 2008 წელს); ზედაპირული წყლის ობიექტებიდან წყალაღების მოსაკრებლის აღდგენა („ფასიანი ბუნებათსარგებლობის“ პრინციპი). აღსანიშნავია, რომ დღეისათვის ზედაპირული წყალი ერთადერთი ბუნებრივი რესურსია, რომლითაც სარგებლობა უფასოა. კანონპროექტით დადგენილი ნორმების ამოქმედება საქართველოს მთელ ტერიტორიაზე გათვალისწინებულია ეტაპობრივად. სხდომას, კომისიის თავმჯდომარის, საქართველოს მეცნიერებათა აკადემიის აკადემიკოს ალექსანდრე დიდებულიძის მიწვევით ესწრებოდა სტუ-ს ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორი, აკადემიკოსი გივი გავარდაშვილი.

- **2023 წლის 20 სექტემბერს,** ინსტიტუტმა მიიღო მონაწილეობა საქართველოს განათლებისა და მეცნიერების სამინისტროს, აჭარის ავტონომიური რესპუბლიკის განათლების, კულტურისა და სპორტის სამინისტროსა და ბათუმის

შოთა რუსთაველის სახელმწიფო უნივერსიტეტის ორგანიზებით, ბათუმში გამართულ სამეცნიერო-საგანმანათლებლო ღონისძიებაში: „საზღვაო ქვეყნის ლურჯი პოლიტიკა“. ღონისძიების ფარგლებში წარმოდგენილი იყო შავი ზღვისა და ზღვისპირა რეგიონის ბიომრავალფეროვნების, ეკოლოგიის, ბუნებრივი რესურსების, კლიმატის, სოციალურ-ეკონომიკური, პოლიტიკური, კულტურულ-ისტორიული და სხვა მიმართულებით არსებული უახლესი სამეცნიერო კვლევების პრეზენტაცია, გამოფენები, კონფერენცია, ვორკშოპები, შემეცნებითი ვიქტორინები, ექსპერიმენტები მოსწავლეებისათვის და სხვა აქტივობები. ღია ცის ქვეშ სამეცნიერო პავილიონების გამოფენაში მონაწილეობა მიიღეს უმაღლესი საგანმანათლებლო დაწესებულებების, სამეცნიერო-კვლევითი ცენტრებისა და სხვა ორგანიზაციების წარმომადგენლებმა. წარმოდგენილი იყო შავი ზღვისა და რეგიონის კვლევების ამსახველი სხვადასხვა სახის სამეცნიერო პროექტის შედეგები, სახალისო აქტივობები მოსწავლეებისათვის, გამოფენები, ვიქტორინები და სხვა.

ფოტო 14-18. გამოფენის მსვლელობისას
Photo 14-18. during the exhibition

- **2023 წლის 10 ნოემბერს** საქართველოს მეცნიერებათა ეროვნული აკადემიაში ტრადიციისამებრ, საზეიმოდ აღინიშნა მეცნიერების მსოფლიო დღე, რომელიც 2001 წელს „იუნესკოს“ მიერ იყო დაფუძნებული. საზეიმო ღონისძიება შესავალი სიტყვით გახსნა აკადემიის პრეზიდენტმა, აკადემიკოსმა როინ მეტრეველმა და დამსწრე საზოგადოებას საქართველოს პრემიერ-მინისტრის ირაკლი ღარიბაშვილის მისალოცი წერილი გააცნო, ხოლო საქართველოს პატრიარქის მისალოცი წერილი ქართველ მეცნიერებს საპატრიარქო ტახტის მოსაყდრემ, სენაკისა და ჩხოროწყუს მიტროპოლიტმა, მეუფე შიომ წაიკითხა. გამომსვლელთა შორის იყვნენ: საქართველოს განათლებისა და მეცნიერების მინისტრის მოადგილე ნოდარ პაპუკაშვილი, აკადემიკოსები: დავით გურგენიძე, თინათინ სადუნიშვილი და ვლადიმერ პაპავა. აღსანიშნავია, რომ საქართველოს ტექნიკური უნივერსიტეტის რექტორმა დავით გურგენიძემ აკადემიას საჩუქრად გადასცა ელექტრონული არითმომეტრი. ქართველ მეცნიერებს ეს დღე თავიანთი ვიდეო მიმართვით მიულოცეს აკადემიკოსებმა: მზექალა შანიძემ და დავით მუსხელიშვილმა. ღონისძიებაზე გაჟღერდა ასეთი მოსაზრება, რომ სამომავლოდ დაარსდება ქართველი მეცნიერის ეროვნული დღე.

- **2023 წლის 20–24 ნოემბერს** საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორის აკადემიკოს გივი გავარდაშვილის ოფიციალური მოწვევით ინსტიტუტში სტუმრად იმყოფებოდნენ ვარმია მაზურის ოლშტენის (პოლონეთი) უნივერსიტეტის წყლისა და გარემოს დაცვის ინჟინერინგის ფაკულტეტის პროფესორები: რენატა ტანდირაკი, იოლანტა გროჩოვსკა, მიხაილ ლოპატა. საუბარი შეეხო საერთაშორისო თანამშრომლობას საგრანტო პროექტის მომზადებაში, ერთობლივ სამეცნიერო კვლევითი სამუშაოების განხორციელებას წყლისა და გარემოს დაცვის ინჟინერიაში, საერეთაშორისო კონფერენციების ერთობლივ ჩატარებას და ახალგაზრდა მეცნიერების გაცვლითი პროგრამების მომზადებას ევროკავშირის Erasmus+ პროგრამის გამოყენებით.

ფოტო 19-21. შეხვედრისას
Photo 19-21. at the meeting

- **2023 წლის 28 ნოემბერს** საქართველოს მეცნიერებათა ეროვნულ აკადემიაში ჩატარდა ინოვაციებისა და მაღალი ტექნოლოგიების ცენტრის სხდომა, რომელზეც განხილულ იქნა აკადემიკოს გივი გავარდაშვილის მოხსენება: „თოვლის ზვავების რეგულირების ინოვაციური ღონისძიება“. სხდომა გახსნა ინოვაციებისა და მაღალი ტექნოლოგიების ცენტრის ხელმძღვანელმა, აკადემიკოსმა გიორგი კვესიტაძემ. სხდომას ესწრებოდნენ საქართველოს მეცნიერებათა ეროვნული აკადემიის პრეზიდენტი, აკადემიკოსი როინ მეტრეველი, ვიცე-პრეზიდენტი, აკადემიკოსი რამაზ ხუროძე, აკადემიის აკადემიკოს-მდივანი, აკადემიკოსი ვლადიმერ პაპავა, აკადემიკოსები და მოწვეული სტუმრები. მოხსენება ეხებოდა საქართველოს ყველაზე სენსიტიური ობიექტის - საქართველოს სამხედრო გზისა და მის მიმდებარე ტერიტორიებზე განთავსებული ტურისტული ინფრასტრუქტურისა და მოსახლეობის თოვლის ზვავებისაგან დაცვის უსაფრთხოებას. მომხსენებელმა აღნიშნა, რომ კვლევები განხორციელდა საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტსა და გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია ა(ა)იპ გარემოს დაცვის ეკოცენტრის მეცნიერ-თანამშრომლების მიერ შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდის გამოყენებითი ინოვაციური საგრანტო პროექტის CARYS-19-305 ფარგლებში. მოხსენებამ დიდი ინტერესი გამოიწვია. მომხსენებელმა უპასუხა დამსწრე საზოგადოების კითხვებს და აღნიშნა, რომ ამ მიმართულებით კვლევები კვლავაც გაგრძელდება.

ფოტო 22. მოხსენებისას
Photo 22. while reporting

საზღვარგარეთ:

- **2023 წლის 8 სექტემბერს,** პოლონეთის ქ. ოლშტენის ვარმია და მაზურის უნივერსიტეტში საერთაშორისო კონფერენციის ფარგლებში საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორმა, აკადემიკოსმა გივი გავარდაშვილმა გამართა შეხვედრები უნივერსიტეტის ვიცე-რექტორთან პროფესორ ჯერზი ჯარასზევსკისთან (პოლონეთი), პროფესორ ჰეიკიკი მაკინენთან (ფინეთი), პროფესორ სერგი ლოპეზ ვერგესთან (ესპანეთი), პროფესორ კესტუსის რომანენსკასთან (ლიეტუვა), პროფესორ რენატა ტანდირაკთან (პოლონეთი) და სხვა წარმომადგენლებთან. საუბარი შეეხო საერთაშორისო თანამშრომლობას საგრანტო პროექტებში.


ფოტო 23-26. შეხვედრებისას
Photo 23-26. at the meetings

ინსტიტუტის საგრანტო საქმიანობა

- **2023 წლის 14 თებერვალს** ინსტიტუტსა და გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია ა(ა)იპ გარემოს დაცვის ეკოცენტრს შორის გაფორმებული ხელშეკრულების თანახმად, ხელი მოეწერა კონტრაქტს საქართველოს იუნესკოს საქმეთა ეროვნულ კომისიასთან საგრანტო პროექტის ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები“ დაფინანსების შესახებ.

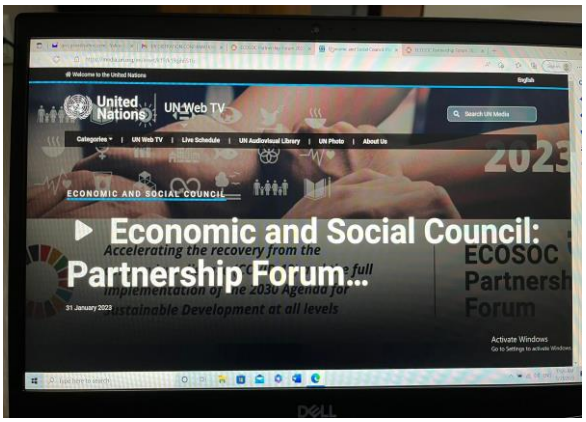
- **2023 წლის მარტში** საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის მიერ ორგანიზებული საერთაშორისო სამეცნიერო კონსორციუმის (მსოფლიოს 6 ქვეყნის - აშშ, საქართველო, უკრაინა, რუმინეთი, ბულგარეთი, თურქეთი) მიერ მომზადებულმა საგრანტო პროექტმა - ,,შავი ზღვის უსაფრთხოებისა და დაბინძურების რისკების

კონტროლი რიცხვითი მოდელების გამოყენებით“ - ნატოს მიერ დაფინანსება მიიღო (2023-2025 წწ).

საერთაშორისო და რესპუბლიკურ კონფერენციებში, ფორუმებში, სემინარებში, კონგრესსა და სიმპოზიუმებში მონაწილეობა

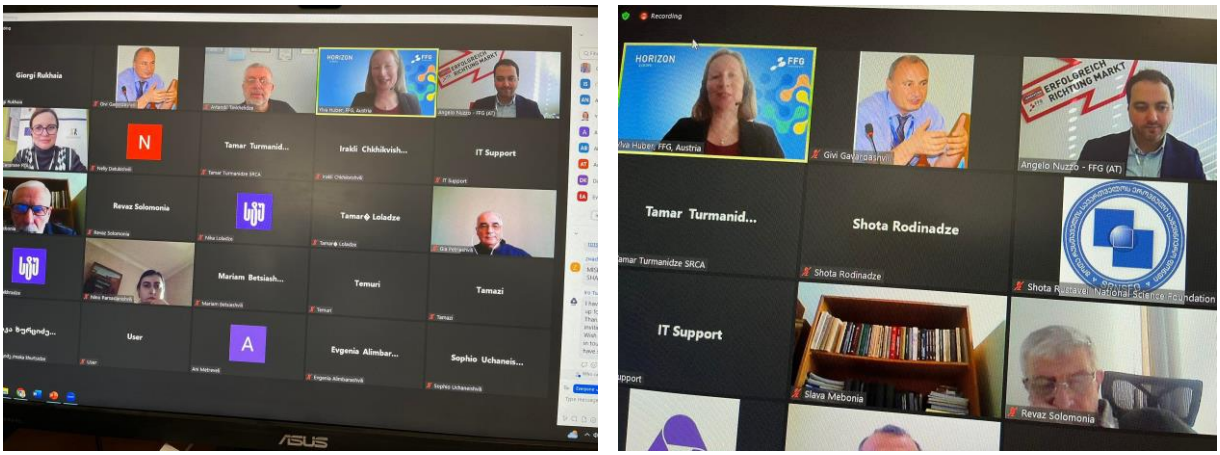
საქართველო

- **2023 წლის 30 იანვარს** ონლაინ რეჟიმში ჩატარდა გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) პარტნიორობის ფორუმი (ნიუ-იორკი, აშშ), რომელშიც მონაწილეობას იღებდა საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორი, აკადემიკოსი გივი გავარდაშვილი.



ფოტო 27-28. ფორუმის მიმდინარეობისას
Photo 27-28. During in Partnership Forum

- **2023 წლის 9 თებერვალს** ჩატარდა ონლაინ სემინარი - „ინტერსექტორული თანამშრომლობის შესაძლებლობების მხარდაჭერა კვლევასა და ინდუსტრიას შორის“, რომელშიც მონაწილეობდა საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორი, აკადემიკოსი გივი გავარდაშვილი.



ფოტო 29-30. სემინარის მიმდინარეობისას
Photo 29-30. During the workshop

- **2023 წლის 22 მარტს** წყლის რესურსების დაცვის საერთაშორისო დღესთან დაკავშირებით საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტმა და ა(ა)იპ გარემოს დაცვის ეკოცენტრმა ჩაატარეს სამეცნიერო სემინარი: ,,წყალი – სიცოცხლე, სიამოვნება, სტიქია'', რომელზეც მოწვეულნი იყვნენ ქ. თბილისის №221, №159, №63, №128 საჯარო და GEO SKY SCHOOL და „მწვანე სკოლა“ კერძო სკოლების მოსწავლეები და მასწავლებლები, აგრეთვე შპს „მომავლის ტექნოლოგიების“ დამფუძნებელი მამუკა ჯანგავაძე, დირექტორი დავით ჯორბენაძე, საქართველოს გარემოს დაცვისა და სოფლის მეურნეობის სამინისტროს შპს ,,საქართველოს მელიორაციის“ უფროსი სპეციალისტი ინგა არინდაული და სტუმარი სომხეთიდან წყლის რესურსების პრობლემებისა და ჰიდროტექნიკური ნაგებობების სამეცნიერო კვლევითი ინსტიტუტის დირექტორი, პროფესორი ოვანეს ტოკმაჯიანი.

  ინსტიტუტის დირექტორმა, აკადემიკოსმა გივი გავარდაშვილმა და თანამშრომლებმა მოწვეულ სტუმრებს წარმოუდგინეს პრეზენტაციები საქართველოს წყლის რესურსების (ზღვები, მდინარეები, ტბები, მიწისქვეშა წყლები, კაშხლები, წყალსაცავები და სხვ.) შესახებ, ასევე მოსწავლეები ადგილზე გაეცნენ ინსტიტუტის ჰიდროტექნიკურ ლაბორატორიას, თანამედროვე აპარატურის (ისრაელი, აშშ) საშუალებით წყლის ქიმიური ლაბორატორიული ანალიზისა და მცენარედან წყლის ევაპოტრანსპირაციის ჩატარების პროცესს. მოსწავლეებს დაურიგდათ საჩუქრები და გადაეცათ სემინარზე მონაწილეობის სერტიფიკატები.


ფოტო 31-32. სამეცნიერო სემინარის მიმდინარეობისას
Photo 31-32. During the scientific seminar

- **2023 წლის 31 მაისს - 4 ივნისს** დუშეთის მუნიციპალიტეტის მერიის საკონფერენციო დარბაზში გაიმართა ინსტიტუტის მიერ ორგანიზებული საერთაშორისო კონფერენცია თემაზე ,,ღვარცოფები: რისკი, პროგნოზირება, უსაფრთხოება“. საერთაშორისო ღონისძიებაში მონაწილეობა მიიღეს: საქართველოს, აზერბაიჯანის, პოლონეთის, სლოვაკეთის, ლიეტუვას, და უზბეკეთის პროფესორ-სპეციალისტებმა.

  საერთაშორისო ღონისძიება ჩატარდა შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდის გამოყენებითი საგრანტო პროექტის AR-18-1244 „ღვარცოფსარეგულაციო ელასტიური ბარაჟი“ ფინანსური მხარდაჭერით.

ფოტო 33-34. საერთაშორისო კონფერენციის მიმდინარეობისას
Photo 33-34. During the international conference

ფოტო 35. საერთაშორისო კონფერენციის მონაწილეები
Photo 35. Participants of the international conference

- **2023 წლის 21-23 აგვისტოს** საქართველოს მეცნიერებათა ეროვნულ აკადემიაში საქართველოს მეცნიერებათა ეროვნული აკადემიის სოფლის მეურნეობის განყოფილებისა და გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია, ა(ა)იპ გარემოს დაცვის ეკოცენტრის ორგანიზებით, შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდის გამოყენებითი კვლევების საგრანტო პროექტის ,,ღვარცოფსაწინააღმდეგო ელასტიკური ბარაჟი“ (AR – 18-1244) ფარგლებში ჩატარდა საერთაშორისო სამეცნიერო კონფერენცია – ,,ღვარცოფების რეგულირება ინოვაციური ნაგებობით“, სადაც მონაწილეობას იღებდნენ მეცნიერ-სპეციალისტები – იტალიიდან, თურქეთიდან, უკრაინიდან, აზერბაიჯანიდან, სომხეთიდან, ბელორუსიდან და საქართველოდან. კონფერენცია შესავალი სიტყვით გახსნა და საპატიო სტუმრებს მიესალმა აკადემიის პრეზიდენტი, აკადემიკოსი როინ მეტრეველი. კონფერენციის საორგანიზაციო კომიტეტის თავმჯდომარე იყო აკადემიკოსი გივი გავარდაშვილი.

  კონფერენციაზე სიტყვით გამოვიდნენ: საქართველოს ტექნიკური უნივერსიტეტის რექტორი, აკადემიკოსი დავით გურგენიძე, შოთა რუსთაველის საქართველოს ეროვნული სამეცნიერო ფონდის გენერალური დირექტორი, პროფესორი ერეკლე ასტახიშვილი, იტალიელი მეცნიერი, ირიგაციისა და დრენაჟის საერთაშორისო კომისიის საპატიო ვიცე-პრეზიდენტი, პროფესორი მარკო არჩიერი, თურქეთის კარადენიზის ტექნიკური უნივერსიტეტის პროფესორი კადირ სეიჰანი, აკადემიკოსი გივი გავარდაშვილი და სხვები.

  http://science.org.ge/?p=14317&fbclid=IwAR0sR-j3l_cmJn6AEBdTZZzPKz_Xh2j0IKWrtC_3FYpqNUdyzhtiRQcolvQ

ფოტო 36-38. კონფერენციის მსვლელობისას
Photo 36-38. During the conference

- **2023 წლის 22 აგვისტოს** საერთაშორისო კონფერენციის ,,ღვარცოფების რეგულირება ინოვაციური ნაგებობებით'' მონაწილეებისათვის მოეწყო პროფესიული ექსკურსია. მოწვეულმა სტუმრებმა ადგილობრივ მეცნიერ-სპეციალისტებთან ერთად დაათვალიერეს ჟინვალის წყალსაცავი, მლეთის ხევში, გრანტის ფარგლებში აშენებული ,,ღვარცოფსარეგულაციო ელასტიკური ბარაჟი'' და დარიალ ჰესის სათავე ნაგებობა.

ფოტო 39-42. პროფესიული ექსკურსია
Photo 39-42. Professional excursion

- **2023 წლის 24 აგვისტოს** საერთაშორისო კონფერენციის ,,ღვარცოფების რეგულირება ინოვაციური ნაგებობებით'' ფარგლებში საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტში გაიმართა შეხვედრა კონფერენციის მონაწილეებსა და ინსტიტუტის თანამშრომლებს შორის.

  შეხვედრაზე წარმოდგენილი იყო ინსტიტუტში მიმდინარე კვლევები და პროექტები. პრეზენტაციების შემდეგ გაიმართა დისკუსია.

ფოტო 43-46. შეხვედრისას
Photo 43-46. at the meeting

- **2023 წლის 15-18 სექტემბერს,** გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაციამ ა(ა)იპ გარემოს დაცვის ეკოცენტრმა გაერთიანებული ერების განათლების, მეცნიერებისა და კულტურის ორგანიზაციის (UNESCO) 2022-2023 წწ. "მონაწილეობის პროგრამის" ფინანსური მხარდაჭერით ქ. თბილისში ჩაატარა სამეცნიერო კონფერენციის - ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები" პირველი ეტაპის პირველი ღონისძიება თემაზე - მოწყვლადი ინფრასტრუქტურის რისკების შეფასება კრიტიკული მდგომარეობისა და რისკების პორტფოლიოს ანალიზის (CAPRA) მოდელის გამოყენებით.

ფოტო 47-49. საერთაშორისო კონფერენციის მსვლელობისას
Photo 47-49. During the international conference

ფოტო 50-51. საერთაშორისო კონფერენციის მონაწილეები
Photo 50-51. Participants of the international conference

- **2023 წლის 13-15 ოქტომბერს** სტეფანწმინდის მუნიციპალიტეტის სოფ. სნოში გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაციამ ა(ა)იპ გარემოს დაცვის ეკოცენტრმა გაერთიანებული ერების განათლების, მეცნიერებისა და კულტურის ორგანიზაციის (UNESCO) 2022 - 2023 წწ. "მონაწილეობის პროგრამის" ფინანსური მხარდაჭერით ჩაატარა სამეცნიერო კონფერენციის ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები" პირველი ეტაპის რიგით მეორე ღონისძიება თემაზე ,,თოვლის ზვავის საწინააღმდეგო ინოვაციური კონსტრუქცია".
  გარემოს დაცვის ეკოცენტრის თანამშრომლებთან ერთად საერთაშორისო სამეცნიერო კონფერენციის მუშაობაში მონაწილეობდნენ: საქართველოს მეცნიერებათა ეროვნული აკადემიის, საქართველოს ტექნიკური უნივერსიტეტისა (სტუ) და სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის თანამშრომლები, რეგიონალური მიზნობრივი ბენეფიციარები სტეფანწმინდის (ყაზბეგის) მუნიციპალიტეტიდან, ადგილობრივი თვითმმართველობის წარმომად-გენლები და მოსახლეობა.


ფოტო 52-53. საერთაშორისო კონფერენციის მსვლელობისას

Photo 52-53. During the international conference

ფოტო 54. საერთაშორისო კონფერენციის მონაწილეები

Photo 54. Participants of the international conference

ფოტო 55-56. პროფესიულ ექსკურსიაზე
Photo 55-56. On a professional excursion

- **2023 წლის 20-22 ოქტომბერს** გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია ა(ა)იპ გარემოს დაცვის ეკოცენტრმა გაერთიანებული ერების განათლების, მეცნიერებისა და კულტურის ორგანიზაციის (UNESCO) 2022 - 2023 წ.წ. "მონაწილეობის პროგრამის" ფინანსური მხარდაჭერით დუშეთის მუნიციპალიტეტის მერიის საკონფერენციო დარბაზში ჩაატარა სამეცნიერო კონფერენციის ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები" პირველი ეტაპის რიგით მესამე ღონისძიება თემაზე - ,,ღვარცოფსარეგულაციო ელასტიკური ბარაჟი".

გარემოს დაცვის ეკოცენტრის თანამშრომლებთან ერთად საერთაშორისო სამეცნიერო კონფერენციის მუშაობაში მონაწილეობდნენ: საქართველოს მეცნიერებათა ეროვნული აკადემიის, საქართველოს ტექნიკური უნივერსიტეტის (სტუ), სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის, დუშეთის მუნიციპალიტეტის მერიისა და მასში შემავალი განათლების რესურსცენტრის თანამშრომლები, დუშეთის მუნიციპალიტეტში შემავალი სოფლების გამგებლები და ადგილობრივი მოსახლეობის წარმომადგენლები, სულ 60-მდე მონაწილე.

სამეცნიერო კონფერენციის მუშაობაში მოწვეული იყო პოლონეთიდან ჩესტოჰოვას ტექნოლოგიური უნივერსიტეტისა და ნისას გამოყენებითი მეცნიერების უნივერსიტეტის პროფესორი ადამ უიმა. კონფერენციის მსვლელობის პერიოდში განხორციელდა პროფესიული და კულტურული ექსკურსიები.

ფოტო 57-58. კონფერენციის მსვლელობისას
Photo 57-58. During the conference

ფოტო 59. კონფერენციის მონაწილეები
Photo 59. Conference participants

ფოტო 60. პროფესიულ ექსკურსიაზე
Photo 60. On a professional excursion

- **2023 წლის 8 - 10 დეკემბერს** ქ. ყვარელში სასტუმრო შატო ,,ყვარელის" საკონფერენციო დარბაზში, გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია ა(ა)იპ გარემოს დაცვის ეკოცენტრმა გაერთიანებული ერების განათლების, მეცნიერებისა და კულტურის ორგანიზაციის (UNESCO) 2022 - 2023 წ.წ. "მონაწილეობის პროგრამის" ფინანსური მხარდაჭერით ჩაატარა სამეცნიერო კონფერენციის ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები" მეორე ეტაპის რიგით პირველი ღონისძიება თემაზე - ქალაქ ყვარლის მოსახლეობის უსაფრთხოება წყალდიდობებისა და ღვარცოფებისაგან. კონფერენციის მუშაობაში მონაწილეობდნენ: საქართველოს მეცნიერებათა ეროვნული აკადემიის, საქართველოს გარემოს დაცვისა და სოფლის მეურნეობის სამინისტროს, საქართველოს ტექნიკური უნივერსიტეტის (სტუ), სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის, ღვინის ეროვნული სააგენტოს, ქინძმარაულის ღვინის ქარხნის, კინოსტუდია ქართული ფილმის, ადგილობრივი არასამთავრობო ორგანიზაციებისა და ინდმეწარმეების წარმომადგენლები, ქ. ყვარლის მერი, ბატონი გივი ზაუტაშვილი, ამავე მერიის ინფრასტრუქტურის, სივრცითი მოწყობის, ძეგლთა დაცვის, მშენებლობისა და არქიტექტურის სამსახურის ხელმძღვანელი, ალექსანდრე

გიგაური, ქ. ყვარლის მერიის სხვადასხვა სამსახურების წარმომადგენლები, ბიზნესმენები და ქ. ყვარლის ადგილობრივი მოსახლეობა.

9 დეკემბერს განხორციელდა პროფესიული და კულტურული ექსკურსიები - მდ. დურუჯის ღვარცოფული ტიპის კალაპოტში, კუდიგორის წყალსაცავსა და ქინძმარაულის მევენახეობის ტერიტორიაზე.

10 დეკემბერს შედგა შემაჯამებელი შეხვედრა - მრგვალი მაგიდა.

ფოტო 61-63. კონფერენციის მსვლელობისას
Photo 61-63. During the conference

ფოტო 64-65. კონფერენციის მონაწილეები
Photo 64-65. Conference participants

ფოტო 66-67. პროფესიულ ექსკურსიაზე
Photo 66-67. On a professional excursion

- **2023 წლის 26 და 28 დეკემბერს** იუნესკოს 2022-2023 წწ მონაწილეობის საერთაშორისო პროექტის #4/2240116105/pp ,,ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები‘‘ ფარგლებში

გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაციამ ა(ა)იპ გარემოს დაცვის ეკოცენტრმა ქ. თელავში სასტუმრო ,,Zuzumbo Resort & Spa" გამართა საერთაშორისო კონფერენცია თემაზე ,,ქალაქ თელავის მოსახლეობის უსაფრთხოება წყალდიდობებისა და ღვარცოფებისაგან".

კონფერენციის მუშაობაში მონაწილეობდნენ: საქართველოს მეცნიერებათა ეროვნული აკადემიის, საქართველოს ტექნიკური უნივერსიტეტის (სტუ), სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის, ქ. თელავის მერიის სხვადასხვა სამსახურების უფროსები, იაკობ გოგებაშვილის თელავის სახელმწიფო უნივერსიტეტის პროფესორები, ახალგაზრდა მეცნიერები და სტუდენტები, თელავის არასამთავრებო ორგანიზაციები, ბიზნესმენები და ქ. თელავის ადგილობრივი მოსახლეობა.

28 დეკემბერს განხორციელდა პროფესიული ექსკურსიები - მდ. თელავის ხევის კალაპოტში და მდ. კისისხევის ეროზიულ-ღვარცოფული ტიპის კალაპოტში, ხოლო დღის ბოლოს შედგა შემაჯამებელი შეხვედრა - მრგვალი მაგიდა.

ფოტო 68-70. კონფერენციის მსვლელობისას
Photo 68-70. During the conference

ფოტო 71. კონფერენციის მონაწილეები
Photo 71. conference participants

ფოტო 72-73. პროფესიულ ექსკურსიაზე
Photo 72-73. On a professional excursion

- 2023 წლის 27 დეკემბერს ახმეტის მუნიციპალიტეტის სოფელ ოჟიოს საჯარო სკოლის სპორტულ დარბაზში გაიმართა საერთასორისო კონფერენცია თემაზე - ,,სოფელ ჯვარბოსლის (მთათუშეთი, ახმეტის მუნიციპალიტეტი) მოსახლეობის უსაფრთხოება ეროზიულ - ღვარცოფული პროცესებისაგან“.

  კონფერენციის მუშაობაში მონაწილეობდნენ: საქართველოს მეცნიერებათა ეროვნული აკადემიის, საქართველოს ტექნიკური უნივერსიტეტის (სტუ), სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის, ქ. ახმეტის მერიის სხვადასხვა სამსახურების უფროსები და განათლების რესურსცენტრის თანამშრომლები, სოფელ ოჟიოს საჯარო სკოლის მასწავლებლები და მოსწავლეები, ადგილობრივი მოსახლეობა.

  კონფერენციის ბოლოს საერთაშორისო ღონისძიების მონაწილეებმა სოფელ ოჟიოს საჯარო სკოლის ეზოში დარგეს მრავალწლიანი მწვანე ნარგავები იუნესკოს სახელობის სკვერისა და ხეივნის მოსაწყობად.

ფოტო 74-76. კონფერენციის მსვლელობისას
Photo 74-76. During the conference

ფოტო 77. სოფ. ოჟიოს სკოლის დირექტორთან, ქალბატონ ჟანა ახალკაციშვილთან

Photos 77. with the director of the Ozhio village school, Ms. Zhana Akhalkatsishvili

ფოტო 78-79. მწვანე ნარგავების დარგვისას

Photos 78-79. When planting green plants


ფოტო 80-81. ჩატარებული სამუშაოების შედეგი

Photos 80-81. The result of the performed works

ფოტო 82-83. კონფერენციის მონაწილეები
Photo 82-83. Conference participants

საზღვარგარეთ

- **2023 წლის 7-8 სექტემბერს,** პოლონეთის ქ. ოლშტინის ვორმიისა და მაზურის უნივერსიტეტში ჩატარდა საერთაშორისო სამეცნიერო-ტექნიკური კონფერენცია. კონფერენციაზე მიწვეული იყო საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორი, აკადემიკოსი გივი გავარდაშვილი.

ფოტო 84-85. კონფერენციაზე პრეზენტაციისას
Photo 84-85. In a conference presentation

- **2023 წლის 19-20 დეკემბერს** ბაქოში ჩატარდა აზერბაიჯანის მეცნიერის, დამსახურებული მეცნიერის, აკადემიკოსის, ვასიფ ბაბაზადეს დაბადებიდან 85 წლისთავისადმი მიძღვნილი საერთაშორისო სამეცნიერო კონფერენცია „GEOLOGY: UNITY OF THEORY AND PRACTICE“ პრეზენტაციის ფარგლებში, რომელშიც მონაწილეობის მისაღებად მიწვეული იყვნენ ინსტიტუტის დირექტორი, აკადემიკოსი გივი გავარდაშვილი და უფროსი მეცნიერი თანამშრომელი ქეთი დადიანი.

ფოტო 86. კონფერენციაზე პრეზენტაციისას
Photo 86. In a conference presentation

ფოტო 87-88. კონფერენციის მსვლელობისას
Photo 87-88. During the conference

სასწავლო-სამეცნიერო საქმიანობა

- **2023 წლის 13 ივლისს** საქართველოს ტექნიკური უნივერსიტეტის ც.მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის ირიგაციისა და დრენაჟის განყოფილების თანამშრომელმა ფერიდე ლორთქიფანიძემ საქართველოს ტექნიკური უნივერსიტეტის აგრარული მეცნიერებებისა და ბიოსისტემების ინჟინერინგის ფაკულტეტზე წარმატებით დაიცვა სადისერტაციო ნაშრომი - „საქართველოს დეგრადირებული ნიადაგების რეაბილიტაცია მცენარე ტოპინამბურის საველე კვლევების განხორციელებით ალაზნის მლაშე ნიადაგების მაგალითზე“ (ხელმძღვანელი - აკადემიკოსი გიცი გავარდაშვილი).

ფოტო 89-90. სადისერტაციო ნაშრომის დაცვისას
Photo 89-90. During the defense of the thesis

დაჯილდოება

- **2023 წლის 31 აგვისტოს** საქართველოს მეცნიერებათა ეროვნული აკადემიის აკადემიკოსს, ტექნიკის მეცნიერებათა დოქტორს, პროფესორ გივი გავარდაშვილს 39 პროექტისა და პრაქტიკაში აშენებული 13 ნაგებობის ავტორს დღეს საქართველოს ეკონომიკისა და მდგრადი განვითარების მინისტრის ბრძანებით მიენიჭა საქართველოს დამსახურებული მშენებლის საპატიო წოდება.

ფოტო 91. დაჯილდოებისას
Photo 91. At the award ceremony

- **2023 წლის 10 ნოემბერს** საქართველოს მეცნიერებათა ეროვნული აკადემიაში ტრადიციისამებრ, საზეიმოდ აღინიშნა მეცნიერების მსოფლიო დღე, რომელიც 2001 წელს „იუნესკოს“ მიერ იყო დაფუძნებული. მეცნიერების მსოფლიო დღესთან დაკავშირებით საქართველოს მეცნიერებათა ეროვნულმა აკადემიამ ჰიდრომელიორაციის დარგში სამეცნიერო მიღწევებისათვის საპატიო სიგელით დააჯილდოვა სტუ-ს ც. მირცხულავას სახელობის წყალთა მეურნეობის მთავარი მეცნიერი, ტექნიკის მეცნიერებათა დოქტორი ედუარდ კუხალაშვილი.


საქართველოს მეცნიერებათა ეროვნული აკადემია
Georgian National Academy of Sciences

იუნესკოს მიერ დაწესებულ მეცნიერების მსოფლიო დღესთან დაკავშირებით
საქართველოს მეცნიერებათა ეროვნული აკადემია
საპატიო სიგელით აჯილდოებს
ტექნიკის მეცნიერებათა დოქტორ ედუარდ კუხალაშვილს
ჰიდრომელიორაციის დარგში სამეცნიერო მიღწევებისათვის

Georgian National Academy of Sciences awards honorary diploma
on World Science Day established by UNESCO to:
Doctor of Technical Sciences **Eduard Kukhalashvili**
for scientific achievements in the field of hydromelioration

ROIN METREVELI
President of the Georgian National Academy of Sciences
Tbilisi

რაინდ მეტრეველი
საქართველოს მეცნიერებათა ეროვნული აკადემიის პრეზიდენტი
თბილისი

10.11.2023

ფოტო 92-93. დაჯილდოებისას
Photo 92-93. at the award ceremony

მასმედიასთან ურთიერთობა

- **2023 წლის 10-16 თებერვლის** გაზეთში „GEORGIA TODAY“ დაიბეჭდა საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორის, აკადემიკოს გივი გავარდაშვილის სტატია - ინოვაციური მეცნიერება, გარემოს დაცვა, უსაფრთხოება.


6 | BUSINESS

GEORGIA TODAY
FEBRUARY 10 - 16, 2023

Innovative Science, Environmental Protection, Safety

TRANSLATED BY KETEVAN SKHIRTLADZE

PLEASE INTRODUCE OUR READERS TO YOUR AND THE INSTITUTE'S SCIENTIFIC WORK.

WHAT CAN YOU TELL US ABOUT YOUR INSTITUTION?

TELL US ABOUT YOUR INNOVATIVE PROJECTS IN THE DIRECTION OF ENVIRONMENTAL PROTECTION.

TELL US ABOUT A HYDROMELIORATION PROJECT YOU HAVE RUN.

WHAT CAN YOU TELL US ABOUT INNOVATIVE TECHNOLOGIES?

WHAT MODERN SCIENTIFIC LITERATURE HAVE YOU BEEN INVOLVED IN CREATING?

WHAT CAN YOU TELL US ABOUT THE FUTURE OF THE INSTITUTE'S WORK AND THE 2023 PLAN?

ფოტო 94. სტატია „GEORGIA TODAY“-ში
Photo 94. Article in "GEORGIA TODAY"

- **2023 წლის 7-13 აპრილის** გაზეთში „GEORGIA TODAY“ დაიბეჭდა სტატია - წყლის მსოფლიო დღე - წყალი: სიცოცხლე, სიამოვნება, ბუნება, რომელშიც მოთხრობილი იყო საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტში წყლის რესურსების დაცვის საერთაშორისო დღესთან დაკავშირებით ჩატარებული სამეცნიერო სემინარის შესახებ.

8 | SOCIETY GEORGIA TODAY APR. 7 - 13, 2023

World Water Day – Water: Life, Pleasure, Nature

TRANSLATED BY KETEVAN SHORTLADZE

To recognize the International Day of Protection of Water Resources, the Tsotne Mirtskhulava Water Management Institute of the Georgian Technical University (GTU) and the Organization of the Economic and Social Council of the United Nations (ECOSOC) of the consultative status of Ecocenter for Environmental Protection (Ecocenter), held a scientific seminar on March 22.

With the motto, "Water – life, pleasure, nature," students and teachers of 7 Tbilisi public and private schools No221, No139, Nosi, No628 (GBO SKY SCHOOL and "Green School"), specialists of the Ministry of Environment Protection and Agriculture of Georgia, and LLC "Georgian Amelioration" were invited to join the celebration. Guests from Armenia created Professor Ognes Tokmajian, Mamuka Jangavadze, founder of "Future Technologies" LLC, and Director Davit Jorbenadze. Guests were also invited from the Office of the Permanent Coordinator of the United Nations in Georgia.

"The scientific seminar was opened by the director of the Tsotne Mirtskhulava Water Management Institute, academician, doctor of technical sciences, and professor, Givi Gavarashvili addressed.

"International Water Day was established by the UN Assembly in 1993, and this year is its 30th anniversary," noted Prof. Gavarashvili.

"Indeed, today is a remarkable day for our planet and, of course, for our country, including our institute, which was established in 1925 as the Transcaucasian Water Management Institute, and was officially registered in 1929.

"During the 94 years of its operation, the institute changed its name many times, it was the Transcaucasian Water Management Institute, then the Institute of Hydrotechnics and Melioration, the Institute of Water Management and Engineering Ecology of the National Academy of sciences of Georgia, then, after the reforms, the Institute of Water Management of the Georgian National Academy of Sciences, and finally the Tsotne Mirtskhulava Water Management Institute of GTU.

"The institute can be called the alma mater of water resources studies, environmental protection, engineering ecology, hydromelioration and reliability and risk studies of hydrotechnical structures," Gavarashvili said.

During the celebratory seminar, Head of the Institute's Natural Hazards and the Environment department, academic doctor of Geography, chief scientist Robert Dzikonidze introduced the attending public to the role of natural disasters in the case of mechanical pollution of water resources. Head of the Seas and Basins Department of Water Management at the Institute of Georgian Technical University, Chief Scientist Irina Ivrdiashvili, introduced the guests to the geomorphological features of the territory of Georgia, which determine the rich and diverse types of water resources. She noted that on the 69,700 square kilometer territory of Georgia, there are 26,060 rivers, among which 3,993 are in eastern, and 16,109 are in western Georgia, 860 lakes, 20 large irrigation canals, up to 60 glaciers, and numerous underground waters, artesian pools, thermal and mineral waters.

"There are 51 water reservoirs in the territory of Georgia, constructed in mountain and foothill regions is due to their significant water resources and their high energy potential," Ivrdiashvili noted. "These reservoirs in the headwaters of rivers at high points are highly efficient and have a low negative impact on the environment. They enrich naturalLandscapes and encourage recreation and tourism, and increase agricultural productivity by irrigating land."

Chief Scientist Shorena Kupreishvili, Head of the Irrigation and Drainage Department and academic doctor, spoke to the seminar guests about the wetlands of Kolkheti.

"The total area of wetlands of Kolkheti is some 225 thousand hectares, on which it is necessary to carry out complex capital reclamation works to best utilize the space agriculture. At the same time, the full and effective exploitation of the Kolkheti region significantly depends on the widespread hydrographic network, riverbeds (both natural and artificial) and the regulation of the runoff formed during the harvesting of intensive precipitation.

"To develop a system of complex measures for the reclamation of Kolkheti's heavy wetlands, important research works have been carried out by many scientific institutions, a challenge met by the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, under the leadership of Professor Givi Gavarashvili," Kupreishvili noted.

Spotlighted during the seminar was the arrangement of the field monitor for the study of the innovative three-way combined drainage (Georgia patent with certificate # GE P 2005, 3571 B) was carried out under the grant project No 61/21.

"Research of new alternative drainage measures for the Kolkheti plain on the example of three-way combined drainage" with leading doctoral student Maka Gogrichiani scientific supervisor, academician Givi Gavarashvili (2021-2024). To carry out field experiments on the three-way combined drainage, a research polygon was organized at the test base of Didi Ilkhalchi Agrarian College of the Senaki district of the Technical University of Georgia. The conducted studies and obtained results showed that since 2013, the drainage has worked and there has been no swamping in the entrance area of the yard. The research conducted by Ana Gavarashvili in the direction of water resources management is also important – on the Black Sea, and Nokis Gavarashvili – on the Vere Gorge, whose project proposals won a grant competition.

Tamziko Supatashvili, a scientific employee of the innovative group of the Institute, and an academician doctor of agroengineering, at the seminar presented a report on the topic: "Water quality control."

She talked about basic control parameters in water, the physical, chemical, and physico-chemical characteristics. She showed the school children present practical examples – experiments to determine the acidity in water by means of a pH meter (by an Israeli company) and how to determine iron content by means of a portable spectrophotometer (by HACH, USA).

Olga Kharaishvili, candidate of technical sciences and senior scientist gave a speech to the school students, noting that water is an essential vital component for normal plant development.

"Water helps photosynthesis, absorption of nutrients, and the maintenance of cell turgor," she told them. "The plant mainly evaporates water from its leaves. Through the gills (gill transpiration), steam is released from the mesophyll cells into the atmosphere. Water evaporates from the epidermis (peridermal transpiration). Transpiration ensures the movement of water and substances dissolved in it from the roots to the leaves. The plant's ability to evaporate water protects the plant from overheating. Transpiration changes under the influence of environmental factors. The amount of transpiration is determined by the intensity of transpiration. Determining the intensity of transpiration by weight method is an important process," she said.

To demonstrate transpiration, she did an experiment, with a flask, and a weighed rubber stopper with a plant leaf attached. The result showed the intensity of transpiration – that 42 g of water was evaporated by the plant leaf in 38 minutes.

At the next seminar, Professor Ognes Tokmajian, director of the Scientific Research Institute of Water Resources Problems and Hydrotechnical Structures from Armenia, Mamuka Jangavadze, the founder of "Future Technologies" LLC, and Inga Arzinbadi, a specialist of "Georgian Amelioration" Ltd., etc., spoke.

Academician Givi Gavarashvili rounded up the event by once again congratulating the attending public and schoolchildren on International Water Day and wishing them many successes in the national use of water, one of the main natural resources of the country. In the hydrotechnical laboratory of the institute, the participants of the seminar took a group photo, and school students were given souvenirs and certificates of participation in the seminar.

Academician Givi Gavarashvili at the opening of the seminar. After his paragraph.

Tamziko Supatashvili conducting experiments

Olga Kharaishvili reporting

Shorena Kupreishvili during the presentation

General photo of the workshop participants in the hydrotechnical laboratory

ფოტო 95. სტატია „GEORGIA TODAY“-ში
Photo 95. Article in "GEORGIA TODAY"

- **2023 წლის 20 ივნისს** "პალიტრანიუსისა" და რადიო "პალიტრის" გადაცემა "საქმის" სტუმრები იყვნენ საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის დირექტორი, აკადემიკოსი, ტექნიკის მეცნიერებათა დოქტორი გივი გავარდაშვილი და თსუ-ს მიხეილ ნოდიას სახელობის გეოფიზიკის ინსტიტუტის მთავარი მეცნიერი, ფიზიკა-მათემატიკის მეცნიერებათა დოქტორი, პროფესორი დემურ დემეტრაშვილი. გადაცემაში განხილული იყო კახოვკის ჰესის აფეთქების შედეგად გამოწვეული შესაძლო ეკოლოგიური პრობლემები და საკურორტო სეზონი.

  https://palitranews.ge/video/222921-sakme-chavardeba-tu-ara-sakurorto-sezoni/?fbclid=IwAR0sR-j3l_cmJn6AEBdTZZzPKz_Xh2j0IKWrtC_3FYpqNUdyzhtiRQcolvQ

ფოტო 96. გადაცემის მსვლელობისას
Photo 96. During the transmission

- **2023 წლის 4 აგვისტოს** "პალიტრანიუსის" პოლიტიკური თოქ-შოუ "360 გრადუსში" მიწვეულები იყვნენ: საგანგებო სიტუაციების მართვის სამსახურის უფროსი თემურ მღებრიშვილი, გარემოს ეროვნული სააგენტოს გეოლოგი მერაბ გაფრინდაშვილი, ქართველ კასკადიორთა ჯგუფის ხელმძღვანელი ირაკლი საბანაძე, ჟურნალისტი გელა მთიულიშვილი, სანაგებო სიტუაციების მართვის ექსპერტი თემურ გიორგაძე, სეისმოლოგი ზურაბ ჯავახიშვილი, ღვარცოფების საერთაშორისო ასოციაციის პრეზიდიუმის წევრი, აკადემიკოსი გივი გავარდაშვილი, გის-ის აკადემიის დამფუძნებელი და გის-ის ექსპერტი ზურაბ ლაოშვილი. გადაცემაში განხილული იყო 2023 წლის 3 აგვისტოს შოვში მომხდარი ტრაგედიის სავარაუდო მიზეზები.

https://palitranews.ge/video/225899-360-gradusi-shovis-tragedia/?fbclid=IwAR0TCLoYHhm8axN4ima-1EHx6WbOG2nXSFAzE9sWnZIv3EBXjDXo6KR5bo0

ფოტო 97. გადაცემის მსვლელობისას
Photo 97. During the transmission

C H R O N I C L E

INFORMATION ABOUT TSOTNE MIRTSKHULAVA WATER MANAGEMENT INSTITUTE OF GEORGIAN TECHNICAL UNIVERSITY 2023

In the institute, which is established in 1925, work 78 collaborators, among them 56 % are scientific worker, 1 - academician, head of agricultural department of Georgian National Scientific Academy, 4 – engineering academy, 5 – doctor of sciences, 28 – acad. doctor, 2 – PhD student and 19 master.

THE SCIENTIFIC RESEARCH ACTIVITY OF THE INSTITUTE

- About 40 articles, 11 monographs and 5 textbooks were published in the periodicals of 2023 by the institute's scientific employees;
- In the institute are working out the scientific theme with program financing ,,The Research of Water Management and Environmental Protection on the Background of Climate Change" (Head of Theme, professor Givi Gavardashvili) with 6 scientific direction, which is actual for scientific treatment of environmental protection measures on the background of frequent natural disaster in the country.

THE SCIENTIFIC RELATIONSHIP OF THE INSTITUTE

Georgia

- **On January 20, 2023,** Dovil Rudokaite and Vilda Grybauskienė (Kaunas Technological Educational Center) visited from Kaunas (Lithuania) Tsotne Mirtskhulava Water Management Institute of Georgian Technical University. During the meeting, the conversation touched on several important issues; the guests visited the hydrotechnical laboratory of the Institute and made a presentation to the Institute's researchers **(Photos 1-4).**

- **On March 14, 2023,** a working meeting was held in Tbilisi with the Shota Rustaveli National Science Foundation of Georgia within the framework of the twinning program of the EU public services "Supporting opportunities for intersectoral cooperation between research and industry" **(Photos 5-7).**

- **On March 23-24, 2023,** Juho Haapala, Ph.D. student of the Department of Water and Environmental Development of the Environmental and Chemical Engineering Faculty of the University of Oulu (Finland) was on a working visit to the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University **(Photo 8).**

- **On April 11, 2023,** business meeting was held at the Japan International Cooperation Agency (JICA) in Tbilisi. The conversation touched upon the directions of international cooperation

between Japanese Agency and Tstone Mirtskhulava Water Management Institute of Georgian Technical University and the joint preparation of international grant projects, as well as the issues of study and internship of students and young scientists in Japan. The meeting was attended by (to the left): Ms. Ishii Hozumi (Project Formulation Advisor), Mr. Mori Hiroyuki (Resident Representative), Mr. Konstantine Tsereteli (Programs Officer), Academician Givi Gavardashvili (Director of the Institute), Associate Professor Konstantine Bziava (Senior Researcher of the Institute) **(Photo 9).**

- **On May 3, 2023,** an information day of the NATO program "Science for Security and Peace" (NATO SPS) was held in Tbilisi, in which the representatives of the Ministry of Education and Science of Georgia, the Ministry of Foreign Affairs, Mr. James Appathurai, Deputy Assistant Secretary General for Emerging Security Challenges, NATO, scientists of the Tsotne Mirtskhulava Water Management Institute of the Georgia Technical University and various institutes **(Photos 10-11).**

- **On May 9, 2023,** information was posted on the website of the National Academy of Sciences of Georgia: http://science.org.ge/?p=13399&fbclid=IwAR0pQCK2AuullTDafmxXEOdynr1qGhCZlkK6YXiDFG_BY5emq6um8ADAoWc - "For the first time in Georgia, the Black Sea Scientific Research Observatory (NPBSO) will be established", which briefly describes that under the co-leadership of Academician Givi Gavardashvili, for the first time in Georgia, at the Kolkheti pilot-ecological station of the Institute, Taking into account the NATO standards, the Black Sea Observatory (NPBSO) will be established, where the scientists of the institute will study the ecological problems of the Black Sea.

- **On May 15, 2023,** another session of the Innovation and High Technologies Center was held at the National Academy of Sciences of Georgia, which was dedicated to the issues of extracting fresh and mineral waters and increasing the export of bottled water. The following came out with reports at the session: Zurab Kakulia, Zurab Varazashvili, Marine Mardashova (Institute of Hydrogeology and Engineering Geology of GTU), Vakhtang Geladze (GTU's Center for the Study of Enterprise Forces and Natural Resources of Georgia), Academician Givi Gavardashvili (Tsotne Mirtskhulava Water Management Institute of GTU), Archil Kholashvili (Ilia University and "IDS Borjomi Georgia"), Eter Kharaishvili and Nino Lobzhanidze (TSU), Giga Nadiradze (Energy and Water Supply Regulatory Commission, Irakli Mikadze and Roman Rurua (People's Movement for the Economic Rise of Georgia) **(Photos 12-13).**

- **On June 14, 2023,** in the session hall of the Georgian Academy of Agricultural Sciences, the meeting of the Agrarian Innovations Commission of the Academy of Agricultural Sciences # 6 (38) was held with the following agenda: "Management of water resources" - information on the draft law of Georgia. Mariam Makarova - Head of the Water Division of the Environment and Climate Change Department of the Ministry of Environment Protection and Agriculture of Georgia gave a report on the mentioned issue. She informed the audience that a new draft law "Management of water resources" was prepared, which was approved by the Government of Georgia and submitted to the Parliament of Georgia. In April of this year, the draft law successfully passed the first hearing at the plenary session. She also touched on the novelties of the draft law in detail: separation of competences of authorized bodies; establishment of a basin

management system; prioritization of water uses within basins; restoration of the permit system for water abstraction from surface water bodies and discharge of waste water into surface water bodies (cancelled in 2008); Restoring the fee for water abstraction from surface water bodies (principle of "paid use of nature"). It should be noted that today surface water is the only natural resource that is free to use. Implementation of the norms established by the draft law is planned for the entire territory of Georgia in stages. Academician Givi Gavardashvili, Director of Institute, attended the session at the invitation of the chairman of the commission, Academician of S/M Academy of Sciences, Aleksandre Didebulidze.

- **On September 20, 2023,** the Institute took part in the scientific and educational event organized by the Ministry of Education and Science of Georgia, the Ministry of Education, Culture and Sports of the Autonomous Republic of Adjara and Batumi Shota Rustaveli State University: "Blue Policy of the Maritime Country". The event included the presentation of the latest scientific researches, exhibitions, conferences, workshops, cognitive quizzes, experiments for students and other activities on the biodiversity, ecology, natural resources, climate, socio-economic, political, cultural-historical and other areas of the Black Sea and coastal region. . Representatives of higher educational institutions, scientific-research centers and other organizations took part in the exhibition of scientific pavilions in the open air. The results of various scientific projects depicting the researches of the Black Sea and the region, fun activities for students, exhibitions, quizzes and others were presented **(Photos 14-18).**

- **On November 10, 2023,** the National Academy of Sciences of Georgia celebrated the World Science Day, which was established by UNESCO in 2001, according to tradition. The ceremonial event was opened by the president of the Academy, academician Roin Metreveli, and introduced the congratulatory letter of the Prime Minister of Georgia Irakli Gharibashvili to the audience, and the congratulatory letter of the Patriarch of Georgia was read to the Georgian scientists by the seat of the patriarchal throne, Metropolitan of Senaki and Chkhorotsku, Reverend Shio. Among the speakers were: Deputy Minister of Education and Science of Georgia Nodar Papukashvili, academicians: Davit Gurgenidze, Tinatin Sadunishvili and Vladimir Papava. It should be noted that Davit Gurgenidze, rector of the Technical University of Georgia, presented the academy with an electronic arithmetic meter as a gift. Academicians Mzekala Shanidze and Davit Muskhelishvili congratulated Georgian scientists on this day with their video address. Such an opinion was voiced at the event that the National Day of Georgian Scientists will be established in the future.

- **On November 20-24, 2023,** the professors faculty of water and environmental protection engineering from the University of Warmia and Mazury in Olsztyn (Poland), Renata Tandyrak, Jolanta Grochowska, Michał Łopata were visiting at the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University with the official invitation of Academician Givi Gavardashvili, director of the Institute.

  The conversation related to international cooperation in the preparation of a grant project, implementation of joint scientific research works in water and environmental protection engineering, joint holding of international conferences and preparation of exchange programs for young scientists using the EU Erasmus+ program **(Photos 19-21).**

- **On November 28, 2023,** a session of the Center for Innovation and High Technologies was held at the National Academy of Sciences of Georgia, where academician Givi Gavardashvili's report was discussed: "Innovative Measure of Snow Avalanche Regulation". Academician Giorgi Kvesitadze, head of Innovation and High Technologies Center, opened the session. The session was attended by the President of the National Academy of Sciences of Georgia, Academician Roin Metreveli, Vice-President, Academician Ramaz Khurodze, Academician-Secretary of the Academy, Academician Vladimir Papava, academicians and invited guests. The report was about the security of the most sensitive object of Georgia - the military road of Georgia and the tourist infrastructure located in its surrounding areas and the protection of the population from snow avalanches. Speaker noted that the researches were carried out by the scientific staff of Tsotne Mirtskhulava Water Management Institute of Georgian Technical University and NNLE "ECOCENTER for Environmental Protection" - the Consultative Status Organization of the United Nations Economic and Social Council (ECOSOC) within under the Applied Innovative Grant Project (CARYS-19-305) of the Georgian Shota Rustaveli National Science Foundation. The report generated a lot of interest. The speaker answered the questions of the audience and noted that research in this direction will continue **(Photo 22).**

Abroad

- **On September 8, 2023** in Poland in Olsztyn at the University of Warmia and Mazury, within the framework of the international conference, the director of the Institute, academician Givi Gavardashvili met with the vice-rector of the university, Professor Jerzy Yarashevsky (Poland), Professor Heikiki Makkinen (Finland), Professor Sergi Lopez Verge (Spain), with Professor Kestus Romanenska (Lithuania), Professor Renata Tandyrak (Poland) and other representatives. The conversation touched on international cooperation in grant projects **(Photos 23-26).**

GRANT ACTIVITY OF THE INSTITUTE

- **On February 14, 2023,** according to the agreement signed between the Institute and NNLE "ECOCENTER for Environmental Protection", a contract was signed with the National Commission for UNESCO Affairs of Georgia on the financing of the grant project "Prediction of natural disasters and innovative risk reduction measures".

- **On March 2023,** the grant project prepared by the International Scientific Consortium (6 countries of the world - USA, Georgia, Ukraine, Romania, Bulgaria, Turkey) organized by the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University - "Numerical Control of Black Sea Safety and Pollution Risks by Using Numerical Models" - received funding from NATO (2023-2025).

PARTICIPATION IN INTERNATIONAL AND REPUBLICAN CONFERENCES, FORUMS, SEMINARS, CONGRESSES AND SYMPOSIUMS

Georgia

- **On January 30, 2023**, the United Nations Economic and Social Council (ECOSOC) partnership forum (New York, USA) was held online, in which participated academician Givi Gavardashvili, director of the Tsotne Mirtskhulava Water Management Institute **(Photos 27-28).**

- **On February 9, 2023,** was held online seminar "Supporting opportunities for intersectoral cooperation between research and industry", in which participated academician Givi Gavardashvili, director of the Tsotne Mirtskhulava Water Management Institute **(Photos 29-30).**

- **On March 22, 2023,** in connection with the International Day for the Protection of Water Resources, the the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University and NNLE "ECOCENTER for Environmental Protection" held a scientific seminar: "Water - life, pleasure, nature", to which were invited pupils and teachers of public and private schools of Tbilisi: №221, №159, №63, №128, GEO SKY SCHOOL and "Green School", as well as Mamuka Jangavadze, founder of "Future Technologies" LLC, Director Davit Jorbenadze, Inga Arindauli, senior specialist of "Georgia Reclamation" LLC of the Ministry of Environment Protection and Agriculture of Georgia and a guest from Armenia, director of the Scientific Research Institute of Water Resources and Hydrotechnical Structures Problems, professor Hovhannes Tokmajyan. The director of the institute, academician Givi Gavardashvili and his staff gave presentations to the invited guests about the water resources of Georgia (seas, rivers, lakes, underground waters, dams, reservoirs, etc.), and the pupils got to know the institute's hydrotechnical laboratory on the spot. They also got acquainted with the process of chemical laboratory analysis of water and evapotranspiration of water from plants using modern equipment (Israel, USA). Pupils were given gifts and certificates for participation in the seminar **(Photos 31-32).**

- **On May 31 - June 4, 2023**, an International Conference entitled "Debris Flows: Risk, Prediction, Safety" Organized by the institute was held in the Conference Hall of the City Hall of Dusheti Municipality. Professors and specialists from Georgia, Azerbaijan, Poland, Slovakia, Lithuania and Uzbekistan participated in the given international event.

  The International Conference was held under the financial support of the Shota Rustaveli National Science Foundation of Georgia applied grant project AR-18-1244 "Elastic debris flow-regulating barrage" **(Photos 33-35).**

- **On August 21-23, 2023** at the National Academy of Sciences of Georgia was held an international scientific conference - "Regulation of floods with an innovative structure", Organized by the Department of Agriculture of the Georgian National Academy of Sciences and the NNLE "ECOCENTER for Environmental Protection" and funded by the Shota Rustaveli National Science Foundation of Georgia applied research grant project "Debrisflow Regulated Elastic barrage" (AR - 18-1244), where scientific specialists participated - from Italy, Turkey, Ukraine, Azerbaijan, Armenia, Belarus and Georgia. The conference was opened with an

introductory speech and honored guests were welcomed by the President of the Academy, Academician Roin Metreveli. Academician Givi Gavardashvili was the chairman of the organizing committee of the conference.

The following spoke at the conference: Rector of Technical University of Georgia, Academician Davit Gurgenidze, General Director of Shota Rustaveli National Science Foundation of Georgia, Professor Erekle Astakhishvili, Italian scientist, Honorary Vice-President of the International Commission on Irrigation and Drainage, Professor Marko Archieri, Professor of Technical University of Karadeniz of Turkey Kadir Seyhan, Academician Givi Gavardashvili and others **(Photos 36-38):**
http://science.org.ge/?p=14317&fbclid=IwAR0sR-j3l_cmJn6AEBdTZZzPKz_Xh2j0IKWrtC_3FYpqNUdyzhtiRQcolvQ

- **On August 22, 2023,** a professional excursion was organized for the participants of the international conference "Regulation of debris flows with innovative construction". The invited guests, together with local scientists-specialists, visited the Zhinvali reservoir, Mletis khevi, the "Debris flow regulating elastic dam" built under the grant, and the main building of the Darial HPP **(Photos 39-42).**

- **On August 24, 2023,** a meeting was held between the participants of the conference and the employees of the institute in the Tsotne Mirtskhulava Water Management Institute Georgian Technical University within the framework of the international conference "Debris flow regulation with innovative construction".

  Current researches and projects in the institute were presented at the meeting. A discussion was held after the presentations **(Photos 43-46).**

- The Organization in Category of Consultative Status with the Economic and Social Council (ECOSOC) of UN - NNLE “ECOCENTER for Environmental Protection” has hosted the first event entitled “Risk Assessment of Vulnerable Infrastructure using Critical State and Risk Portfolio Analysis (CAPRA) Model” of the first stage of the Scientific Conference “Forecasting Natural Disasters and Risk Reduction Innovative Measures”, which was held in Tbilisi, **15-18 September, 2023.** Given event was undertaken under the financial support of the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2022 - 2023 “Participation Program” **(Photos 47-51).**

- **On October 13-15, 2023,** in the village Sno of Stepantsminda municipality the second event of the first stage of the scientific conference "Prediction of natural disasters and innovative risk reduction measures" on the topic of "Innovative construction against snow avalanches" was organized by The Organization with Consultative Status of the Economic and Social Council (ECOSOC) of UN - NNLE “ECOCENTER for Environmental Protection” and with the financial support of the 2022–2023 "Participation Program" of United Nations Educational, Scientific and Cultural Organization (UNESCO) Along with the employees of the Environmental Protection Ecocenter, the international scientific conference was attended by Employees of Georgian National Academy of Sciences, Georgian Technical University (GTU), Tsotne Mirtskhulava Water Management Institute of GTU, regional target beneficiaries from Stepantsminda (Kazbegi) municipality, representatives of local self-government and population **(Photos 52-56).**

- **On October 20-22, 2023,** in the City Hall of the Dusheti Municipality the third event of the first stage of the scientific conference "Prediction of natural disasters and innovative risk reduction measures" on the topic of "Debris Flow Regulation Elastic Barrage" was organized by the Organization with Consultative Status of the Economic and Social Council (ECOSOC) of UN - NNLE "ECOCENTER for Environmental Protection" and with the financial support of the 2022–2023 "Participation Program" of United Nations Educational, Scientific and Cultural Organization (UNESCO). Along with the employees of the Environmental Protection Ecocenter, the international scientific conference was attended by Employees of Georgian National Academy of Sciences, Georgian Technical University (GTU), Tsotne Mirtskhulava Water Management Institute of GTU, Resourcecenter of the Education, regional target beneficiaries from Dusheti municipality, representatives of the City Hall of Dusheti Municipality and governors of villages of the Municipality, local population and stakeholders (around 60 people).

  Invited Professor Adam Ujma (BEng, PhD) from Czestochowa University of Technology and University of Applied Sciences in Nysa (Poland) has been attended and actively participated in the above-mentioned international event.

  During International Conference professional and cultural excursions were carried out **(Photos 57-60).**

- NNLE "ECOCENTER for Environmental Protection" – the Organization in Category of Consultative Status with the Economic and Social Council "ECOSOC" of the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2022-2023 under the financial support of the "Participation Program", **on December 8-10, 2023,** in the Conference Hall of the Hotel Chateau ,,Kvareli" in city Kvareli has carried out the first event of the second stage of the scientific conference "Prediction of Natural Disasters and Innovative Measures to Reduce Risks - Safety of the Population of the city of Kvareli Against Floods and Debris Flow". Representatives of the Georgian National Academy of Science, Ministry of the Environmental Protection and Agriculture of Georgia, Georgian Technical University (GTU), Tsotne Mirtskhulava Water Management Institute, National Wine Agency, Kindzmarauli Winery, Georgian Film Studio, Local Non-Governmental Organizations and Entrepreneurs, Mayor of the city Kvareli, Mr. Givi Zautashvili, Head of Infrastructure, Spatial Arrangement, Monument Protection, Construction and Architecture Service of the same City Hall, Mr. Aleksandre Gigauri, representatives of various services of Kvareli City Hall, businessmen and local residents of Kvareli were attended above mentioned event. Professional field trip and cultural excursions were carried out on December 9 to the alluvial type bed of the Duruji river, Kudigori reservoir and Kindzmarauli vineyard. A summary meeting - round table was organized in December 10 **(Photos 61-67).**

- NNLE "ECOCENTER for Environmental Protection" – the Organization in Category of Consultative Status with the Economic and Social Council "ECOSOC" of the United Nations Educational, Scientific and Cultural Organization (UNESCO) 2022-2023 under the financial support of the "Participation Program" #4/2240116105/pp entitled "Prediction of Natural Disasters and Innovative Measures to Reduce Risks", **on December 26, 28, 2023**, in the Conference Hall of the Hotel "Zuzumbo" in city Telavi has carried out an International Conference on "Safety of the Population of the city Telavi Against Floods and Debris Flow".

Representatives of the Georgian National Academy of Science, Georgian Technical University (GTU), Tsotne Mirtskhulava Water Management Institute of GTU, Heads of various departments of Telavi City Hall, Iakob Gogebashvili Telavi State University, young researchers and students, Local Non-Governmental Organizations, Businessmen and local residents of Telavi city were attended above mentioned event.

On December 28, professional excursions were carried out - to the river-bed of the Telavi River gorge and to the erosion-debris flow type river-bed of the Kisishkevi River, and at the end of the day, a summary meeting – a round table - was held **(Photos 68-73).**

- **On December 27, 2023,** an international conference was held in the sports hall of the public school of the village Ozhio, Akhmet municipality, on the topic - "Safety of the population of the village Jvarboseli (Mtatusheti, Akhmeta municipality) against erosion and debris flow".

Representatives of the Georgian National Academy of Science, Georgian Technical University (GTU), Tsotne Mirtskhulava Water Management Institute of GTU, Heads of various departments of Telavi City Hall and staff of the education resource center, Teachers and students of Ozhio village public school, local population were attended given event.

At the end of the conference, the participants of the international event planted perennial green plants in the yard of the public school of the village Ozhio to decorate the square and the alley named after UNESCO. Many thanks to Mrs. Zhana Akhalkatsishvili, director of the public school of Ozhio village, for promoting the national event at a high level.

Many thanks to UNESCO for funding our project "Prediction of Natural Disasters and Innovative Measures to Reduce Risks" **(Photos 74-83).**

Abroad

- **On September 7-8, 2023,** an international scientific and technical conference was held at the University of Wormia and Masuria in Olsztyn, Poland. Academician Givi Gavardashvili, director of the Institute, was invited to the conference **(Photos 84-85).**

- **On December 19-20, 2023,** an international scientific conference dedicated to the 85th anniversary of the birth of the Azerbaijani scientist, honored scientist, academician Vasif Babazade was held in Baku as part of the presentation "GEOLOGY: UNITY OF THEORY AND PRACTICE", in which the director of the institute, academician Givi Gavardashvili, and senior researcher at the institute, Keti Dadiani, were invited **(Photos 86-88).**

TEACHING-SCIENTIFIC ACTIVITY

- **On July 13, 2023,** Ph.D. student Feride Lortkifanidze, an employee of the Irrigation and Drainage Department of the Institute successfully defended her dissertation at the Faculty of Agricultural Sciences and Biosystems Engineering of the Georgian Technical University - "Rehabilitation of degraded soils in Georgia, implementation of field studies of Jerusalem artichoke plant of by example of the brackish soils of River Alazani " (leader - academic Gitsi Gavardashvili) **(Photos 89-90).**

AWARDS

- **On August 24, 2023,** by order of the Minister of Economy and Sustainable Development of Georgia, Academician of the National Academy of Sciences of Georgia, Doctor of Technical Sciences, Professor Givi Gavardashvili, the author of 49 projects and 13 structures built in practice, was awarded the honorary title of "Honored Builder of Georgia" **(Photo 91).**

- **On November 10, 2023,** the National Academy of Sciences of Georgia celebrated the World Science Day, which was established by UNESCO in 2001, according to tradition. On the occasion of the World Science Day, the National Academy of Sciences of Georgia awarded a certificate of honor to Eduard Kukhalashvili, Doctor of Technical Sciences, Chief Scientist of Tsotne Mirtskhulava Water Management Institute **(Photos 92-93).**

RELATIONS WITH MASS MEDIA

- **On February 10-16, 2023** in the newspaper "GEORGIA TODAY" published an article of the director of the institute, academician Givi Gavardashvili – "Innovative science, environmental protection, safety" was printed **(Photo 94).**

- **On April 7-13, 2023,** in the newspaper "GEORGIA TODAY" published an article "World Water Day - Water: Live, Enjoy, Nature", in which it was told about the scientific seminar held at the Tsotne Mirtskhulava Water Management Institute of the Georgian Technical University in connection with the International Day of Water Resources Protection **(Photo 95).**

- **On June 20, 2023,** the guests of the TV program "Business" of "Palitranius" and radio "Palitra" were the Director of the Tsotne Mirtskhulava Water Management Institute of Georgian Technical University, Academician, Doctor of Technical Sciences Givi Gavardashvili and the Chief Scientist of the Micheal Nodia Institute of Geophysics of Tbilisi State University Doctor of Physics and Mathematics, Professor Demuri Demetrashvili **(Photo 96).**
  https://palitranews.ge/video/222921-sakme-chavardeba-tu-ara-sakurorto-sezoni/?fbclid=IwAR0sR-j3l_cmJn6AEBdTZZzPKz_Xh2j0IKWrtC_3FYpqNUdyzhtiRQcolvQ

- **On August 4, 2023,** "Palitranius" political talk-show "360 degrees" invited: Mr. Temur Mghebrishvili - Head of the Emergency Management Service, Mr. Merab Gafrindashvili - Geologist of the National Environmental Agency, Mr. Irakli Sabanadze - Head of the Georgian Stunt Group, Journalist Mr. Gela Mtiuliishvili, Mr. Temur Giorgadze - Construction Situation Management Expert, Seismologist Mr. Zurab Javakhishvili, Academician Givi Gavardashvili - Member of the Presidium of the International Association of Landslides, Mr. Zurab Laoshvili - GIS Academy founder and GIS expert **(Photo 97)**.
  https://palitranews.ge/video/225899-360-gradusi-shovis-tragedia/?fbclid=IwAR0TCLoYHhm8axN4ima-1EHx6WbOG2nXSFAzE9sWnZIv3EBXjDXo6KR5bo0

AUTHOR INDEX

ავტორთა სამიებელი

CONTRIBUTIONS TO THE COLLECTED SCIENTIFIC PAPERS OF THE TSOTNE MIRTSKHULAVA WATER MANAGEMENT INSTITUTE OF THE GEORGIAN TECHNICAL UNIVERSITY

The main objective of collected papers is to favor the development of science and to publish the results and materials of studies and new achievements obtained by scientists and professionals.

The collected papers should include the following scientific directions:

- Water management;
- Hydraulic engineering and irrigation;
- Hydrology and meteorology;
- Environmental protection;
- Safety and risk of hydraulic structures;
- Construction;
- Earth sciences.

Contributions to the collected scientific papers are as follows:

1. Papers can be submitted in Georgian or English languages, no more than 10 pages. Paper summaries must be attached to the papers Georgian and English Summaries (to the paper in English language – English Summary). One author can submit no more than two papers.
2. The paper submitted to the Institute must include the letter of reference from the organization, where the study took place;
3. The paper must be submitted electronically to the following e-mail: **gwmi1929@gmail.com**.
4. Sheet format – A4, interval – 1.5 and font size 12, margins 25 mm for four sides; the paper must be submitted in DOC format (MS Word), recorded on CD-R; for Georgian Text – **Sylfaen**; for English and Russian Texts – **Times New Roman**; computer version of drawings and photos – in **JPG** or **TIF** format, 200 dpi;
5. The paper should include the following sequence:
    - Direction (in the upper right corner);
    - Paper Title;
    - Author (or authors) name, surname and patronymic with e-mail of contact person;
    - Organization, where the study took place, including post address;
    - Preamble;
    - General Part (object of study and methods);
    - Conclusions and Recommendations;
    - Bibliography (no more than 10);
    - Summary (10-15 lines);
    - Key Words (no more than 6).
6. Bibliographical references should include the following sequence: Author's (Authors') Name and Initials, Research Paper Title, Title and Number of Proceedings or Journal, Place of Publication (city), Year, Pages. The sequence of bibliographical references should be appropriate to the quotations given in the text;
7. Rejected papers will not be returned to authors.

საქართველოს ტექნიკური უნივერსიტეტის ცოტნე მირცხულავას სახელობის წყალთა მეურნეობის ინსტიტუტის სამეცნიერო შრომათა კრებულში სტატიების გამოქვეყნების პირობები

კრებულის დანიშნულებაა მეცნიერების განვითარების ხელშეწყობა, მეცნიერთა და სპეციალისტთა მიერ მოპოვებული ახალი მიღწევების, გამოკვლევათა მასალებისა და შედეგების გამოქვეყნება.

კრებულში შესაძლებელია გამოქვეყნდეს შემდეგი სამეცნიერო მიმართულების სტატიები:

- წყალთა მეურნეობა;
- ჰიდროტექნიკა და მელიორაცია;
- ჰიდროლოგია და მეტეოროლოგია;
- გარემოს დაცვა;
- ჰიდროტექნიკური ნაგებობების საიმედოობა და რისკი;
- მშენებლობა;
- დედამიწის შემსწავლელი მეცნიერებები.

კრებულში გამოსაქვეყნებელმა სტატიებმა უნდა დააკმაყოფილოს შემდეგი მოთხოვნები:

1. სტატია შეიძლება წარმოდგენილი იქნეს ქართულ ან ინგლისურ ენებზე, არა უმეტეს 10 გვერდისა. სტატიას უნდა დაერთოს ანოტაციები (ქართულ ენაზე წარმოდგენილ სტატიას – ქართულ და ინგლისურენოვანი ანოტაციები; ინგლისურენოვან სტატიას ინგლისური ანოტაცია). ერთ ავტორს შეუძლია წარმოადგინოს არა უმეტეს ორი სტატიისა.
2. ინსტიტუტში შემოსულ სტატიას უნდა დაერთოს იმ დაწესებულების მიმართვა, სადაც ნაშრომი იქნა შესრულებული;
3. სტატია მიიღება ელექტრონული ვერსიის სახით შემდეგ მისამართზე: **gwmi1929@gmail.com**.
4. ფურცლის ფორმატი – A4, ინტერვალი – 1,5 და შრიფტი – 12, მინდორი 25 მმ ფურცლის ოთხივე მხარეზე; სტატია შესრულებული უნდა იყოს **DOC** ფაილის სახით (MS Word), ჩაწერილი CD-R დისკზე. ქართული ტექსტისათვის გამოყენებულ უნდა იქნეს **Sylfaen** შრიფტი; ინგლისური და რუსული ტექსტებისათვის – **Times New Roman**; ნახაზების ან ფოტოების კომპიუტერული ვარიანტი – **JPG** ან **TIF** ფორმატში გარჩევადობით **200-300dpi**;
5. სტატია შედგენილ უნდა იქნეს შემდეგი თანმიმდევრობით:
   - სამეცნიერო მიმართულება (მარჯვენა ზედა კუთხეში);
   - სტატიის სახელწოდება;
   - ავტორის (ან ავტორების) სახელი, მამის სახელი და გვარი, საკონტაქტო პირის E-mail-ის მითითებით;
   - ორგანიზაციის დასახელება, სადაც შესრულებულია ნაშრომი, საფოსტო მისამართის მითითებით;
   - შესავალი;
   - ძირითადი ნაწილი (კვლევის ობიექტი და მეთოდიკა);
   - დასკვნები და რეკომენდაციები;
   - გამოყენებული ლიტერატურა (არა უმეტეს 10-ისა);
   - ანოტაცია (10–15 სტრიქონი) 3 (ქართული, რუსული და ინგლისური) ენაზე;
   - საკვანძო სიტყვები (არა უმეტეს 6-ისა) 3 (ქართულ, რუსულ და ინგლისურ) ენაზე.
6. გამოყენებული ლიტერატურა წარმოდგენილი უნდა იქნეს შემდეგი თანმიმდევრობით: ავტორის (ავტორების) გვარი და ინიციალები, შრომის დასახელება, კრებულის ან ჟურნალის დასახელება და ნომერი, გამოცემის ადგილი (ქალაქი), წელი, გვერდები. გამოყენებული ლიტერატურის თანმიმდევრობა უნდა შეესაბამებოდეს სტატიის ტექსტში მითითებულ ციტირებას;
7. გამოსაქვეყნებლად დაწუნებული სტატიები ავტორებს არ უბრუნდება.

ფოტო. იუნესკოს ეგიდით ინსტიტუტში ჩატარებული კონფერენციის მონაწილეები

2023 წელს ინსტიტუტსა და გაეროს ეკონომიკური და სოციალური საბჭოს (ECOSOC) საკონსულტაციო სტატუსის ორგანიზაცია ა(ა)იპ გარემოს დაცვის ეკოცენტრს შორის გაფორმებული ხელშეკრულების თანახმად, ხელი მოეწერა ხელშეკრულებას საქართველოს იუნესკოს საქმეთა ეროვნულ კომისიასთან საგრანტო პროექტის „ბუნებრივი კატასტროფების პროგნოზირება და რისკების შემცირების ინოვაციური ღონისძიებები“ დაფინანსების შესახებ.

On 2023, according to the agreement signed between the Institute and NNLE “ECOCENTER for Environmental Protection”, a contract was signed with the National Commission for UNESCO Affairs of Georgia on the financing of the grant project "Prediction of natural disasters and innovative risk reduction measures".